The Value of

Proprietary Health and Safety Software

To Proactive Health and Safety Management

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Summary

There has been little research in health and safety management concerning the application of information technology to the field. This thesis attempts to stimulate interest in this area by analysing the value of proprietary health and safety software to proactive health and safety management.

The thesis is based upon the detailed software evaluation of seven pieces of proprietary health and safety software. It features a discussion concerning the development of information technology and health and safety management, a review of the key issues identified during the software evaluations, an analysis of the commercial market for this type of software, and a consideration of the broader issues which surround the use of this software. It also includes practical guidance for the evaluation, selection, implementation and maintenance of all health and safety management software. This includes a comprehensive software evaluation chart.

The implications of the research are considered for proprietary health and safety software, the application of information technology to health and safety management, and for future research.

Dedication

In memory of my grandparents Norman and Kathleen Bates.

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Abbreviations

ACOP	Approved Code of Practice
ALARP	As Low As Reasonably Practicable
BS5304	British Standard 5304: Safeguarding of Machinery
BS8800	British Standard 8800: Guide to Occupational Health and Safety Management Systems
BSI	British Standards Institution
CAD	Computer Aided Design
CAS	Chemical Abstracts Service
CDM	Construction (Design and Management) Regulations
CD-R	Compact Disk - Recordable
CD-ROM	Compact Disk - Read Only Memory
CD-RW	Compact Disk - Re-Writable
CHIP	Chemicals (Hazard Information and Packaging for Supply) Regulations
COSHH	Control of Substances Hazardous to Health Regulations
CSCW	Computer Supported Cooperative Work
DOS	Disk Operating System
DSE	Health and Safety (Display Screen Equipment) Regulations
DVD	Digital Versatile Disk
EEC	European Economic Community
EDO RAM	Extended Data Out Random Access Memory
E-Mail	Electronic Mail
EU	European Union
GOMS	Goals, Operators, Methods and Selection rules model
GUI	Graphical User Interface
H&S	Health and Safety

HSWA	Health and Safety at Work Act
HCI	Human-Computer Interaction
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HS(G)65	HSE (1991) *Successful Health and Safety Management*
HSM	Health and Safety Management
IBM	International Business Machines Incorporated
IOSH	Institute of Occupational Safety and Health
IT	Information Technology
MB	Megabytes
MEL	Maximum Exposure Limit
MHSW	Management of Health and Safety at Work Regulations
MHz	Megahertz
MIT	Massachussets Institute of Technology
MMX	Multimedia Extensions
MORT	Management Oversight and Risk Tree
MS-DOS	Microsoft Disk Operating System
NHS	National Health Service
NWR	Noise at Work Regulations
OES	Occupational Exposure Standard
OSH	Occupational Safety and Health
PC	Personal Computer
PPE	Personal Protective Equipment
PPM	Parts Per Million
RAM	Random Access Memory
RIDDOR	Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations

ROSPA	Royal Society for the Prevention of Accidents
RPE	Respiratory Protective Equipment
SRI	Stanford Research Institute
TWA	Time-Weighted Average
UK	United Kingdom
US	United States
VR	Virtual Reality
VRAM	Video Random Access Memory
WYSIWYG	What You See Is What You Get
WWW	World Wide Web

Chapter 1: Introduction

If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties.

Francis Bacon (1605) *The Advancement of Learning.*[1]

This thesis describes the research that I have undertaken at the Health and Safety Unit in Aston University between 1994 and 1997. The research was largely conducted in conjunction with a small software company. They set the original research brief which was to develop specifications for a piece of proprietary computer software which would provide an integrated health and safety management system. I spent 6 months with the software company in 1995, completing the first task towards the original research goal. This was the production of detailed software evaluation reports based upon the company's three existing pieces of proprietary health and safety software. It was intended that this analysis would lay the foundations for examining how the three separate programs could be integrated into one comprehensive health and safety software system. Following my time with the software company, I extended the research by examining four pieces of proprietary health and safety software that were produced by other software companies and I generated further software evaluation reports from these.

In the early stages of the research into an integrated health and safety software system, I was personally highly committed to the belief that health and safety software was undoubtedly a valuable route forward for the field of health and safety. I had advanced to the research project from a psychology degree where I had produced three artificial intelligence programs for natural language processing as my final year project, and was intrigued by the research proposal because it involved examining a field where specialist computer software had yet to make a large scale impact. In other words, I came into the research project assuming that specialist computer software would inevitably help to advance health and safety management, and assuming that there was a

[1] Quoted by Partington, A. (ed) (1996) in *The Oxford Concise Dictionary of Quotations.*

very real need for such software. The case for health and safety software appeared to be transparent; it could surely only enhance and enrich health and safety management.

As I conducted the software evaluations for the software company I soon came to question the assumptions that I had implicitly made prior to commencing the research project. Slowly but surely I found question after question arising, issue after issue needing consideration. The stage was soon reached where I felt that so many important issues had emerged which needed detailed consideration that it would have been unwise to press ahead with the goal of designing specifications for an integrated health and safety software system without first ensuring that the project had solid foundations. The original research concept assumed that there is a need for computer hardware and software to be used in health and safety management. It assumed that there is a need for specialist health and safety software. It assumed that there is a need for an integrated health and safety software system. It assumed that small software companies, like the one with whom I undertook the research, can meet this need. It assumed that such software can be made today. It assumed that organisations are able to evaluate their health and safety management needs, decide whether or not they need health and safety software, decide which software they need, decide how much to invest, and decide how to implement and maintain the software that they purchase.

Moreover, the original research concept assumed that the use of computer technology in health and safety can only be for the good of all. It assumed that proprietary software can be produced for health and safety that will suit a wide range of organisations. It assumed that health and safety software is a good way for organisations to invest their precious health and safety resources, and a good product on which software companies can concentrate their resources. It assumed that there is sufficient knowledge and tools in the field of health and safety to form the basis of computer software that is designed to aid health and safety management. It assumed that computer software can adequately convey health and safety knowledge and tools. It assumed that current thinking on health and safety management is correct - that current health and safety management models, theories and definitions are suitable and sufficient for their purpose.

I could not take these assumptions for granted. So whilst the first part of the research involved producing the technical software evaluations for the software company, the later part of the research involved utilising the insight that had been gained into health and safety software through the software evaluations to examine in depth the underlying assumptions that I had identified. Thus the research project veered away from the original research concept, and moved towards a new research concept that was developed in conjunction with my supervisor. The new research concept involved examining at a broad level whether specialist software is appropriate for health and safety management, or whether adapted commercial "office" software is more appropriate. It also involved examining at a broad level how organisations can attempt to determine whether or not they need health and safety software, how they can evaluate the health and safety software that is available on the commercial market, and how they can reach informed decisions concerning the purchase of health and safety software. The research thus sought to ask a series of questions such as: whether proprietary health and safety software is fundamentally usable; whether it is best for small companies to produce proprietary health and safety software when commercial giants like Microsoft can produce versatile office software to meet the varied needs of businesses; whether when organisations want to purchase proprietary health and safety software it is a case of wanting technology for the sake of technology; and whether health and safety is a field where computer software can be helpful.

To help to set the scene for the research, I have provided a short history of the progress that has been made in the fields of health and safety and computer technology. The history is by no means comprehensive, it merely provides a useful comparative summary of how the fields have developed and how we have now reached a point where organisations seek to purchase specialist computer software to aid them in health and safety management. Following the short history, I will discuss why computer software may appear to be an attractive option for health and safety management, and why there is a need to examine the value of computer software to the field of health and safety at an academic level.

1.1 Progress in the Fields of H&S and Information Technology

1.1.1 Early History

> *If a builder constructs a house for a man but does not make his work strong with the result that the house which he built collapses and so causes the death of the owner of the house ... the builder shall be put to death.*
>
> The Code of Hammurabi, King of Babylonia, 1792-1750 BC.[2]
>
> *When thou buildest a new house, then thou shalt make a battlement for thy roof, that thou bring not blood upon thine house, if any man fall down thence.*
>
> *The Bible*, Deuteronomy, Chapter 22, Verse 8.[3]

The field of health and safety obtained something of a head-start on the field of information technology, when King Hammurabi of the Babylonian Empire created the first organised code of law during his reign from 1792 to 1750 B.C. (Grolier, 1995). This code of law, known to the modern world as the Code of Hammurabi, was found virtually intact on a durable diorite pillar in Susa, Iran in 1901. It consisted of 282 legal provisions that were systematically arranged under distinct headings such as trade, business, family, labour, real estate, and personal property. The Code of Hammurabi was guided by principles that are still familiar to this day, such as that *"the strong should not injure the weak"*, and that *"the punishment should fit the crime"*. Penalties for failing to comply with the code were severe, prescribing *"an eye for an eye, a tooth for a tooth"*. Within this code, several of the written laws referred to matters of health and safety. The health and safety laws were written in a non-prescriptive style: they specified *what* should be accomplished but not *how* it should be accomplished. Whilst the code served to provide a legislative framework for health and safety, with clear methods of enforcement and punishment for non-compliance, within this framework it was left to the individual to decide exactly how they would ensure that they complied with the legislation.

[2] Quoted in lecture notes for MSc in Risk Management & Safety Technology at Aston University 1995.

[3] Quoted by Kletz (1991) in *An Engineers View of Human Error*.

1.1.2 The Industrial Revolution

> *This century of experiment in factory legislation affords a typical example of English practical empiricism. We began with no abstract theory of social justice or the rights of man. We seem always to have been incapable even of taking a general view of the subject we were legislating upon. Each successive statute aimed at remedying a single ascertained evil. It was in vain that objectors urged that other evils, no more defensible, existed in other trades or classes, or with persons of ages other than those to which the particular Bill applied. Neither logic nor consistency, neither the over-nice consideration of even-handed justice nor the quixotic appeal of general humanitarianism, was permitted to stand in the way of a practical remedy for a proved wrong.*
>
> Quotation from Webb in 1910 on the piecemeal development of factory legislation in the United Kingdom4.

The Industrial Revolution was inspired largely by the growing desire to replicate human physical and mental functions through the creation of machines and automata. By the 1800s, automata had become hugely popular showpieces in homes and exhibitions. They so impressed those who viewed them that they inspired Edmund Cartwright to develop the power loom that was to revolutionise the northern mill industry, and Charles Babbage to develop designs for the first computer (Schaffer, 1996). Whilst the power loom aimed to replicate the human physical skills that were involved in producing textiles, Babbage's computer, known as the Analytical Engine, aimed to replicate the human mental skills that were involved in making mathematical calculations.

It was not until the Industrial Revolution that the need for health and safety legislation became evident in the United Kingdom. The Industrial Revolution swept through the country bringing great changes to work, technology, and living standards (Briggs, 1979). Machinery was created which could replicate much of the physical work of humans, and along with the emergence of the new technologies of coal and iron, and steam power, it led to the development of large-scale mills and factories that were designed for mass production through the use of mechanised machinery (Briggs, 1979; Evans, 1996). The new machinery allowed work to be conducted faster than ever before, it allowed products to be produced to a consistent standard, and it

[4] Quoted by Robens (1972) *Safety and Health at Work.* Report of the committee.

reduced the need for the lengthy training of employees. The machines came to be seen as the all-powerful creators whilst the workers came to be seen as cheap, expendable components that could be "plugged into" the mechanical systems, as the following quotation demonstrates:

> *Whilst the engine runs, the people must work - men, women and children are yoked together with iron and steam. The animal machine ... is chained fast to the iron machine, which knows no suffering and no weariness.*
>
> J. P. Kay (1832) *Moral and Physical Condition of Operatives Employed in the Cotton Manufacture in Manchester*[5].

The mass-production machinery brought with it a host of new work hazards, including rotating and moving parts that could kill or maim, as well as atrocious working conditions. Without protective legislation, work hours and conditions were left entirely to the whim of the factory owners, mill owners, and land owners (Briggs, 1979). A Reform Movement soon emerged to demand that the government create labour and health and safety legislation (Evans, 1996). This was opposed equally vehemently by those who felt that to do so would be against the sacred principles of the free market economy, would severely weaken the British economy, and would lead to mass unemployment and poverty. The Reform Movement provoked public outcry with the publication of graphic reports and illustrations describing the appalling work conditions in factories, mills and mines. They used the momentum that this generated to harry the government to enact inch by inch the protective legislation that they desired. Unfortunately, as quickly as health and safety legislation was being enacted and modified, employers were finding loopholes to exploit, and new hazards and horror stories were coming to light (see for example, Robottom, 1986 and Tonge, 1993). The United Kingdom's health and safety legislation thus grew rapidly into a complex web of detailed, prescriptive laws.

Once the first health and safety legislation was in place in the United Kingdom, the need to comply with it served slowly to prompt the development of health and safety management. Given that the early health and safety legislation was constructed in a

[5] Quoted by Briggs (1979) in *The Age of Improvement 1783-1867*.

reactive manner, with the primary force behind it being the extensive and explicit campaigning of the Reform Movement, it is perhaps unsurprising that the reactive approach to managing health and safety filtered down from the governments of the Industrial Revolution to the many businesses faced with the difficulties of complying with the new legislation. With the reactive approach to health and safety legislation and management, the aim was to prevent the repetition of bad working conditions and accidents which had already occurred in the workplace. The reactive approach soon became the dominant paradigm for health and safety, and has remained unchallenged in its authority until recent years (Booth, 1993b).

Whilst health and safety was making slow but steady progress with constant changes to legislation, the development of computer technology was taking an even slower, and less sure route. Charles Babbage devised what is now commonly viewed as the first modern computer, the Analytical Engine, on paper in 1834. The Analytical Engine was to be constructed from mechanical components, driven by steam-power and capable of performing basic mathematical calculations. An assembly of gears and shafts would be able to deal with 50-digit numbers, while a rack of gearwheels could store up to 1000 such numbers, and a calculating unit could add two numbers in less than ten seconds and multiply them in less than a minute (Moravec, 1988). In concept the Analytical Engine contained all of the elements of a modern digital computer, but despite 37 years of dedication by Babbage it was never completed in his lifetime. Only in 1991 to mark the occasion of the 200th anniversary of Babbage's birth was an Analytical Engine built at the London Science Museum based precisely on Babbage's original designs and funded by the large computer companies of today. It had taken modern experts 6 years to build the 11 foot long and 7 wide monster made up of 4000 bronze, cast iron and steel parts, and weighing just under three tonnes. In tests the Analytical Engine was found to work exceedingly well, and could calculate to 31 figures of accuracy (Swade, 1996)[6].

[6] Swade (1996) presents intriguing evidence which indicates that the first fully working computer was built by Thomas Fowler, a self-taught printer and bookseller, in 1841. Fowler's computer was created in wood and designed to undertake calculations. It operated through binary techniques rather than the decimal techniques of Babbage's Analytical Engine. As modern computers are based on binary techniques it could be argued that Fowler's computer offered greater possibilities than Babbage's computer.

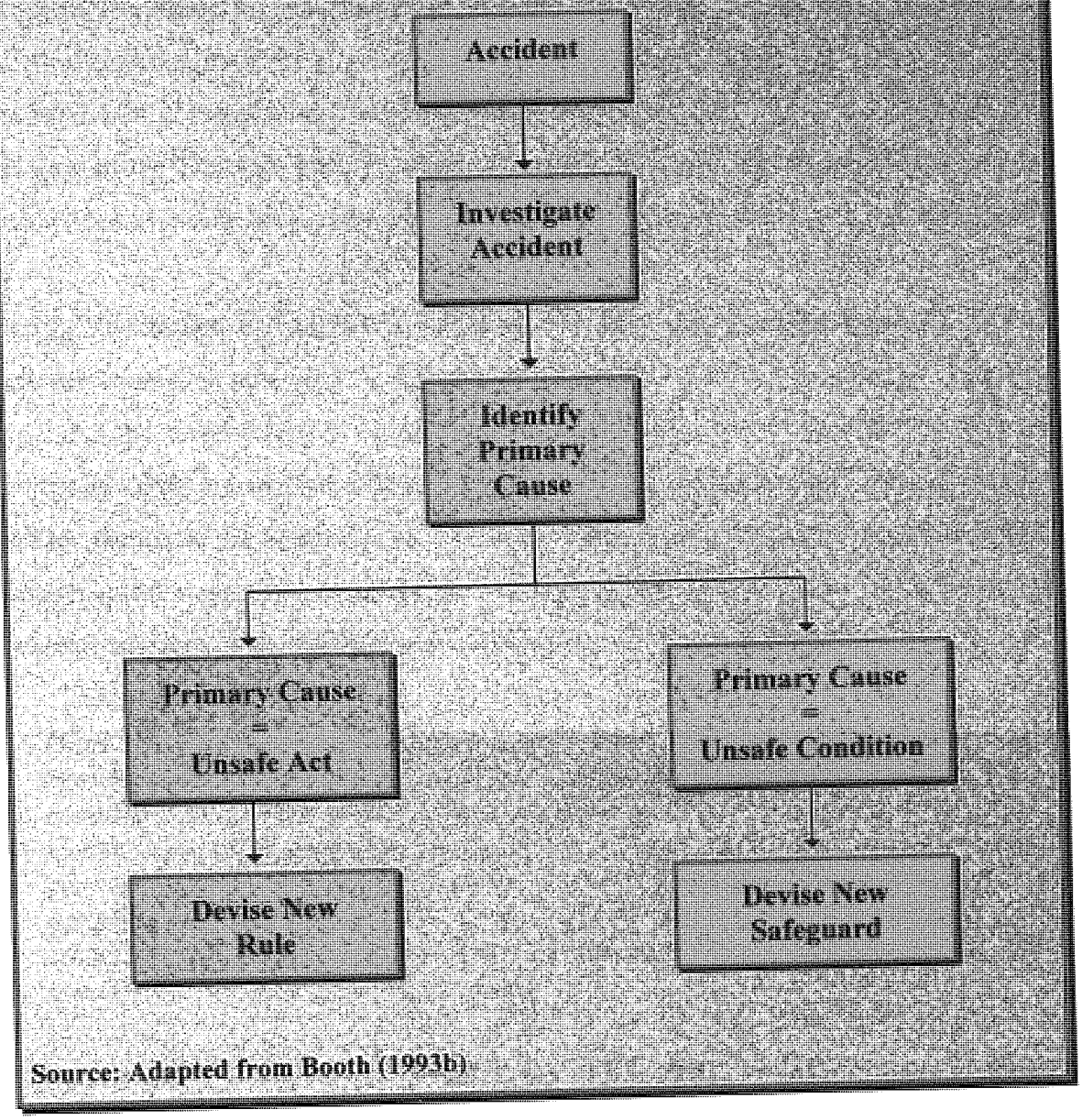
1.1.3 The Modern Era

In the modern era from 1900 to 1970, the reactive approach to health and safety management remained the dominant paradigm. It consisted of attempting to manage health and safety by introducing new rules and safeguards following an accident so as to prevent its repetition (HSC, 1993). The results of this approach can clearly be seen in the various Factory Acts, as well as in the rulebooks and safeguards devised by many individual organisations. The core belief of the reactive approach is that if an organisation complies with prescriptive health and safety legislation, and responds to any accidents within the workplace by investigating them, identifying their root cause and devising new procedures or safeguards so as to prevent their recurrence, then they are doing everything within their power to manage successfully health and safety.

Throughout this time period the reactive approach to health and safety management remained firmly based on an over-simplified, naive view of accident causation. The view placed great emphasis upon the need to determine whether an accident was primarily caused by an *unsafe act* or an *unsafe condition* (Booth, 1993b). Once this crucial detail had been determined, the process of developing appropriate control measures became much easier for managers and legislators. If an accident was due to an unsafe act, then a new rule would be devised to prevent its recurrence. If an accident was due to an unsafe condition, then a new safeguard would be devised to prevent its recurrence. In general, legislators tended to favour the *unsafe condition-new safeguard* solution to accident prevention, whilst businesses tended to favour the *unsafe act-new rule* solution (HSC, 1993). The reactive approach to health and safety management is illustrated in Figure 1.1.

This naive theory of accident causation perhaps reached its zenith when it was expressed in the form of Heinrich's Domino Theory, which was presented in the seminal 1931 health and safety text *Industrial Accident Prevention* (see Heinrich, Peterson and Roos, 1980). The popular Domino Theory provided a clear, simple, linear model to explain the complex phenomenon of accident causation (see Figure 1.2). It

Figure 1.1: The Reactive Approach to Health and Safety Management



Source: Adapted from Booth (1993b)

Figure 1.2: Heinrich's Domino Theory of Accident Causation

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Source: Heinrich, Peterson, and Roos (1980)

attempted to demonstrate how all accidents can be traced back to a single unsafe act or unsafe condition that is responsible for their occurrence. To prevent repetitions of an accident, the unsafe act or unsafe condition simply has to be eliminated. The theory was developed at the time when the science of eugenics was prominent, which claimed that the behaviour of individuals is determined by their genes. The influence of eugenics can be seen in the Domino Theory, where all unsafe acts and unsafe conditions can be traced back to the ancestry and social environment of the individual who initiated them.

One of the ironies of Heinrich's model is that although it explicitly proclaims that accident causation is a simple, linear process, it could be argued that it implicitly expresses the multi-causality of accidents. Although Heinrich's work in the field of health and safety represented a step forward in many ways, his accident causation model perhaps restricted the field in other ways. In imposing the impressive domino theory upon accident causation, some of the earliest theorising on the multi-causality of accidents was lost, such as that expressed by Myers (1929, p135):

> *When a worker, who has already safely carried out the same industrial operation thousands of times, happens to meet with an accident, it is easy and convenient to attribute the occurrence to his carelessness or inattention. Such explanations are a confession of ignorance ... Several possible factors, some personal, some environmental, may be cited, all of which have been traced in particular cases, although it is possible that some may be contributory to others, and that there may yet be other contributory causes to account for the momentary inadaptability of the worker.*

While eugenics and the Domino Theory were at the height of their popularity, a variety of mechanical calculators were being produced and sold to businesses for use by clerks and accountants. As mechanics advanced, the speed and reliability of these devices increased. The 1920s and 1930s saw calculators powered by electric motors, and incorporating electromagnets and special switches. In 1934 Konrad Zuse built several large, automatic electromechanical computers in his parents' living room in Germany. With financial backing from the German government, Zuse set up a company to sell the first computers following the second world war. Meanwhile in America, in 1890 the US Census Office had held a competition to find improved techniques for managing the national census that had to be taken every decade according to the constitution. The

census was taking longer and longer to complete as the population expanded - the previous decade's census had taken 7 years to compile manually. The winner of the competition was a young engineer called Herman Hollerith who devised machinery to count automatically holes in punched cards (Moravec, 1988). Over the next 50 years Hollerith's invention evolved into a battery of "tabulating" machines, while his company grew into the massive International Business Machines (IBM) that was to dominate the computer industry until the late 1980s.

Towards the end of World War II, government-funded projects resulted in the creation of electronic tube computers which used radio and radar techniques. The first commercially manufactured machine of this type was the UNIVAC I, and its first customer the US Census Bureau in 1951. By the end of the 1950s there were about 6,000 electronic computers in industry, government and universities (Moravec, 1988). Their electronics were built around vacuum tubes and they became known as the "first generation of computers". Science fiction writers wrote numerous short stories about these machines, envisioning larger and larger computers with ever-increasing powers. Isaac Asimov's *The Last Question* (Asimov, 1956) imagined a computer that was so large that its workings took up a whole planet. This was the exact opposite of Babbage's early vision that computing machines would become increasingly small until their components could fit in the palm of his hand (Swade, 1996).

By 1960 a second generation of computers had emerged, which were based on the newly developed transistor rather than the vacuum tube. The transistor meant that smaller, faster, cheaper, more reliable computers could be built with greater memory capacity. These were rapidly superseded by the third generation of computers which were introduced in the late 1960s by IBM. The IBM computers consisted of *hybrid integrated circuits* with dozens of tiny transistors and other electrical components bonded onto wiring printed on minute ceramic chips (Moravec, 1988). Computers were becoming more powerful, smaller and cheaper.

During this same time period, research into improving human-computer interaction which took place at universities and laboratories mostly in the United States, but also in

Canada and the United Kingdom, made crucial breakthroughs which laid the foundations for the Information Technology Revolution. According to Myers (1996):

> *... virtually all of today's major interface styles and applications have had significant influence from research at universities and labs, often with government funding. Without this research, many of the advances ... would probably not have taken place ....*

Descriptions of the key developments can be found in Myers (1996). They include computer games and the joystick by Slug Russel at MIT in 1962; the direct manipulation of graphical objects with a pointing device and the first drawing program by Ivan Sutherland in 1963 at MIT; computer-aided design by Ross and Coons at MIT in 1963; 3-D by Timothy Johnson at MIT in 1963; the mouse at Stanford Research Laboratory[7] in 1965; the word-processing program in 1962, the practical realisation of hypertext[8] in 1965, multiple tiled windows in 1968, and computer supported cooperative work[9] in 1968 by Doug Engelbert at Stanford Research Laboratory; virtual reality by Ivan Sutherland at Harvard from 1965-1968; computer interfaces based upon icons, menus and gesture recognition[10] developed at MIT's Lincoln Labs in 1968; multi-media[11] in the FRESS project at Brown in 1968; and overlapping windows by Alan Kay in 1969 at the University of Utah.

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[7] Now SRI: Stanford Research Institute.

[8] Hypertext was originally proposed by Vannevar Bush in 1945 (Myers, 1996). It is the concept of linking documents to related documents. In the field of computing, it can be found in multi-media encyclopaedias, help systems, the latest office programs, and the world-wide web on the internet. Typically, a highlighted word within a document can be selected by the user in order to move to a new document associated with the word.

[9] 'Computer supported cooperative work' (CSCW) refers to technology which allows multiple users to work together through remote participation from different sites. Examples of current CSCW technology include e-mail, the internet, and video-conferencing.

[10] 'Gesture recognition' refers to computer technology which is able to accept input by recognising particular communicative gestures made by the user. Today the most common gesture recognition technology is still the lightpen and associated writing tablet.

[11] 'Multi-media' originally referred to computer technology capable of featuring integrated text and graphics. Today the term is taken to mean computer technology that is capable of featuring integrated text, graphics (including drawings, charts, photographs, animations, and videos) and sound (including music, speech, and sound effects).

1.1.4 The Information Technology Revolution

> *Changes are occurring rapidly. One could argue that we are witnessing an acceleration of the pace of change through the application of computer technology.*
>
> Chamot, D. (1984) *Problems of Transition*[12].

The time period from 1970 to 2000 will probably be recorded in history as the Information Technology Revolution, since during this span the world has witnessed the largest global revolution since the Industrial Revolution. Once more the source of the revolution has been the production of machines which are intended to help people to undertake tasks with greater speed and accuracy than was previously feasible, only this time computing machinery which can enhance mental tasks has sparked the revolution, rather than mechanical machinery which can enhance physical tasks. However, whilst the information technology field has been passing through historical milestones, so too has the field of health and safety.

The reactive approach which was adequate for health and safety management in the 19th Century and perhaps even the early 20th Century, has been found to be substantially wanting in the midst of technological society. The limitations of the approach have been dramatically illustrated in numerous large-scale disasters which have occurred during the last 25 years, such as Flixborough, Chernobyl, King's Cross, Piper Alpha, Clapham Junction, the Challenger space shuttle, and the Herald of Free Enterprise (See Table 1.1). They have also been explicitly drawn out by the *ACSNI Human Factors Study Group Third Report* (HSC, 1993) in its examination of nuclear power plant safety, and by Booth (1992, 1993a, 1993b). What these tragedies made alarmingly clear was that the reactive approach of waiting for an incident to occur, and then attempting to prevent its recurrence, is drastically wrong. Instead of health and safety relying upon a passive approach that merely involved "mopping up" after an incident, the field needed to take an approach that involved actively seeking to identify hazards and assess risks so that control measures can be put in place before accidents occur - not in their aftermath.

[12] Quotation from original source.

Table 1.1: A Summary of the Limitations of the Reactive Approach to H&S Management

1.	It focuses only upon preventing the repetition of accidents that have already occurred.
2.	Health and safety rules and safeguards tend to be over-strict because they are developed purely in reaction to specific accidents that have occurred. The more extreme the consequences of an accident, the more extreme the rules and safeguards that tend to be devised. An example of this can be found following the King's Cross fire, when the London Underground rapidly over-reacted by removing all wooden escalators and banning smoking, without first examining the deeper causes and risks involved (Department of Transport, 1988).
3.	There is a piecemeal build-up of control measures all devised in response to different accidents at different points in time. This mass of rules and safeguards is unlikely to have been examined so as to ensure consistency and practicality. Thus they may conflict both with each other and with what is needed to accomplish work tasks.
4.	Violations are likely to occur frequently in the workplace in order to resolve the conflicts between the different rules and safeguards, and the need to complete jobs on time.
5.	Over time it is likely that the reasons for the implementation of many of the control measures will become distant, and that the rules and safeguards may be known, but not the hazards and risks that they were meant to control. Rules and safeguards may even exist for controlling risks which are no longer present in the workplace. An example of this can be found with the UK machinery safety legislation which, prior to 1993, was still based around guarding early cotton mill processes and steam engines.
6.	It is unable to keep up with the pace of technological change. With new machines, new processes, new work practises, and new chemical substances being introduced constantly to the workplace, whilst older technologies become obsolete, hazards and risks change constantly. If control measures are only implemented after the occurrence of accidents, they will be implemented far too late and will soon become obsolete.
7.	It cannot help to prevent the occurrence of the first accident. There are many industries, such as the major hazard industries, where the first accident may be intolerable. This has been vividly demonstrated by the explosion at the NYPRO Ltd. plant at Flixborough in 1974 (Department of Employment, 1975), and the Piper Alpha disaster in 1988 which was the first major fire/explosion at the platform in 17 years yet claimed 167 lives (Department of Energy, 1990).
8.	It involved managing health and safety based solely upon the information obtained from accident data and accident investigations. Accident data has been shown to be notoriously problematic to collect, evaluate, and derive meaningful results (e.g. Thygerson, 1992).
9.	It was founded upon a shallow theory of accident causation, which has been shown to be extremely naive in the light of more recent theories (e.g. Reason, 1990; Johnson, 1980; Hale and Glendon, 1987). As a result accident investigations tended to stop at the first identifiable cause for which there was a known solution - the immediate unsafe act or unsafe condition. . Rasmussen (1987) has labelled this the "Stop-Rule". However, multi-causal theories of accident causation have shown that accidents have a wide-range of contributory causes that need to be identified and examined (Ridley, 1990).
10.	Its focus upon the over-simplified concepts of unsafe act and unsafe condition, and their relative importance in accident causation, has resulted in a failure to recognise the full complexity of human error. This complexity is demonstrated clearly by Reason (1990), and in the analyses and classifications of human error made by Rasmussen (1987) and Reason (1987). It is now recognised that there are different types of human error, each of which have different causes, and thus need different control measures to prevent their recurrence.
11.	It failed to recognise that unsafe acts could be due to intentional violations - in which case introducing new rules could not be expected to prevent repetitions of the unsafe act. The report into the Houghton Main Colliery explosion provides a classic example, when after noting that engineers were failing to complete statutory registers, it later recommended that rules be made for the engineers to record additional information in the registers (HSE, 1976).

The growing recognition of the limitations of the reactive approach has led in recent years to the development of an alternative proactive approach to health and safety management. The proactive approach differs from the reactive approach in that its emphasis falls upon organisations taking responsibility themselves for actively planning and organising for health and safety, identifying hazards, assessing risks, developing and implementing control measures, and monitoring and reviewing the whole process. The proactive approach requires organisations to take a much wider, more holistic view of health and safety. It focuses upon the need for organisations to develop a complete system for health and safety management. According to texts such as the Health and Safety Executive's *Successful Health and Safety Management* (HSE, 1991) and the British Standards Institution's *BS8800: Guide to Occupational Health and Safety Management Systems* (BSI, 1996), a proactive health and safety management system should encompass not only the traditional health and safety tool of reactive monitoring, but also newer tools such as active monitoring, risk assessment and auditing. These four tools should be integrated into one comprehensive health and safety management system, within which information constantly flows between the constituent elements, ensuring that the system as a whole is comprehensive. Because the proactive approach explicitly recognises the complexity of health and safety management, it has allowed more sophisticated models of accident causation to be developed which can help to provide a better understanding of accident causation and prevention.

The proactive approach to health and safety was envisioned to some extent by Lord Robens in the report of the committee that he had led in an investigation of the role of legislation in the management of safety and health at work. This report laid the groundwork for the development of the *Health and Safety at Work etc. Act (HSWA) 1974*. Robens believed that a significant change was needed in the way in which health and safety was conceptualised, managed, and legally underpinned within the United Kingdom (Robens, 1972). The influence of this vision can be seen throughout the *Health and Safety at Work Act 1974*, which explicitly required organisations to take responsibility for health and safety, and implicitly urged organisations to seek actively to manage and regulate health and safety for themselves. Although the implicit request for self-regulation did not succeed in changing the way in which organisations

approached health and safety management, the European Union have made the stance explicit in the health and safety directives that they have issued under Article 118A of the Single European Act (Shaw, 1993). These directives have appeared in the United Kingdom in the form of recent legislation such as the *Management of Health and Safety at Work Regulations (MHSW) 1992,* the *Control of Substances Hazardous to Health Regulations (COSHH) 1988* and the *Noise at Work Regulations (NWR) 1989* which has placed legal obligations on employers to undertake suitable and sufficient risk assessments and to provide adequate training. This legislation has tended to be written in a far less prescriptive style than that which preceded it, and has formed part of a general move towards deregulation in the field of health and safety (Dewis, 1995).

The changes in health and safety legislation have resulted in the proactive approach to health and safety management becoming more common in the workplace. They have firmly placed the onus upon organisations to take responsibility for managing health and safety themselves within a guiding legal framework. Organisations can no longer simply follow rigid legislative detail to the letter, they are now required to *think* about health and safety management and to develop their own health and safety management systems. Just as the reactive approach to health and safety filtered down from the legislation of the governments of the Industrial Revolution to the businesses of the time, so too can the proactive approach filter down from the health and safety legislation of the governments of the Information Technology Revolution to contemporary businesses. Whilst initially the transition from reactive to proactive health and safety management may prove daunting to many organisations, in the long-term it is hoped that the new approach will provide a better foundation for health and safety management (Booth, 1993a, 1993c).

The field of information technology has been undergoing its own rapid changes whilst health and safety has made slow, but monumental progress. By the mid-1970s the fourth-generation of computers had emerged which were built from minute silicon chips that were only a few millimetres in size but could contain thousands of electronic components. They were quickly replaced by the microprocessor - a chip with tens of thousands of components that is by itself a complete computer. Progress had become so

fast that by the end of the 1970s, the concept of computer generations had fallen by the wayside. Research at universities and government-funded laboratories in the United States during the 1970s continued to make crucial developments. For example, the WYSIWYG ("what you see is what you get") concept[13] for interaction with direct manipulation interfaces emerged at Xerox PARC in the 1970s, and the first spreadsheet program was created by Frankston and Bricklin for the Apple II in 1977-78 whilst they were students at MIT and Harvard Business School (Myers, 1996).

In the 1980s IBM's sole domination of the computer industry was finally overthrown by three companies: Microsoft, Intel and Apple. Microsoft emerged in 1980 when they purchased the rights to a disk operating system (DOS) for the 8086-based PC for $100,000, then modified the program and reached an agreement with IBM for the latter to use DOS as the operating system for their forthcoming PCs. The IBM PC was launched the following year, and by 1982 it was being cloned by other manufacturers. However, it was not until 1984 that the precursor to the current PC was born as the IBM PC AT (Personal Computer World, May 1998). This provided the basis for hardware compatibility amongst PCs, and led to the standardisation of the diversified computer market in the form of the many clone IBM-compatible PCs.

The Apple Macintosh was also developed in 1984 which became "*the first high resolution, mouse-based computer system with a graphical user interface to be commercially successful in the mass market*" (Preece, 1994). Its design was a step forward from the earlier Apple Lisa computer. Both the Apple Lisa and the Apple Macintosh were inspired when Apple founder Steve Jobs visited Xerox PARC in 1979 and viewed the work on computer interfaces which had been undertaken there. With ease of use the main criterion, the Apple Macintosh windowing system featured an impressive graphical user interface which provided the user with icons, tool bars, scroll bars, status bars, and a wealth of visual information. This made a stunning contrast with the crude Microsoft Disk Operating System (MS-DOS) that the majority of

[13] The WYSIWYG concept refers to designing computer software so that work appears on screen in the same way that it will appear when printed (See e.g. Preece, 1994, p18). Most of today's software follows this principle. This is in stark contrast to earlier software, such as word-processors, when it was impossible to tell what work would look like on paper without printing it.

IBM-compatible PCs utilised at the time. Microsoft had announced its own windowing system for IBM-compatible PCs in 1983, but had received little interest from computer manufacturers. It wasn't until 1985, following the success of the Apple Macintosh, that Microsoft Windows 1.0 was released on the commercial market with little impact. Microsoft Windows 2.0 was released in 1987 and sold a million copies within a year successfully introducing the concept of a windowing system with a graphical user interface to an even wider mass market. This trend accelerated when Microsoft Windows was refined from the rudimentary versions 1 and 2 to the more sophisticated version 3 in 1990, version 3.1 in 1992, version 3.11 in 1993, Windows '95 in 1995, and the current version Windows '98 in 1998.

The development of the Apple Macintosh and Microsoft Windows meant that the personal computer had become a tool that was no longer the exclusive province of the fully-trained computer expert but could now be used at home and at work by the average person with little knowledge or understanding of computers. With both of these systems, the graphical user interface separated the user from the computer mechanics, and allowed software to be developed with attractive and intuitive visual interfaces that made it easier to learn and use. The windowing systems heralded a change in the role of the computer within society, and a change in the nature of the computer user. These changes have in turn altered the nature of computer hardware and software design. It is no longer possible to design rough hardware and software intended for the use of computer experts only; today the design process has to be user-centred, with the products carefully designed for their specific user markets.

Throughout the 1980s and 1990s the computer has continued to evolve. The sheer pace of the evolution can be witnessed by considering the developments which have taken place in PC hardware during this period. 186 computer processors have been replaced firstly by 286s then 386s then 486s, and then during the last 3 years by pentium processors, then pentium pro processors, then pentium processors with MMX

technology, and then by pentium II processors with MMX technology[14]. Computer processors have advanced from a relatively sedate 50 megahertz speed to impressive 450 megahertz pentium processing speeds. The amount of RAM that computers possess has increased from 8 megabytes to 128 megabytes and upwards. Computer hard-disks have expanded from less than 100 megabytes to over 12 gigabytes. Computer programs now exist that are larger than computer hard-disks were only 3 years ago. The slow 3.5" floppy disk drive has been largely superseded by Iomega Zip and Jaz disk drives that can rapidly store and retrieve 100 megabytes or 1 to 2 gigabytes of data. CD-ROM drives have raced through single speed, double speed, quad speed, and have now passed through 36X speed, whilst read-and-write CD-Rs have been developed and have advanced to quad speed. DVD drives have broken through onto the higher specification computers and will probably replace the CD-ROM drive by the end of the century. Graphics cards and sound cards have advanced immensely, and allow the average multi-media computer to run fast, smooth, high definition graphics with an impressive array of sound effects. Digital cameras and digital video cameras are available which can record information which can later be fed directly into computers for editing. Further, the US government unleashed the internet on the world and communications will never be the same [15].

[14] I have referred here to the progression of Intel computer processors since they have arguably provided the industry standard in recent years. The term 'pentium' is merely the Intel trademark for the 586 processor. Other computer processor companies have not necessarily followed Intel's lead with MMX technology and the Pentium II. There is at the time of writing a rift in the market, with many computer processor companies wishing to stay with the development of the socket 7 processor (the original pentium), whilst Intel have abandoned this system in favour of the much larger Pentium II processor which does not fit into a socket on the motherboard but requires a PCI slot instead. The Pentium II has flown in the face of conventional wisdom about computer processors becoming smaller and smaller with time, by being massively larger than any PC processor from the last two decades. For an interesting discussion of the role of the Intel Corporation in the IT field during the 1980s and 1990s, please refer to Grove (1997).

[15] The internet originated in a computerised communications network devised by the US government intended for military use. When the technology was made available to the general public, the internet was born in 1982 when a collection of linked nets was built up around the world (Personal Computer World, May 1998). By 1983 the internet had 1000 hosts, and modem speeds were developing rapidly. Research at universities and government-funded laboratories in the United States and United Kingdom in the 1990s led to the development of the world wide web by Tim Berners-Lee at the government-funded European Particle Physics Laboratory (CERN) in 1990, and the world wide web browser at the University of Illinois' National Centre for Supercomputer Applications (NCSA) in 1990 (Myers, 1996). It was only then that the internet took on its current multi-media format with the graphical user interfaces which has made it readily accessible and understandable to a much wider market.

Over the last five years in particular, the rate of technological change has been phenomenal in the field of computing. The rapid advances in computer hardware have finally made possible the full realisation on the commercial market of the software which was originally created in research centres during the 1960s and 1970s. The market for computer software has expanded massively, as the computer has become commonplace not just in the work environment, but also in educational institutions and in many homes. As a result every year hundreds of new or updated pieces of computer software are launched for every conceivable purpose. Microsoft released their Windows '95 operating system for the PC in 1995 which offered many advances over their previous windowing system, and rapidly became the market leader, but with time has proven to be still far from ideal. Multi-media computer software products are now in abundance and have helped to make information available to all in a friendly and attractive format; games software is ever faster, ever more impressive and serves as a driving force for computer hardware development; and office software is progressing through new incarnations every 2 years.

Already, as we near the end of the century, the driving force for computer hardware and software development comes from the home not from the workplace. It is the home consumers who have made the high quality, cutting-edge, multi-media computer their entry level standard[16], leaving many businesses struggling to catch up (Akass, 1998)[17]. The home consumer will purchase the latest computer technology in order to run the latest operating system so that they can take full advantage of the many facilities that the computer can offer them. For example, the typical home consumer will wish to utilise office software, the internet, e-mail, and the latest multi-media and games software. The home consumer only has to purchase one or two computers and so can afford to be selective in their choice. Particularly since whilst advances have been made so rapidly in computer hardware, the costs of purchasing a high quality computer have continued to fall. Multi-media PCs can be bought for considerably less than £1000 which would

[16] A current entry level standard multi-media PC would feature a CD-ROM, sound card, graphics card, speakers, internal zip drive, internal modem, and high resolution monitor.

[17] "*It is the home users with their demanding games who have gone for the current generation of multi-media PCs. Word-processing and spread-sheeting, which account for a huge proportion of business work, do not need top-spec PCs*" (Akass, 1998).

have cost around £2000 just three years ago. This has meant that high quality computer technology has become available to a much wider consumer market. In contrast to home consumers, many businesses are only beginning to move towards multi-media computers now that the costs have fallen and they are beginning to realise how they can use the new technology to their competitive advantage[18]. Even then, the rate of change is much slower, since organisations have to purchase and maintain multiple computers rather than one or two.

Nevertheless, a plethora of business software has emerged to take advantage of the new technology. From communications programs to accounting programs, computer-aided-design programs to multi-media reference sources, word-processors to databases, graphics programs to management programs. Software is available for every purpose, every niche in the market. Tasks that were once the exclusive domain of human experts who exercised their mental skill and judgement are now packaged on do-it-yourself, ready-made CD-ROMs. There are proprietary programs for creating forms, creating legal documents, producing budgets, monitoring stock, creating business policies, assessing finances, designing office plans, producing family trees, and making nutritional calculations. In every field, in every industry, an array of specialist software has emerged that claims to make tasks easier, quicker, and better. The field of health and safety is no exception.

1.2 A Desirable Merger ?

> *Computers and computing are ubiquitous in modern society. In nearly every part of modern life, the hardware and software of computer technology enable the delivery of services and products of higher quality to more people in less time than would otherwise be possible. Indeed, computing and increasingly powerful computers are the driving force behind the movement of society into the information age, affecting transportation, finance, health care, and most other aspects of human life...*
>
> Hartmanis and Lin (1992) *Computing The Future*[19].

[18] There are no doubt many work environments where a multi-media computer would still be considered a luxury rather than a necessity. Also it is still quite common for businesses to purchase multi-media computers without the sound card and speakers so as to obtain a price reduction.

[19] Quotation from original source.

> *With the application of computers and microchips in every sector of the economy, we are witnessing nothing less than the redefinition of work.*
>
> Chamot, D. (1984) *Problems of Transition*[20].

The 1990s has seen an historical transition in the field of health and safety with a move away from the traditional reactive approach to health and safety management and towards a new, more holistic, proactive approach. The new proactive approach, supported by a backbone of recent legislation, places the onus firmly upon organisations to take responsibility for health and safety. No longer will the state tell organisations detail-by-detail what they must do to manage successfully health and safety. Organisations are instead required to take the initiative to develop and maintain their own health and safety management systems. The transition can clearly be seen in the large scale repeal or revocation of prescriptive legislation such as the *Factories Act 1961* (see Dewis, 1995), and the introduction of non-prescriptive legislation such as the *Management of Health and Safety at Work Regulations (MHSW) 1992* which requires managers to venture into the mysterious realms of *risk assessment* (HSC, 1992a, 1992b). If reactive health and safety management offered a safe, limited environment for business managers to act within, proactive health and safety management appears to offer the wide-open spaces for which many businesses, and health and safety experts have yearned.

For the vast majority of businesses, the proactive approach to health and safety management requires greater involvement and activity than before. Organisations need to learn the nature and details of new health and safety legislation. They need to negotiate their way through the labyrinth of available guidance notes, approved codes of practise, and industry standards. They need to refer to a variety of health and safety texts for information and advice. They need to develop proactive health and safety policies which reflect their commitment to health and safety. They need to develop plans so as to ensure that their proactive health and safety policies are put into action. They need to understand the meaning of central health and safety terms such as "hazard" and "risk". They need to learn how to conduct, analyse and act upon risk assessments. They need to

[20] Quotation from original source.

develop their own risk assessment, reactive monitoring, active monitoring and auditing systems. They need to be able to gather health and safety information and data, analyse and interpret it, present and communicate it, and store it over the long-term in a manner that is easily accessible, understandable and usable. They need to store health and safety information and data in a way which will not deteriorate with time, which will offer protection against theft, damage and corruption, will prevent unauthorised access to sensitive material, and will be consistent and reliable.

Essentially, information is at the heart of the proactive approach to health and safety management. With the proactive approach there are greater quantities of health and safety information and data that organisations can collect, store, manipulate, and communicate than with the reactive approach. This is largely because the proactive approach encourages organisations to make use of information from the four key sources of data, namely reactive monitoring, active monitoring, auditing, and risk assessment, rather than from the first source alone, as in the case of reactive health and safety management. For the proactive approach to be successful, organisations need to make the best use of health and safety information. Ideally this involves being able to design an integrated health and safety management system that is based around the four key data sources, and to ensure that the system operates so that each element informs and is informed by every other element (HSE, 1991).

In the United Kingdom, as with health and safety legislation, theory and practice, the four key proactive health and safety management tools have emerged at different points in time in a piecemeal manner. Organisations have thus often taken the approach of developing at different points in time, four very separate information systems for reactive monitoring, active monitoring, auditing and risk assessment. The information from these four sources is rarely integrated. Often the four systems are designed so differently in terms of the way in which they collect, analyse and store data, that it is impossible to make meaningful comparisons and references between them. If it is possible to make comparisons, it is often an arduous task, with there being no easy means of integrating the data and making sense of the results.

Given these problems, it becomes easy to see why the idea of computer software which can facilitate health and safety management may appear to be attractive. A cursory examination of health and safety magazines such as *The Safety and Health Practitioner* will reveal that there is currently a wide variety of computer software that is available on the commercial market which aims to provide organisations with facilities to aid health and safety management. The majority of the software which is advertised through such publications is proprietary, in that it aims to provide an off-the-shelf solution to proactive health and safety management tasks through a set design which is intended to match the needs of a wide range of organisations. It is usually intended to be used by the health and safety expert and novice alike in organisations large and small. Typically, the software cannot be tailored by the software company for an individual organisation; the only customisation of the software that is possible comes through the client organisation's initial selection of the program version or the program modules that they require.

Proprietary health and safety software can be of several types. Firstly, it can be based upon one or more of the four key proactive health and safety management tools. Thus there are programs which concern incident recording, or auditing, or even a combination such as risk assessment and auditing. Occasionally, a computer program claims to offer an integrated proactive health and safety management system. Secondly, it can be based upon specific health and safety legislation. Thus there are programs that aim to aid compliance with the *Health and Safety (Display Screen Equipment) Regulations (DSE) 1992,* or with the *Control of Substances Hazardous to Health Regulations (COSHH) 1994,* or with several pieces of legislation. Thirdly, it can be based upon health and safety management within a particular industry. Thus there are programs for incident recording in the medical industry, and risk assessment in the construction industry. Sometimes a piece of software will fall within two or more categories, as in the case of a program designed to aid organisations in the construction industry to achieve legal compliance with the *Construction (Design and Management) Regulations (CDM) 1994.*

Each type of proprietary health and safety software usually seeks to offer organisations a range of facilities. Thus a piece of health and safety software may include a risk assessment facility, a substance database, a legislation database, a health and safety booklist, a report facility, a statistics facility, and a diary facility. In addition to these specialist facilities, health and safety software will also normally include integral facilities such as printing, data importing and exporting, data security, data consistency, graphical user interface and help system. For the software to provide a valuable health and safety management tool, each aspect of the program must be competent from a software design viewpoint and a health and safety management viewpoint. The basic purchase cost of proprietary health and safety software varies greatly, between somewhere in the region of £150 to over £10,000. There are normally a variety of additional "hidden" costs which are associated with purchasing proprietary health and safety software, for items such as extra program modules, extra manuals, support services, product updates and annual software licenses. These can increase substantially the overall cost of the purchase.

Proprietary health and safety software differs from proprietary office software[21], such as Microsoft Word or Microsoft Excel, in that it places a dual competence requirement upon its creators. For any piece of software to be commercially viable, it must be technically competent from a software design viewpoint[22]. In other words, it needs to be stable and consistent, have the various program functions designed and tested to ensure that they work as desired, be easy to learn and use, have information presented clearly on the program screens, be up-to-date in order to be able to take advantage of the latest computer hardware and software, and be compatible with other widely used pieces of office software. However, proprietary health and safety software has demands which go beyond this. If it is to be of value, it needs to be competent not just from a software design viewpoint, but also from a health and safety viewpoint. This dual competence

[21] Throughout the thesis the term "proprietary office software" is used to describe mainstream commercial software applications which are designed to aid general office work. The term thus includes software which is designed for word-processing, spreadsheets, presentations, databases, diaries, drawing, scanning and e-mail. This software is proprietary, in that it provides an off-the-shelf solution to office tasks, and can be used by any organisation for a variety of purposes regardless of their particular industry, locality, organisational size and structure, and management style.

[22] I am including in the term "software design competence" both programming competence and human-computer interaction competence.

requirement makes it difficult to produce a high quality piece of proprietary health and safety software. The task is made all the more difficult when one considers that this type of software is typically produced by small software companies who may or may not be otherwise involved in the field of health and safety.

Within these software companies a small group of individuals are likely to be responsible for the design, creation, testing and marketing of proprietary health and safety software. At least two or more of the individuals will need to have the software design competence that is necessary to produce viable computer programs. Without this software design competence it would be impossible to create marketable proprietary health and safety software. Some of the individuals involved may have competence in the field of health and safety. The exact level of this competence is likely to vary between software companies, with some being more capable than others. Unlike software design competence, it would be possible for software companies to create proprietary health and safety software even if their health and safety competence is limited. If a piece of proprietary health and safety software were to be created under such circumstances, the resulting program would be able to operate but it would probably carry inaccuracies in the health and safety management knowledge and tools that it provides.

1.3 Proactive Health and Safety Management Systems

The theoretical basis for health and safety management is often represented in the form of health and safety models. Most health and safety texts feature their own models of health and safety management systems. These may be flow charts for management activities, or input-output models which are intended to show the dynamic feedback links between system elements; the models may be simplistic so as to be accessible to people from all levels of health and safety knowledge or complex so as to show a range of relevant variables. The most well-known health and safety management system model is probably the one featured in *Successful Health and Safety Management* (HSE, 1991)[23]. It aims to provide a visual representation of a proactive health and safety

[23] *Successful Health and Safety Management* has subsequently been updated by the HSE (1997). I have referred to the earlier version throughout the thesis since this was the text used during the research.

management system, which incorporates the four tools of risk assessment, reactive monitoring, active monitoring and auditing. The system is represented at a generalised level in the model. Whilst reactive monitoring, active monitoring and auditing are featured at the top level of the model, risk assessment is featured at a lower level as part of "Planning and Implementing". The model is supposed to provide a broad approach to health and safety management which can be fitted onto any individual organisation.

Figure 1.3 shows the HSE's model for a proactive health and safety management system. The model is known as HS(G)65 and consists of six main elements: policy, organising, planning and implementing, measuring performance, reviewing performance, and auditing. The elements are linked together through various flows of information between them. The *Successful Health and Safety Management* text progresses to examine each element in turn. I have summarised the guidance for each element in a series of models that I prepared which are presented below. It is important to examine the contents of the HSE's proactive health and safety management system, because each piece of proprietary health and safety software which is available on the commercial market aims to assist managers in one or more of the tasks which are relevant to proactive health and safety management. The HS(G)65 model alone does not explicitly illustrate how risk assessment, reactive monitoring, active monitoring and auditing fit into the broad level categories of policy, organising, planning and implementing, measuring performance, reviewing performance, and auditing.

It should be stressed that I have designed the models to be accurate interpretations of the requirements of proactive health and safety management, as specified by HS(G)65. To further inform the design process I have referred to the British Standard *BS8800: Guide to Occupational Health and Safety Management Systems* (British Standards Institution, 1996), which considers the proactive health and safety management process in depth, and the QUEST model for an integrated proactive health and safety management software suite which was designed by the small software company who were involved in the initial stages of the research (HASTAM, 1995)[24]. The influence of these latter

[24] The QUEST model was later updated for the *QUEST: Risk Management Through Partnership* company brochure (HASTAM, 1996). The original model has been used in this research.

Figure 1.3: The HS(G)65 Model For Proactive Health and Safety Management

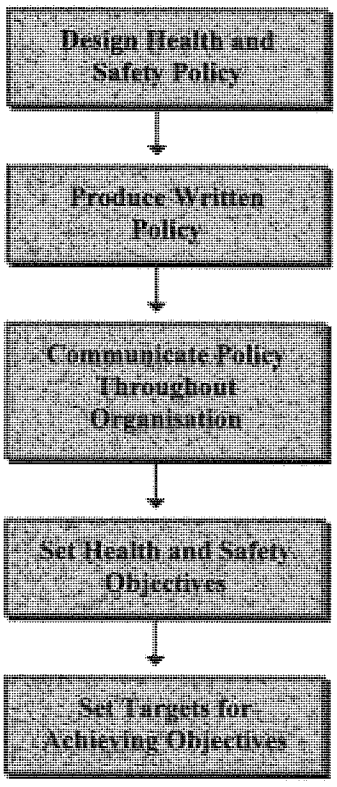
Source: HSE (1991)

two models can be seen clearly in Figure 1.7: The Measuring Performance Element in the HS(G)65 Model which is drawn directly from the QUEST document, and in Figure 1.9: The Reviewing Performance Element in the HS(G)65 Model which is a hybrid of details from HS(G)65 and BS8800. I am not taking the contents of these models for granted, as given knowledge, but am presenting them to emphasise the potential complexity of proactive health and safety management, and thus to demonstrate further why proprietary health and safety software may appeal to organisations as a way of simplifying and making sense of what must appear to be a daunting set of interlinked tasks.

1.3.1 Policy

The first element of the HS(G)65 model is *policy*. This is derived from Section 2(ii) of the *Health and Safety at Work Act 1974* which requires employers with five or more employees to produce a written health and safety policy. Figure 1.4 shows that an organisation will first need to devote thought to the design of their health and safety policy. They need to decide what the contents of the policy will be and how they can best be presented. Once the design of the health and safety policy has been decided upon, organisations need to produce the written policy, and ensure that it is clearly communicated to all employees. According to the HSE (1991), the health and safety policy can provide the foundations for an organisation's health and safety management, if they develop a set of practical objectives from the policy, and devise realistic targets to ensure that the objectives are met. The feedback loops on the HS(G)65 model indicate that once a health and safety policy has been constructed, it should be regularly reviewed and amended so as to keep it up-to-date, relevant, and practical.

Figure 1.4: The Policy Element in the HS(G)65 Model

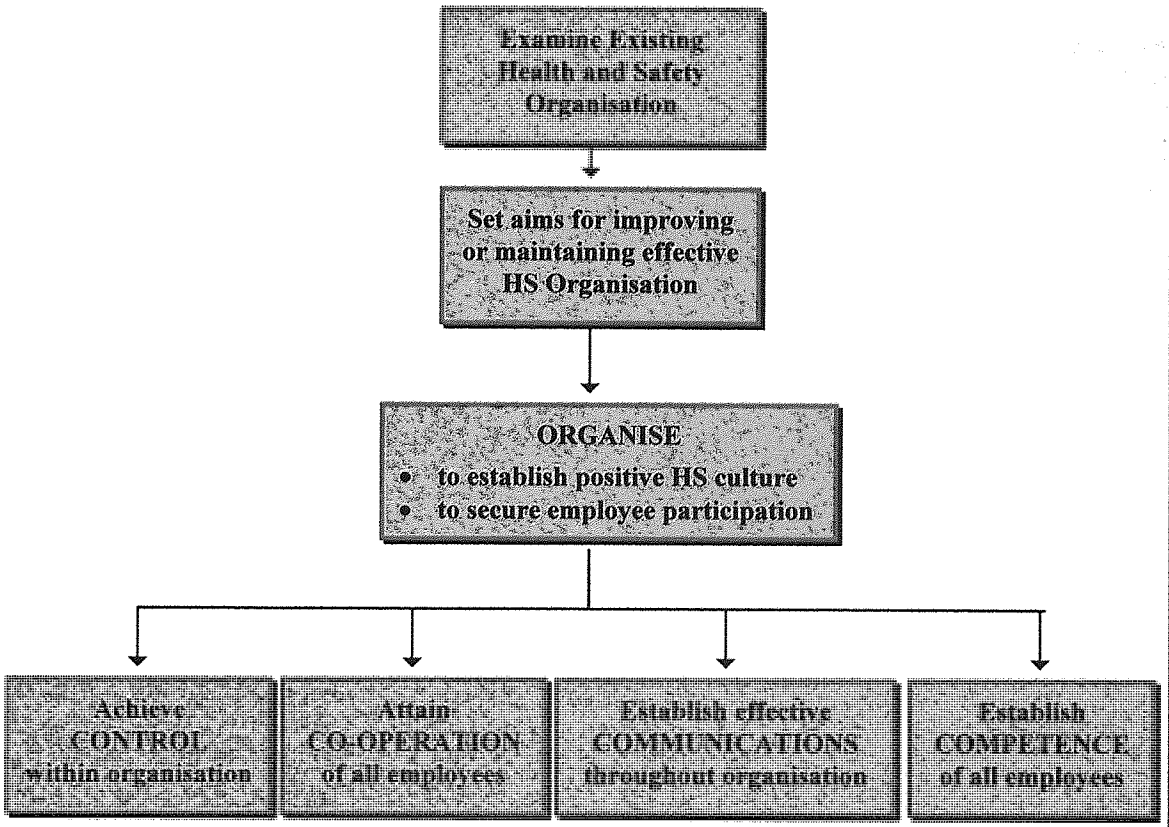


Source: Developed from HSE (1991)

1.3.2 Organising

The second element of the HS(G)65 model is organising. According to the HSE (1991) good organisation is essential for effective health and safety management. Proactive health and safety management involves gathering, storing, manipulating, analysing and communicating a wealth of information and data. Organisation is necessary to ensure that the health and safety management system runs in an smooth and orderly manner. As Figure 1.5 illustrates, the HSE (1991) have placed great emphasis upon four particular areas of organisation: control, co-operation, communications, and competence. Whilst these are clearly important areas, the approach is perhaps limited because it attempts to fit neatly every aspect of organisation under these four convenient headings. The danger is that the model may appear to be excluding other aspects of organisation from consideration.

Figure 1.5: The Organising Element in the HS(G)65 Model

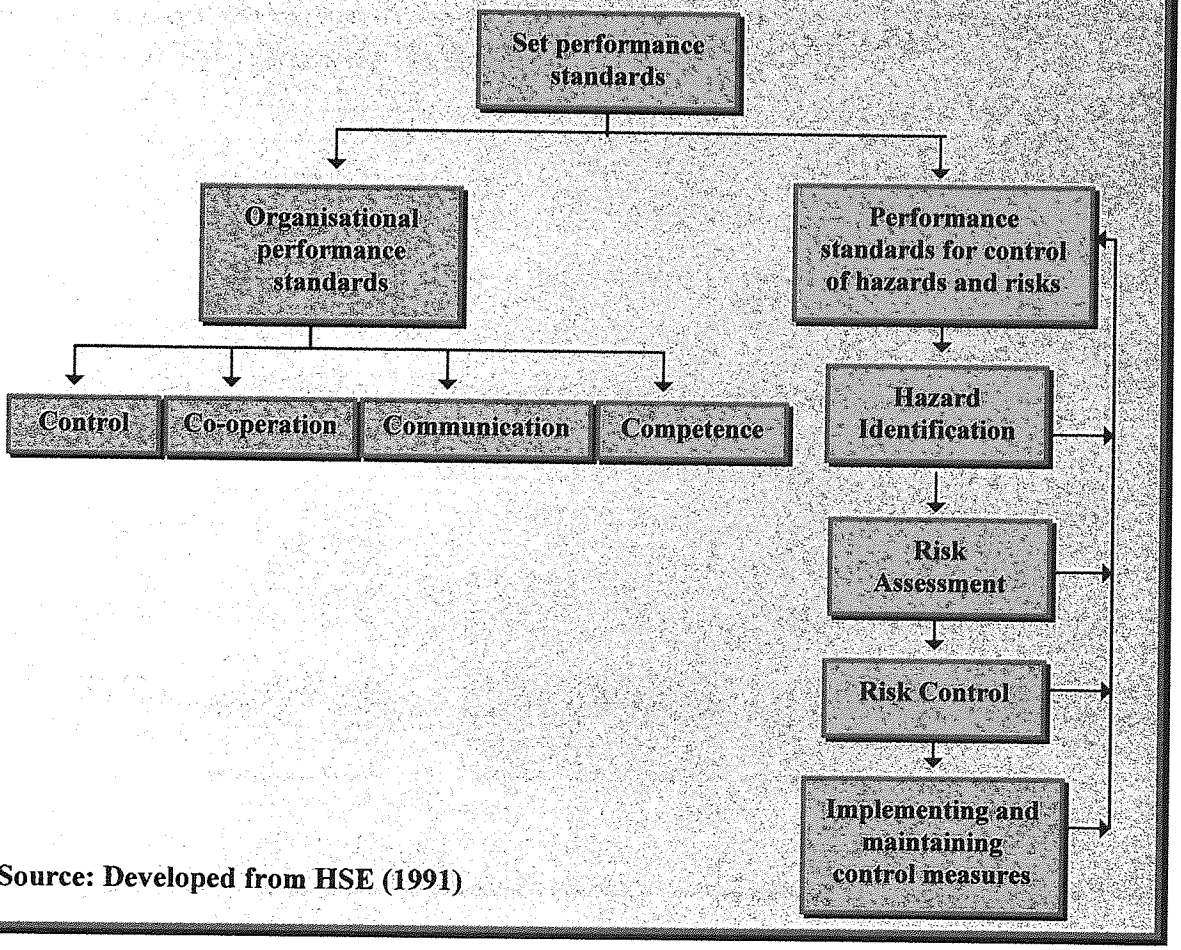


Source: Developed from HSE (1991)

1.3.3 Planning and Implementing

The third element of HS(G)65 is *planning and implementing*. This involves an organisation developing and implementing plans for the management of health and safety. Figure 1.6 demonstrates how the HSE (1991) have divided planning and implementing into two parts. The first part involves an organisation setting organisational performance standards to ensure that control, co-operation, communication, and competence are established throughout the organisation. The second part involves an organisation setting performance standards for risk assessment and control. The organisation has to identify their health and safety hazards, calculate the level of risk that each hazard poses, determine the control measures that are necessary to control the risks, and implement and maintain the control measures. They set performance standards to determine whether the control measures are being implemented correctly and whether they are being effective in terms of reducing risk.

Figure 1.6: The Planning and Implementing Element in the HS(G)65 Model



Source: Developed from HSE (1991)

1.3.4 Measuring Performance

The fourth element of the HS(G)65 model is *measuring performance*. According to the HSE (1991), organisations need to continuously measure their health and safety management performance to determine whether risk controls are being correctly implemented correctly and are being effective in terms of reducing risk. Figure 1.7 shows that to measure performance, organisations first have to select the health and safety variables by which they are going to measure performance (key performance indicators). Data is then gathered for each key performance indicator through reactive and active monitoring. Reactive monitoring involves continuously collecting accident data, conducting accident investigations, and performing epidemiological analyses. It provides a delayed gauge on the effectiveness of the risk control measures that have been implemented. Active monitoring involves continuously checking that risk control measures are in place, in use, and being used correctly. It also involves checking that health and safety performance standards and objectives are being met. The resultant data can be analysed and used to inform other parts of the HS(G)65 system.

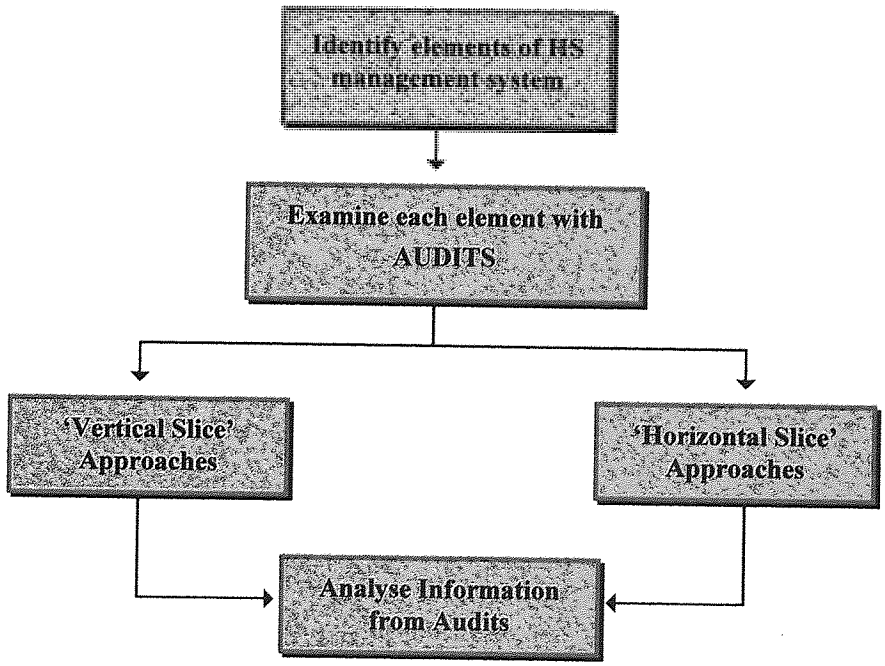
Figure 1.7: The Measuring Performance Element in the HS(G)65 Model

Source: HASTAM (1995)

1.3.5 Auditing

The fifth element of the HS(G)65 model is *auditing*. This involves an organisation routinely examining every part of their health and safety management system so as to ascertain that the system is comprehensive, correct, and up-to-date. Figure 1.8 shows that according to the HSE (1991), the first stage of auditing is to break the heath and safety system down into its composite elements. Audits can then be created or purchased to provide detailed checks for each element. Audits are essentially specialist checklists which aim to certify that each element of the health and safety system is in place, is correct, and is in use. Figure 1.8 illustrates that there are two main approaches to auditing: vertical slice approach and horizontal slice approach. The former involves taking one element of the health and safety management system, such as policy, and examining it in several areas, such as electrical safety and transport; whilst the latter involves examining one element of the health and safety system in detail, such as policy in all areas. Typically the two approaches are combined to provide comprehensive data which can be analysed, with the results being fed back throughout the health and safety system.

Figure 1.8: The Auditing Element in the HS(G)65 Model



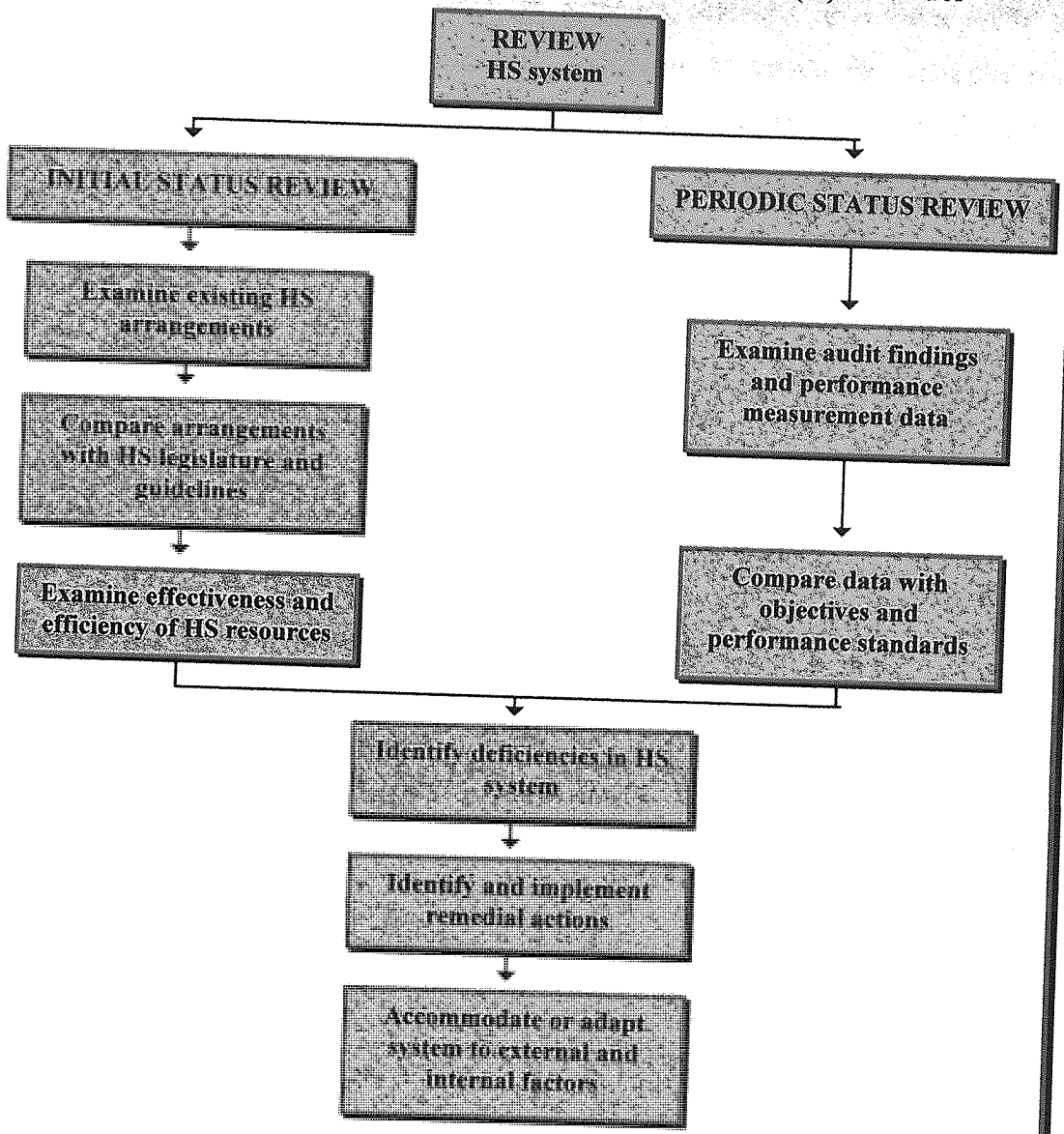
Source: Developed from HSE (1991)

1.3.6 Reviewing Performance

The final element in the HS(G)65 model is *reviewing performance*. To create a successful long-term health and safety system, it is essential that the whole system is constantly reviewed and modified when necessary, so as to ensure that it remains effective, practical, and up-to-date. Figure 1.9 shows that when organisations initially set up a proactive health and safety management system, they will need to examine their existing health and safety arrangements, compare them with the requirements made by health and safety legislation and guidelines, and examine how effectively health and safety resources are utilised. They can then identify any deficiencies in their health and safety management system, develop and implement solutions to improve the system, and make modifications to deal with any changes in the internal and external factors which impact upon the system.

Once a proactive health and safety system has been set up, organisations will need to conduct periodic status reviews. They will need to compare reactive monitoring, active monitoring, risk assessment and auditing data with the organisation's health and safety objectives and performance standards. This combined data should be used to provide a thorough review of every aspect of the health and safety management system. The periodic status review is concluded by identifying any deficiencies in the health and safety management system, devising and implementing actions to remedy these deficiencies, and modifying the system to accommodate for internal and external factors. As the HS(G)65 model illustrates, the review process provides feedback for every part of entire health and safety management system.

Figure 1.9: The Reviewing Performance Element in the HS(G)65 Model



Source: Developed from HSE (1991) and British Standards Institution (1996)

1.4 Software Evaluation

Almost from the earliest days of computer software, attempts have been made to examine and analyse any software which is produced, to search for strengths and weaknesses, to find inherent flaws and potential sources of confusion, to examine the commercial market for the software, to consider the impact that the software will have on the workplace, to consider how users will interact with the software, to identify problems which may arise when the software is used in the workplace, and to observe areas in the software where improvements need to be made. Much of this work is undertaken by software companies themselves as a vital part of an iterative software design process. However, when this is the case, any software evaluations which are conducted will be strictly to meet the software company's own agendas. This may or may not serve the best interests of potential consumers, and the resultant knowledge is unlikely to be made widely available because of business competition.

Outside of software companies, software evaluations are regularly conducted by computer magazines so as to provide advice to potential consumers. The quality of the evaluations that are produced in computer magazines varies greatly, from short reviews only half a page in length and simple marks out of ten at one extreme, to pages of technical analysis at the other extreme. Proprietary office software, such as word-processing, spreadsheet, database and graphics programs, is frequently the subject of such evaluations, since it has a large commercial market and is a basic type of software with which most computer users are familiar. Health and safety software, on the other hand, rarely receives attention in this domain, since it is specialist software for a narrow commercial market. Occasionally, short evaluations of pieces of health and safety software are provided in health and safety magazines. These evaluations normally lack depth and are far from comprehensive. They tend to aim more to describe pieces of health and safety software as health and safety products to be considered for purchase by organisations, than to provide a critical evaluation of the software.

The third main area for software evaluation is as independent research undertaken at colleges, universities and research institutions. Software evaluation research may be

conducted in these settings for many different purposes. The research may aim to add to the general knowledge base concerning software design and human-computer interaction. It may aim to develop software evaluation tools which can be utilised by software companies when designing computer software and by organisations when they consider purchasing computer software. Alternatively it may aim to examine how computer software can best be applied to a particular area, such as computer software for the disabled or for controlling nuclear power plants. The results of software evaluation research may also be used to form the basis for theoretical discussions concerning the value of information technology to society.

There are many different methods of software evaluation, each of which offer different insights into a piece of software. For example, Booth (1989) in a basic introductory text to human-computer interaction provides a list of 14 broad methods of software evaluation for software usability, although he states that the list is not comprehensive and that the evaluation methods are frequently used in combination. When a software evaluation is conducted, suitable evaluation methods would normally be selected according to the nature of the software that is being evaluated, and the aims of the research. There is no single right or wrong approach to software evaluation. The different methods simply yield different types of information which is generated for different purposes, from the technical cognitive task performance breakdown of a GOMS analysis (Card et al, 1980), to the qualitative data that can be gathered through interviewing the users of a piece of software, to saccadic eye movement studies which attempt demonstrate what a user looks at on the screen when they using a particular piece of software, to an observer recording notes as a user interacts with a piece of software, to a computer expert examining a piece of software for strengths and weaknesses, to novice users recording their observations on a piece of software through verbal protocols, to a quantitative analysis of a piece of software's speed of response to user input.

When I commenced this research project there had been no studies at an academic level concerning the value of proprietary health and safety software. This is understandable because it is unlikely to be an area that will be examined during traditional computer

science research, or during traditional health and safety research. Health and safety computer software is a relatively new hybrid that would require the application of an unusual mixture of knowledge and skills in order for any research studies to be comprehensive and meaningful. Potential researchers would need to possess both a knowledge and understanding of health and safety management, and a knowledge of computer technology. The aim of this research project was thus to apply conventional software evaluation skills to a new setting, namely to health and safety software. By conducting software evaluations upon proprietary health and safety software, the foundations will be laid for a broad level examination of the value of health and safety software for health and safety management.

As a final comment before advancing to Chapter 2, I would like to state that although the research project is based upon a critical evaluation of seven pieces of proprietary health and safety software, the analysis refers to the programs as they existed at the time of the research, and in no way reflects upon the quality of the current and future software which is provided by the software companies concerned.

Chapter 2: Software Evaluation

> *... on the one hand the most brilliant workmanship was disclosed, while on the other hand it was intermingled with some astonishing carelessness and clumsiness.*
>
> Flinders Petrie, the early English archaeologist, describing the Great Pyramids at the Giza Plateau in Egypt in 1893 in *Ten Years digging in Egypt* published by the Religious Tract Society[25].

In this Chapter I intend to explain the research path that has been pursued, to examine the alternative research paths that could have been taken, and to describe the technical findings of the research. The contents of this chapter will form the basis for the discussion of the broader issues which are associated with the use of proprietary health and safety software in Chapter 3, the consideration of the issues associated with purchasing health and safety software in Chapter 4, and the development of a software evaluation chart for organisations who are considering such a purchase in Chapter 5 Finally, in Chapter 6 conclusions will be drawn from the research concerning its implications for proprietary health and safety software, for the application of information technology in health and safety, and for future research.

2.1 The Research Path

The practical part of the research project involved undertaking software evaluations on seven pieces of proprietary health and safety software between April 1995 and April 1997. I selected the seven pieces of software to provide a varied view of the proprietary health and safety software market. I believed that this would offer the best foundations for a broad level examination of the value of proprietary health and safety software to the field of proactive health and safety management, and of the problems that organisations may encounter when they attempt to evaluate, select, implement, use and maintain this type of software. The most obvious alternative to the chosen research path would have been to select several pieces of proprietary health and safety software for evaluation which were designed to accomplish the same purpose, such as incident

[25] Quoted in Kletz (1991) *An Engineer's View of Human Error.*

recording or auditing. Although this would no doubt have provided the basis for a useful study, it would have meant that the research would only have been able to obtain a narrow view of the proprietary health and safety software market and would thus have been unable to provide meaningful insights into the numerous, varied questions which were raised in Chapter 1. As to why seven pieces of software were chosen for evaluation, rather than any other number, this was simply to allow sufficient time to thoroughly evaluate each piece of software and to produce detailed software evaluation reports. I wished to evaluate as many pieces of software as was practical within the timeframe of the research project.

For the research project I evaluated full working versions of HASTAM Limited's (I) Microsafe III incident recording program, (II) MicroCOSHH active monitoring program which is designed to aid compliance with the *Control of Substances Hazardous to Health Regulations (COSHH) 1988,* and (III) S-CHASE health and safety auditing program. These evaluations were conducted at the software company. I next evaluated demonstration versions of (IV) WMB Limited's Planning Supervisor program which is designed to aid organisations within the construction industry to achieve compliance with the *Construction (Design and Management) Regulations (CDM) 1994,* and (V) ErgoSystems Limited's Safety Auditor program for health and safety auditing, risk assessment, and training. The demonstration versions featured the complete working programs with only limited functions disabled. I selected these programs because they were the subject of frequently featured advertisements in the Institution of Occupational Safety and Health's monthly magazine *Safety and Health Practitioner*. Both programs had received a fair degree of praise on their release onto the commercial software market. Further, Safety Auditor had become the first piece of health and safety software to win the Institute of Occupational Safety and Health (IOSH) sponsored Safety and Health Product Innovation Award for General Safety in 1996. They thus represented what were widely considered to be high quality health and safety management computer programs. I next evaluated a full working version of (VI) Safecode Limited's IRIS incident recording program for the health sector at the University Hospital Birmingham NHS Trust where the Occupational Health and Safety Department were considering whether to invest in the software. Finally, I examined a full working version of (VII)

Gee Publishing Limited's Health and Safety Lawbase which is intended to provide an interactive reference source for health and safety law. I selected this piece of software for evaluation from advertisements in *The Safety and Health Practitioner*.

The combination of programs that were selected for evaluation provided an interesting coverage of the proprietary health and safety software market. It included programs that are concerned with incident recording, active monitoring, auditing, risk assessment, training, legislation and reference material. It included programs which are intended to be used by any organisation in any industry, and programs which are intended to be used by any organisation within a specific industry. It included programs that are intended to be used to aid compliance with a particular piece of health and safety legislation and those which are not. It included programs which are explicitly based upon a model of health and safety management, and those where the model is implicit. It included programs that are designed to be used through the Microsoft DOS operating system, and programs which are designed to be used through the Microsoft Windows operating system. All of the programs are intended to offer health and safety management knowledge and tools to aid the novice and expert alike.

I chose to evaluate the seven pieces of software by taking a qualitative, subjective approach which is perhaps a combination of an *expert review* and a *hostile user review* (see, e.g. Booth 1989; Macauley 1995). For the software evaluations, I examined each piece of software in detail, checking that every function worked as intended, considering how easy the software was to learn and use, considering the software design competence and health and safety competence of the software, and examining the software's strengths and weaknesses. I experimented extensively with the software, entering dummy data, observing the way that the software worked and responded to commands, checking the correctness of the health and safety knowledge and tools, examining what happened if the user made errors, and making detailed notes. The approach had a hostile user aspect because I aimed to bring an independent, open-mind to the software evaluations, regardless of whether positive or negative findings were made. The approach also had an expert review aspect because I have experience with

both health and safety, and computer technology, and would thus be able to identify weaknesses which the health and safety or computer novice may not observe.

One of the dangers with an expert review approach is that it is possible to overlook problems which may cause difficulty for the novice. However, in this research the probability of this occurring is likely to have been reduced for two reasons. Firstly, when the software evaluations were conducted I was completely unfamiliar with proprietary health and safety software, and was therefore in a similar position to the majority of organisations when they are deciding whether to invest in this software. Secondly, although by the end of the research project, I had accumulated health and safety expertise, I came to the research from a non-health and safety background, and was thus unlikely to take health and safety knowledge and skills for granted during the software evaluations, and was perhaps better able to notice where difficulties may arise for the health and safety novice.

As I evaluated each piece of software in turn, I produced seven software evaluation reports. These were structured so that the software under examination was divided into several key areas, such as main screen, risk assessment, substance database, printing and security system. The exact areas under consideration varied according to the particular piece of software. For each key area I considered how the software worked, what its limitations were and what could be done to improve this aspect of the software. Each software evaluation was undertaken in a comprehensive manner so as to be complete in its own right; therefore where similar issues emerged in two or more different pieces of software, they were fully examined in each associated software evaluation report. This was important so as to emphasise the extent to which particular problems are present in proprietary health and safety software.

The software evaluation reports are written in a technical, business style that was developed in conjunction with the small software company who had set the original research brief. They thus frequently use short sentences, bullet points and graphical illustrations to describe the programs. They are also written primarily in the first person. In conducting the software evaluations, I did not work to any pre-set limits with regards

to what would be considered within the evaluations and what would fall outside the scope of the evaluations. This was important so as to avoid making early judgements as to what would be relevant and irrelevant to the value of proprietary health and safety software. I simply examined each piece of software and made notes on any issues which arose. Thus, the issues that were drawn out during the software evaluations cover a relatively wide spectrum from those concerned with human-computer interaction and software design, to those related to cognitive ergonomics and health and safety management. Because of their technical style, the software evaluation reports tend to discuss the practical issues that were identified during the software evaluations but do not offer the scope to consider in detail the implications of these issues. This is the task for the subsequent chapters of the thesis. It should be emphasised that the software evaluation reports were not produced in one static sequence, but have been continuously developed and re-examined as the research project has progressed. Therefore, the knowledge and understanding that I have gained throughout the software evaluation process has been constantly refined, and although the software evaluation reports are independent, they have all been informed by the knowledge and understanding that I have gained from the software evaluation process as a whole.

I have referred to a large number of computer software texts during the research project, to inform the evaluation of the proprietary health and safety software, and the consideration of the wider issues that are associated with the use of computer technology in health and safety management. For the reader's benefit, these texts have included the following, although it must be noted that this list is not comprehensive: ACGIH (1987), Beekman (1994), Beerel (1987), Booth (1989), Capron and Perron (1993), Cleal and Heaton (1988), Gibbs (1982), Grove (1997), Haugeland (1989), Helander (1988), Hix and Hartson (1993), IBC Technical Services Ltd. (1988), Johnson (1992), Macauley (1995), McGraw (1992), Metropolis et al (1980), Moravec (1988), Norman and Draper (1986), Norton (1994), Norton et al (1995), Paterson (1985), Preece (1994), Ravden and Johnson (1989), Shneiderman (1992), Spufford and Uglow (1996), Whitby (1988), and Yazdani and Narayanan (1984). The texts vary in terms of how much they contain which can contribute to the evaluation of proprietary health and safety software, but taken together they offer many points which

are worthy of consideration. Several of the texts which are related to artificial intelligence are of value in terms of the interesting discussions that they provide concerning the broader issues that are associated with the increasing use of information technology.

2.2 Alternatives Foregone

As with any research project, the current path was taken at the expense of several alternative research routes. The first alternative which was forgone was possibility of developing software specifications for an integrated health and safety management system[26]. This would have involved pursuing a software programming route. There were a number of factors that weighed against this approach. Firstly, it was unlikely that in the research timeframe I could have learned the relevant computer programming language sufficiently well to produce a deliverable of value[27]. Secondly, the amount of time that would have been needed to produce an integrated health and safety computer program would have allowed little time for the consideration of the more fundamental issues concerning health and safety software. Thirdly, although an integrated health and safety program is not yet on the market, commercial businesses will in all likelihood continue to pursue this line with their own resources, whereas they will be unlikely to address the fundamental issues that may question the value of the very product that they create. Fourthly, by the time a single researcher such as myself had produced software specifications for a health and safety management program they would soon have become out of date. In other words the research would only have had value for a limited time period. Finally, software development is a precarious task which may or may not have yielded a valuable result within the research timeframe.

The second alternative line of research which was foregone would have been to examine the implementation and use of proprietary health and safety software in a

[26] This was the original research brief set by the small software company at the outset of the research. Many of the theoretical problems with pursuing this research path were discussed in Chapter 1. The points raised in the current chapter against this research path are in addition to the earlier points.

[27] The computer programming language in question was Microsoft Visual C++, with which I had no previous experience.

company. In a way I have pursued this task informally throughout 1997, assisting a local organisation in their evaluation, selection and implementation processes for incident recording software. During the time that I assisted the organisation, I gained a better understanding of the problems involved in evaluating, selecting, implementing, using and maintaining proprietary health and safety software. Further, I came to realise that I could encapsulate the knowledge that I had gained in evaluating proprietary health and safety software in the form of advice and software evaluation tools so that organisations can undertake their own informed health and safety software evaluations. This has enriched my broad level examination of health and safety software, and helped to identify the issues that need consideration. Although worthy of research in its own right, this line would have involved moving away from the original software evaluation basis of the research project that was founded with the small software company, and would perhaps have meant that the work which had already been undertaken would not be capitalised.

A third alternative which was forgone was to base the research around a series of questionnaires and interviews with organisations concerning proprietary health and safety software. Whilst this research line may have yielded some value, it did not seem to be the logical step to take given the many questions that had been raised by the early software evaluation work for the software company. When these questions, which were outlined in Chapter 1, were considered in combination with the lack of previous academic research related to computer software for health and safety management, it appeared that there was a very strong need to start the research at square one. In this case, square one would involve examining: the proprietary health and safety software market and the current range of proprietary health and safety software; how the software is designed and marketed; the distinct nature of the software compared to other commercial software; the aims which the software is designed to accomplish and the extent to which it meets these; the extent to which the software is designed to undertake health and safety management tasks in a suitable and sufficient manner; the extent to which the software is competent from both software design and health and safety angles; the extent to which the software offers a good investment for the precious health and safety resources of organisations; and the extent to which the software offers a good

product for software companies to produce. To question organisations about their views on proprietary health and safety software, and about how this software could aid them, would have been to jump ahead a step, since it would be to assume that proprietary health and safety software is a useful tool for proactive health and safety management, that organisations know how to evaluate their health and safety management needs, and know how to evaluate this type of software.

Thus only by focusing the research upon the evaluation of proprietary health and safety software would it be possible to discover how much value this software has for proactive health and safety management. Undertaking detailed software evaluations upon several pieces of proprietary health and safety software would allow conclusions to be drawn as to the quality of its informational content; the quality of its software design; the extent to which it matches current views in health and safety management; the extent to which it may aid organisations in their attempts to perform proactive health and safety management tasks; how easy it is for novices and experts to learn and use[28]; the points that organisations should look for when evaluating this software; and how organisations should approach the software evaluation task that should precede a purchase decision. Whilst this may seem like a common-sense approach, it should be noted that, at the time of writing, the majority of the UK population has not been trained in computer technology or health and safety management. Proprietary health and safety software therefore represents a doubly dangerous minefield to potential purchasers, since they need to ensure that their organisation has a genuine need for the software, that it can match their organisation's long-term health and safety management needs, and that it is fundamentally sound both from a software design and a health and safety angle.

2.3 The Software Evaluations

It required some thought as to how best present the software evaluations in the thesis. One possibility which was considered initially was to present the complete set of software evaluation reports as appendices. This approach was tempting because the

[28] By this I mean two things: (i) how easy the software is for *computer* novices and experts to learn and use; and (ii) how easy the software is for *health and safety* novices and experts to learn and use.

strength of the research is that it is not a critique of one or two pieces of proprietary health and safety software, but rather that it is an analysis of proprietary health and safety software as a whole based upon the detailed evaluation of seven different programs. The software evaluation reports work together to provide a good overview of proprietary health and safety software in its various styles and formats, with each report having something of value to say, and adding more detail to the analysis as a whole. However, because of the length of the reports this would have required a separate volume to the main thesis.

Another possibility was to include one or two of the software evaluation reports as technical text in this chapter. The reports could be followed by a discussion of the main points raised. This idea was rejected because the reports are large self-contained documents which would have greatly inhibited the natural flow of the thesis had they been inserted unedited in the middle. Eventually it was decided to allocate this chapter to a detailed discussion of the main points which can be drawn out of the seven software evaluation reports, and to include one of the reports as an appendix to serve as an example of the research work that was undertaken. The software evaluation report that has been selected for inclusion as an appendix is Gee Publishing Limited's Health and Safety Lawbase (see Appendix I). This report was selected since it illustrates several of the points that will be discussed.

Before advancing further it is important to describe the computer hardware and software that was used when the software evaluations were undertaken. HASTAM Limited's Microsafe III and MicroCOSHH were evaluated at the small software company, using a 386SX PC with low RAM and a small hard disk[29]. The computer was linked to a localised computer network. The computer did not possess sophisticated software which would have made it possible to easily copy screen images from the proprietary health and safety software that was being evaluated into the software evaluation reports. HASTAM Limited's S-CHASE, WMB Limited's Planning Supervisor, Ergosystems Limited's Safety Auditor and Gee Publishing Limited's Health and Safety Lawbase

[29] The computer was pre - multi-media: without CD-ROM, sound card, specialist graphics card, speakers, modem, zip drive, and with a processor that lacked a maths co-processor.

were evaluated using my own 90 MHz pentium processor multi-media PC which has 16 MB of RAM, an 850 MB hard disk, a Diamond Stealth 2MB VRAM graphics card, a Creative Labs Soundblaster 16 sound card, a quad speed CD-ROM, an Iomega Zip drive, a US Robotics Sportster Flash modem and 80 watt speakers. At the time of the software evaluations this was cutting-edge technology. Safecode Limited's IRIS was evaluated at the Occupational Health and Safety Department of the NHS hospital using a 133 MHz pentium processor PC with 32 MB of EDO RAM, a 2 gigabyte hard disk, an eight speed CD-ROM, an ATI Mach 64 graphics card, and an Iomega Zip drive. Again this was cutting-edge technology at the time of the software evaluation.

All of the software evaluations were undertaken using the Microsoft DOS operating system and the Microsoft Windows for Workgroups windowing system. The software evaluation reports for S-CHASE, Planning Supervisor, Safety Auditor, Health and Safety Lawbase and IRIS include for illustration images of various program screens which were acquired using Corel Capture Version 5.0. The reports were constructed utilising Microsoft Office Professional Version 4.3. When reference is made in the software evaluation reports to Microsoft Word, Microsoft Access, Microsoft PowerPoint, or Microsoft Excel, it is to the versions that are contained within Microsoft Office Professional Version 4.3.

2.4 A Review of the Issues Raised by the Software Evaluations

Having outlined the research which was undertaken, in this section of the thesis I will provide a review of the findings of the research. Some of the issues raised will be considered in more depth in Chapter 3. For this review I have decided to take an approach that is similar to that taken in the software evaluation reports. I will examine several key areas of proprietary health and safety software and discuss how the seven programs were found to fare in those areas. Some areas will be relevant to all of the programs, whilst others will be relevant to only some of the programs. The attempt that proprietary health and safety software makes to meet the various needs of proactive health and safety management can be seen in the discussions of how well the software provides facilities for policy, assessments, active monitoring, reactive monitoring,

auditing, and reference. This review, whilst reasonably comprehensive, by no means covers all of the points that were identified during the software evaluations.

2.4.1 Operating System

HASTAM Limited's three proprietary health and safety programs Microsafe III, MicroCOSHH and S-CHASE were all designed to operate through the Microsoft DOS operating system. This meant that at the time of evaluation they were already considerably dated and lacked many of the Microsoft Windows qualities with which computer users are familiar. The programs have unappealing plain black and white or blue and white screens, old-fashioned menu systems, no graphic images apart from graphs, no toolbars, no icons, and no macro buttons. Within the software the user can only work upon one screen at a time. These points stand as a considerable deficit against the programs. On the plus side they do have status bars to provide the user with helpful feedback as they use the software, have relatively clear menu systems and are user-driven, allowing the user to choose the order in which they access the program functions. Although CHASE For Windows has now emerged on the commercial health and safety software market, which rectifies many of the above limitations for S-CHASE, updated Microsoft Windows versions are not yet available for Microsafe and MicroCOSHH.

WMB Limited's Planning Supervisor, ErgoSystems Limited's Safety Auditor, Gee Publishing Limited's Health and Safety Lawbase and Safecode Limited's IRIS are designed to operate in the Microsoft Windows environment. In theory this is a point in their favour, since most PC users would expect software to be designed for Microsoft Windows. The majority of health and safety software is now advertised emphasising that it is "Windows software". However, beyond a basic ability to operate in Microsoft Windows, the phrase "Windows software" generally means something more to computer users, with the expectation being that the software will be designed to take advantage of the numerous features of the Microsoft Windows environment, such as tool bars, icons, macro buttons, status bars, high quality graphics and sound, and the ability to work in multiple windows. The extent to which this was the case in the "Microsoft Windows health and safety software" that was examined varied immensely.

Safecode Limited's IRIS faired very poorly as a Microsoft Windows product. It does not feature a modern graphical user interface, instead relying upon an MS-DOS style menu system, and thus lacks toolbars, icons, and status bars. It is only possible for the user to work in one window at a time within the program, and the user is restricted to progressing through the incident recording screens in a rigid screen-by-screen one-way sequence. The single graphic image that is used in the program, that of a skeleton on which the user has to select the point of injury for a person involved in an incident, is due to be removed from the next version of the program[30]. The program screens are presented in a clear and consistent format with suitably sized text, but they are in monotonous grey, black and white colours, and there is little variation between them.

In other words, although IRIS is a Microsoft Windows product, it fails to take advantage of the environment. IRIS appears dated as a Microsoft Windows 3.11 product, which is concerning given that Microsoft Windows '95 has been available on the commercial market for over three years, and the next version of Microsoft Windows, Windows '98, has now been released. One of the reasons why IRIS appears to be so dated is that it seems to be based upon Microsoft Access Version 1, when the "rest of the world" has progressed through Microsoft Access 2.0, Microsoft Access '95 and Microsoft Access '97. IRIS does not explicitly state that this is the case, and the majority of potential users would be unlikely to realise this, particularly since the software support service denies that it is true.

Gee Publishing Limited's Health and Safety Lawbase, WMB Limited's Planning Supervisor and ErgoSystems Limited's Safety Auditor take good advantage of the graphical capabilities of the Microsoft Windows environment. They are visually impressive, but do not feature tool bars or status bars, and do not allow the user to work in more than one window at once. Health and Safety Lawbase uses large icons on its main screen to represent the various program options. This makes it very easy for the user to locate and select the option that they require. Planning Supervisor and Safety Auditor take a different approach, presenting the user with a filing cabinet interface in

[30] This is in response to user feedback which indicated that the skeleton image slowed data input. The skeleton image is a nice idea, but it is insufficient and potentially confusing as a method of recording injury type.

which the labelled drawers represent the different options. This provides an attractive interface which is easy and intuitive to operate. Planning Supervisor and Safety Auditor feature high quality graphics throughout to enhance the presentation of information. In the former it is used to provide visual representations of a risk assessment grid, chemical symbols, and clipart images. In the latter it is used to provide illustrations for on-line training, auditing and risk assessment. All three programs offer a glimpse of how computer technology could be used to present health and safety information in a readily understandable visual format.

2.4.2 Title Screen

One of the aspects of proprietary health and safety software that was examined in the software evaluation reports is the program title screen. Whilst on initial consideration it may not seem to be such an important aspect of software, with deeper thought its value soon becomes evident. The title screen for a piece of software is the potential user's introduction to the program. It is also the image of the program and the software company that the user is presented with day-after-day as they use the program, and quite possibly year-after-year. It is a vital communication tool between the software company and the user, being able to convey a wide range of information, from the name and version of the program, to the extent to which the program is up-to-date, to the program purpose, to legal disclaimers. The title screen can also form the basis for a security system to prevent unauthorised access to the software.

Microsafe III, MicroCOSHH and S-CHASE which were designed by HASTAM Limited are all MS-DOS-based programs. Their title screens are thus basic in design, and would be unlikely to appeal to today's computer user, as they are strongly reminiscent of the title screens which fronted the low-powered, limited computer programs of the 1980s. The title screens convey clearly the program name but do not display the software company's name very well. However, their strong point is that they are used as the basis for a security system to prevent unauthorised program access. When the user accesses one of the programs they are presented with the title screen which features datafields for User ID and Password. The user cannot access the software until they correctly enter these details.

WMB Limited's Planning Supervisor and ErgoSystems Limited's Safety Auditor operate through Microsoft Windows, and present the user with visually impressive title screens. Their title screens follow the Microsoft Windows standard for presentation and are up-to-date with crisp photographic imagery and clearly displayed program details. The title screens are not used as the basis of a security system, but are instead used to display legal disclaimers. These allege that if the user accesses the software they have agreed that the software company has no responsibility for any losses that may occur as a result of using the software. The title screen of Planning Supervisor dubiously requires the user to select an "I Agree" button in order to use the software. Safety Auditor's title screen does not even offer the user this small mercy, instead it automatically flashes past taking the user straight into the program. With the speed with which the title screen flashes past, the user does not receive the opportunity to read the message never mind acknowledge the disclaimer. The use of such legal disclaimers for health and safety software is questionable, and the methods that the programs employ to claim that users have legally agreed with the disclaimers are highly disagreeable. This issue will be returned to in Chapter 3.

Gee Publishing Limited's Health and Safety Lawbase and Safecode Limited's IRIS also operate through the Microsoft Windows operating system. Health and Safety Lawbase features a minimalist title screen which races past in a matter of milliseconds. It does not offer any informational content, merely serving as an acknowledgement that the program is being accessed. IRIS surprisingly does not feature a title screen at all. There is simply a prolonged delay where the user is presented with a blank black screen before they are taken to the program's bland main screen. The user is thus likely to be uncertain as to whether they have accessed the correct program and may be concerned by the blank screen delay. The lack of a title screen in IRIS gives the user an unfavourable initial impression of the program and the software company. The program will not meet users expectations in this area.

2.4.3 Policy

Since the task of drawing up a suitable health and safety policy may seem daunting to many organisations, the possibility of computer software providing health and safety

policy templates to help to guide this process, in much the same way as word-processing software provides letter and fax templates, seems appealing on initial consideration. Such a facility may even encourage organisations to create health and safety policies where none have existed. Only one of the pieces of health and safety software that I examined attempted to provide a facility to enable organisations to construct a health and safety policy. This was Ergosystems Limited's Safety Auditor. The program provides the client organisation with a basic health and safety policy template. The user simply has to progress through five screens of ready-made policy text, inserting the appropriate details for their organisation into the blank datafields. They can then print out copies of their impressive-looking eight page health and safety policy.

Unfortunately, there are several limitations to the Safety Auditor health and safety policy creator. It only provides one health and safety policy template. The user can alter the wording of the ready-made text in this policy template, but cannot alter the policy title, the information displayed on the policy title page, the policy headings, or the datafield labels; cannot add extra policy sections or datafields; cannot delete policy sections or datafields; and cannot alter the ordering of the policy sections or datafields. Similarly, the user cannot alter the presentation format of the health and safety policy. They cannot alter the font styles, font sizes, font colours, heading formatting, page numbering or page margins. This makes the health and safety policy facility extremely inflexible and dictatorial. The program seems to suggest to the user that there is only one way in which to create a health and safety policy and that this way is suitable for all organisations. Instead of organisations designing a health and safety policy to fit their own health and safety management needs, Safety Auditor requires organisations to fit themselves to a fixed health and safety policy template.

Moreover, it is worrying that facilities can exist in computer software which allow organisations to produce impressive-looking, lengthy health and safety policies with the devotion of little thought, understanding, time, effort or conviction. It is surely the policy creation process itself which is of most value to organisations; the need to think and learn in order to produce a health and safety policy. When ready-made health and

safety policy templates are presented without any background information or guidance it seems as if thought is being eliminated from the task rather than being promoted. This theme will be returned to in Chapter 3. The problems with the health and safety policy facility in Safety Auditor extend beyond this however, since the facility does not allow the user to save any policies that they have created. This means that the client organisation cannot keep a copy of their health and safety policy within the program as an on-line reference source, as a safe back-up copy, as a master copy from which to print additional copies in the future, and as a master copy which can be amended easily so as to keep the policy up-to-date. Indeed, if the client organisation wished to print extra copies or make amendments, they would have to start from scratch in re-creating their health and safety policy in the software.

2.4.4 Reactive Monitoring

With the emphasis that the reactive approach to health and safety management placed upon reactive monitoring, and its continued importance as a tool for proactive health and safety management, it is perhaps no surprise that reactive monitoring software is the type of proprietary health and safety software which has been established on the commercial market for the longest period of time. The advantages that computer software could bring to this area are the ability to standardise incident data, the ability to store incident records in an easily accessible format, the ability to store incident records over long time periods, and the ability to use statistical methods to analyse the incident data. HASTAM Limited's Microsafe and Safecode Limited's IRIS aim to provide incident recording and analysis facilities. The former aims to allow these tasks to be accomplished in any type of organisation, whilst the latter aims to allow these tasks to be accomplished in organisations within the health sector.

HASTAM Limited's Microsafe provides a set of five datascreens which the client organisation can use to record their incident data. When the user records an incident in Microsafe they simply have to work through the five screens, which cover "Incident Details", "Injury Data", "Property Damage Data", "Vehicle Damage Data" and "Cost Data", completing the set datafields. To simplify and standardise the data entry task, Microsafe utilises sets of data codes from which the user must select the appropriate one

to represent an incident detail in each datafield. The software provides the client organisation with some flexibility as to how they set up their incident recording system, since it allows the system administrator to create and modify the data coding schemes. Thus the data coding schemes can be tailored to suit the individual organisation. Each data screen includes an "Additional Notes" facility, which allows the user to elaborate upon the information that they have entered in free text. This is a basic yet good facility which has been all too often forgotten in the more recent Microsoft Windows-based health and safety software.

Beyond the numerous deficits that come to Microsafe through its MS-DOS basis, such as the absence of a graphical user interface, small sized text on the screens, and old-fashioned navigation methods, I feel there are several deeper problems with the incident recording system. Whilst the use of data codes to standardise incident data is common in incident recording software, and the Microsafe program does provide more flexibility than some, there is still a fundamental flaw in its approach to reactive monitoring: this is that when incident data is recorded in short data codes alone a wealth of important information is lost. It is hard to summarise incidents in short data codes without ending up with a very bare interpretation of an incident, such as "Foot laceration" to "John Smith" at "5 p.m. Monday 16th July 1997" in "Engineering" due to "Fall". This says nothing about **how** an incident occurred and **how** it should be followed-up by the organisation involved. I appreciate the need to standardise data to allow for the production of highly useful incident statistics, such as the amount of incidents in engineering over the last year. However, for an incident recording system to be of value, I would seek something more. An ability to cater for standardised incident details *and* to allow for the client organisation to record in a flexible format in-depth incident information, such as witness statements, incident reports, incident descriptions, HSE feedback, and discussions of actions to be taken. "Additional Notes" datafields, whilst a good start, are not enough for this to be accomplished, as they suggest that in-depth incident information is merely an aside.

Continuing in this vein, although in Microsafe the system administrator can alter the data codes after they have been initially set, this will result in data corruption and thus

data loss. In other words the data that is contained in existing incident records will be altered and may no longer be correct. This hugely devalues the Microsafe incident recording system since it means that it can only be effective for as long as the original data codes are used without alteration. For the majority of organisations that use the software, their organisational structure, operations, equipment, locations and approach to health and safety management are likely to evolve constantly over the years to meet changing health and safety management needs. These changes would need to be reflected in their incident recording system if it is to remain up-to-date, relevant and effective. Organisations are faced with a poor choice between adapting the data codes to keep them up-to-date which would mean losing all of their existing incident data, or continuing to work with the original data codes which means that the system will continuously deteriorate in value. Essentially, Microsafe cannot work as a *long-term* incident recording system, and since much of the value of reactive monitoring arises from the keeping of incident records over the years to allow for analysis, comparisons, evidence of health and safety management improvements or declines, and the identification of long-term trends, it could be said that the problem severely limits the value of Microsafe as an incident recording system.

Add to the above that the Microsafe program encourages client organisations to take a poor approach to incident causation and the development of actions following an incident. The program requires the user to enter in a small datafield the action that is due following an incident. This datafield could only hold the shortest and broadest of actions, such as "Training" or "Maintenance", which are virtually meaningless since the user is not allowed to record specifics such as the details of the action, why the action has been recommended, who recommended the action, when the recommendation was made, how the recommendation is to be implemented, who is to be responsible for its implementation, or what the target date is for implementation. The program incorrectly teaches the client organisation that each incident should result in one action being taken in direct response to improve health and safety management. It may be that multiple actions need to be taken following a particular incident, or that no actions need to be taken, or that multiple actions need to be taken in response to several incidents. Microsafe cannot deal with this - the concept of *one incident - one action* is

over-simplistic and purely reactionary. The checkbox that is provided to indicate whether the recommended action has been taken or not is also far too simplistic. It can not accommodate for actions which are in progress, and says nothing about the effectiveness of the action. It suggests that if the action has been taken, enough has been done to manage health and safety. The program provides no mention of the need for continuous monitoring to check the implementation and effectiveness of the action, or for continuous risk assessment. As a final point against the Microsafe incident recording system, it is possible for any user with read-and-write security privileges[31] to modify, add and delete incident data in completed incident records. This means that the incident records which are stored within the program are open to the possibility of tampering, accidental alteration, sabotage and data corruption.

Safecode Limited's IRIS provides the user with a system that allows them to record data for a variety of incidents. When the user records an incident in IRIS they first have to choose from a series of drop-down menus the exact type of the incident, be it a "Personal Accident", "Violence/Abuse/Harassment", "Ill Health", a "Clinical Incident", a "Fire Incident", a "Security Incident", a "Vehicle Incident", a "Complaint" or "Other". When the user has selected the incident type, they are taken through a set sequence of data input screens that is specifically tailored for that incident type. Regardless of the type of incident, the last incident recording screen that is presented to the user is the Core Details screen. The incident recording screens are presented clearly with easily readable text and datafields awaiting the incident data. The task of data entry is often simplified and standardised by the provision of drop-down lists of fixed responses and radio buttons[32]. When the incident recording screens have

[31] In a basic security system for computer software, each user may be granted a separate security access status in the hierarchy "administrative security privileges", "read-and-write security privileges" or "read-only security privileges". Administrative security privileges allow the user complete access to every aspect of the software; normally only one or two individuals are granted this status and they are the ones who set up and maintain the software. Read-and-write security privileges allow the user to access data and information that is stored within the software; the user is allowed to read the data and information, and also enter new data and modify existing data where the software allows. Read-only security privileges allow the user only to read the data and information that is stored within the software, they are not allowed to enter or modify data.

[32] "Radio buttons" are small, circular GUI devices which have two states: selected and unselected. They are often utilised when the user is required to choose between several set responses during data input. For example, the question "Was the incident reported ?" may have three radio buttons for the answers "Yes",

been progressed through, the incident record can be saved. It can then be accessed at a later date through the search facility. This facility is relatively sophisticated, and allows the user to search for particular incident records by setting search criteria. It is intended that IRIS will eventually feature a graph facility and a report facility to make use of the collected data.

Although the clear presentation of the incident recording screens in IRIS is impressive, and many potential users will no doubt believe the program to be good on initial glance since it seems to contain all of the features which reactive monitoring software can usefully offer for health and safety management, there are numerous problems with the approach that the program has taken to reactive monitoring. Firstly, the program takes an idiosyncratic stance in its attempt to categorise, divide and sub-divide incidents according to incident type, and then present the user with a sequence of incident recording screens which are tailored to the selected incident type. This is an idea which seems good in theory, as it could offer a more flexible incident recording system than one where the user has to fit incident data into the same incident data structures regardless of the incident type. However, the idea has been poorly executed and in attempting to be too sophisticated, the incident recording system has become confusing, muddled and inconsistent. IRIS features 9 main incident categories with over 37 incident types within those categories. Many of the incident classifications seem arbitrary or contradictory. For example, the "Violence/Abuse/Harassment" incident category is separate from the "Security Incident" category, and the obscure "Other" incident category includes the incident type "Near-miss". Further, IRIS seems uncertain as to what its boundaries should be as a health and safety incident recording system. The inclusion of "Security Incidents" such as "Theft", "False Alarm", "Intrusion" and "Patient Absconded", of "Complaints" to the organisation, and of "Violence/Abuse/Harassment" are questionable.

The attempt to cater for such wide-ranging incident types has resulted in other problems with the software. One of the most notable of these is that whilst an extensive sequence

"No", and "Don't Know". The user selects the required radio button. Only one of the radio buttons can be in a selected state at any one time.

of incident recording screens are available for "Personal Incidents", for many of the incident types there are only a few incident recording screens available with a handful of datafields for completion. In the case of "Vehicle Incidents", IRIS does not yet feature any incident recording screens, whilst in the case of "Security Incidents" and "Violence/Abuse/Harassment" incidents the few incident recording screens that are presented are inadequate for recording the relevant data. Further, the clinical incident recording screens were found to be inadequate for their purpose when checked against the clinical negligence incident recording criteria that are issued by the NHS to medical establishments.

Regardless of the incident type, when the user is viewing or entering incident data, they can only progress forwards through the incident data screens one at a time. This slow one-way system means that the user cannot move backwards to view a previous screen in the sequence, or jump forwards directly to a screen further in the sequence. These navigational problems are inconvenient and time-consuming. Further, they provide the user with little flexibility or control in the way in which they use the incident recording system. The data screens within the incident records are not numbered, which makes it difficult for the user to calculate where exactly they are in the sequence of incident recording screens and how far they are from the end of the record.

The format of the incident recording screens in IRIS is fixed. There is thus no flexibility for the user to add organisation-specific datafields to the screens or remove datafields which are irrelevant for their organisation. This means that client organisations do not have the power to adapt the software to match their evolving incident recording needs. Similarly, the design of the incident recording screens is fixed, with the user having no flexibility to change screen colours, text font, text size or view size to suit better their own preferences. Further, many of the datafields on the incident recording screens can only be completed by selecting from data codes which are pre-set by Safecode Limited. Client organisations have no means to modify the codes, add new codes or delete existing codes to meet their own incident recording requirements. This is extremely problematic because it means that the incident recording system will only be effective if it is certain that the pre-set data codes will match the needs of all client organisations

over the period of time in which they use the software. This is unlikely to be the case, particularly given that many of the data codes are poorly labelled and that the data code sets are far from comprehensive. Once more the IRIS incident recording system lacks flexibility, and offers client organisations little control.

Although the incident recording system is based on pre-set data codes, IRIS does not include on-line definitions or guidance as to how the codes are to be interpreted. This could lead to difficulties when a user attempts to decide which data code best fits a particular incident detail, and could result in an identical incident detail being matched to different data codes by different users. When the data codes are presented in drop-down lists, they are presented in a random order, as opposed to an alphabetical order, which makes it difficult for the user to locate the data code they require. Although the incident recording screens require the user to enter information concerning equipment and personnel who were involved in an incident, IRIS does not feature a personnel database, and only features a very poor equipment database that allows just the names of pieces of equipment to be stored. There is thus no means for a client organisation to keep comprehensive records on personnel and equipment for cross-reference purposes. When the user is entering incident data they can choose a "Multiple Injuries" data code, but there is no datafield available for them to enter the details of the multiple injuries; similarly, at many points in the program the user can select the data code "Other" to describe an incident detail, yet no datafield is provided to allow the user to expand upon this response. Clearly, this is inadequate from a health and safety viewpoint. An incident record would be meaningless which stated that a person received unspecified "Multiple Injuries" which required "Other" treatment and were due to "Other" causes.

The incident recording facility is also limited in that if an incident occurs in which several people are injured, a separate incident record will have to be completed in IRIS for each person. Although these records can be linked, the link facility does not appear to convey any benefit other than informing the user that incident records are related, as the user cannot move directly from one incident record to a linked incident record, and it seems unlikely that the link facility would prevent the incidents from being registered

as separate in any statistics that are produced by the program. A similar problem exists in that for each incident, the user can only enter the name of one piece of equipment which was involved. This is likely to lead to misleading incident records and statistics, as many incidents will involve more than one piece of equipment, and the user will be forced to select which one they feel should be entered into IRIS. The incident recording system also lacks any data consistency checks, which means that it will not identify and query data inconsistencies, that data inconsistencies will probably build-up within the incident records over a period of time, and that the program will appear unintelligent to the user. For example, it is possible to enter without query that a person is suffering from a "recurrent" "amputation" injury that was caused by "radiation". Similarly, it is possible for the user to enter what should be invalid incident records into the IRIS incident database which feature no data except an incident number, only a few pieces of data on different incident screens, or blatantly inconsistent data.

Many of the incident recording screens are listed under an anonymous "Additional Information" heading on the main menubar which is only available from the "Core Details" screen in an incident record. The user is likely to forget that these screens exist, and the division between the screens which are included as part of the incident recording sequence and which are cast aside under "Additional Information" seems arbitrary. The majority of the "Additional Information" datascreens are inadequate for recording the incident data for which they are designed. For example, the "Witnesses" data screen only allows the user to record the names and addresses of two witnesses to an incident. There is no allowance for the user to record the details of more than two witnesses, witness telephone numbers, descriptions of whom the witnesses are, witnesses accounts of the incident, details of when the witnesses made reports and to whom, or notes. The data screens for "Underlying Causes" and "Actions" provide the user with 11 set short, vague items from which they can choose to indicate the underlying cause of an incident and the action that the organisation will take following an incident. The lists cannot be modified by the client organisation in any way and encourage the user to utilise an extremely inappropriate method of examining incident causation and response by trying to fit an incident's cause and the appropriate remedial answer into a pre-set, limited category.

The final problems with the IRIS incident recording system are that the screens feature a macro button with a red cross icon which closes the incident record and results in any data that has not been saved being lost. When the button is selected the user is not warned of this or asked to confirm the command; it would be easy to select accidentally the button or to assume that it is a "Save then Exit" button. Further, because IRIS does not possess a security system, any user can enter, modify or delete incident data. This problem is exacerbated because IRIS provides no means for basic administration details to be recorded manually or automatically concerning when each incident record was entered into IRIS, by whom it was entered, when its data was last modified and by whom. IRIS does not allow any distinction to be made between completed incident records and incident records that are in the process of being completed, thus the data in completed incident records can be altered as easily as that in those still under completion. Finally, there is no means to delete an incident record from IRIS once it has been saved in the incident database, therefore the database will grow larger and larger, and consume more and more hard disk space. This is a considerable problem.

2.4.5 Active Monitoring

Only one of the programs that was examined could be considered to offer truly an active monitoring tool for health and safety management. That is HASTAM Limited's MicroCOSHH which is designed to allow client organisations to undertake active monitoring to aid compliance with the *Control of Substances Hazardous to Health Regulations (COSHH) 1988.* MicroCOSHH aims to provide client organisations with a set of data structures which they can use for recording details of the operations that they undertake, the locations within their organisation, the employees within their organisation, the hazardous substances that are used by their organisation, the control measures which are implemented to reduce the risk posed by the use of those substances, the results of medical checks on employees, and the results of air monitoring. The overall aim of the program is to allow client organisations to record and store over the long-term the above information which is necessary in order for them to comply with the *COSHH Regulations 1988.* Only by keeping this type of information for the long-term can an organisation provide evidence of the types of tasks that have been undertaken at their organisation and the types of substances that have been used;

provide evidence of their attempts to control the use of hazardous substances in the workplace; monitor the long-term effects of exposure to hazardous substances during operations; monitor the implementation and effectiveness of risk control measures; develop better ways of managing the use of hazardous substances in the workplace; and help doctors to determine the cause of ill health in employees or former employees.

The approach that MicroCOSHH takes to active monitoring for COSHH compliance is not greatly impressive. Many of the data structures that are provided are insufficient to allow the user to record the relevant information in much detail. The datafields are fixed and often allow for only one word or one sentence responses. The datafields also lack data consistency checks, which means that MicroCOSHH will not recognise when infeasible data is entered into the system. This means that over time a number of errors may build-up within the stored data, which may negatively effect the value of that data. More importantly, the way that MicroCOSHH is designed means that it can only ever provide a current snapshot of the use of hazardous substances in an organisation. The program does not allow the user to produce an active monitoring record for the use of a particular substance on a particular day, or for a particular operation on a particular day, and then save that record for future reference. The user is instead meant to complete and keep up-to-date the supplied data structures to record the *current state* of every operation, location, employee, and substance within the organisation. Each time these data structures are updated, the data that they previously held is permanently lost. Therefore, the data structures can tell the user nothing except the current state of hazardous substance management in the organisation. This is like undertaking a risk assessment by filling in one form, and whenever a new risk assessment has to be undertaken, the data on the existing form is altered rather than a new form being used. It is a nonsensical approach to a health and safety management task.

Although MicroCOSHH features an archiving system which is intended to allow personnel, operations and location records to be stored outside of the program for posterity, the system is flawed. Each personnel, operation or location record consists of several data screens which together provide the full picture. However, if a personnel, operation or location record is archived, only a few of the associated data screens are

actually archived, which means that only a fraction of the original data is preserved. This is because the data records in MicroCOSHH are so heavily interlinked that it is not possible to pull out certain bits for archiving independent of the interconnecting data. Thus although records can be archived in MicroCOSHH, when they are restored to the program the user will find that they are virtually meaningless. This means that MicroCOSHH cannot fulfil its goal of providing long-term data storage for compliance with the *COSHH Regulations*. Moreover, the design of MicroCOSHH means that archiving can never be possible, unless the whole of the data in the program is regularly stored on say a weekly basis.

2.4.6 Risk Assessment

Whilst risk assessment is the backbone of the new proactive health and safety legislation, it is by far the most difficult aspect of a proactive health and safety management system to represent in proprietary computer software. It is not easy to attempt to provide proprietary health and safety software which is flexible enough to cater for the range of hazards and risks in the workplace, to cater for different sizes of organisation, to cater for different levels of health and safety management knowledge, and to cater for different risk assessment and risk control methods. The question is to what extent proprietary health and safety software can provide suitable and sufficient risk assessment facilities for a range of organisations with different health and safety management needs. Risk assessment facilities which are competent from a health and safety viewpoint and a software design viewpoint. Three of the health and safety computer programs that were examined included a facility that allows the user to undertake health and safety assessments. These were WMB Limited's Planning Supervisor which allows the user to undertake risk assessments for construction projects, Ergosystems Limited's Safety Auditor which allows the user to undertake a variety of risk assessments, and Gee Publishing Limited's Health and Safety Lawbase which allows the user to undertake a variety of health and safety assessments. Because the risk assessment facility in Safety Auditor is so heavily entwined with the auditing facility, it will be discussed later in this chapter under the auditing heading.

WMB Limited's Planning Supervisor includes a facility which allows the user to undertake basic risk assessments for a construction project to aid compliance with the *Construction (Design and Management) Regulations (CDM) 1994.* The program includes a hazard identification checklist of which the user can print copies for completion away from the computer. This information can then be used as the basis for the on-line risk assessment process. The risk assessment screen is relatively well presented. It includes drop-down lists from which the user can select the hazard for which they are conducting a risk assessment, and a risk control database to which they can refer to find basic risk control measures for the hazard. It also includes an easy to use severity-likelihood grid on which the user can indicate the level of risk before and after control measures are implemented. The program's substance database can be easily accessed from this screen for reference purposes.

It could be argued that Planning Supervisor demonstrates how difficult it is to represent clearly even a basic risk assessment system in computer software. The program has genuinely made a good attempt in the area, but the risk assessment system has still ended up confusing to use. The user has to first identify the "Hazard Name", then select the "Activity Category" in which the hazard is present, then select the exact "Activity" in which the hazard is present, and then select the "Hazards" which are associated with the activity. This means that the term hazard is used in two different ways - for "Hazard Name" as an item such as "Scaffolding" or "Generator Access", and for "Hazards" as the type of harm which may occur, such as "Collapse", "Trip", and "Struck by Mobile Plant". Even the latter interpretation of hazard is not clear, since the hazard list also includes items such as "Electricity", "Confined Spaces" and "Manual Handling". Thus in this risk assessment system the "Hazard" may be "Scaffolding" and may have the "Hazards" of "Collapse" and "Fall from Height" associated with it. This is highly confusing. There seems to be no clear use of the term "Hazard" in Planning Supervisor.

Whilst the risk assessment facility offers possibilities, it is far too limited in scope and is inflexible. For example, the list of hazards that the user is confined to choose from is fixed as: "Rads, Chems and Metal Splash"; "Confined Spaces"; "Fall from Height"; "Struck by Mobile Plant"; "Trip"; "Collapse"; "Manual Handling"; "Moving Object";

"Electricity"; "Contact with Moving Machinery"; "Fire"; "Hazardous Substances"; "Noise and Vibrations"; and "Explosion". This list is far from comprehensive and the user is not allowed to modify the list, add to the list or delete from the list to suit better their own organisation or a particular construction project. Thus client organisations are constrained to identifying only the types of hazard which are recognised by Planning Supervisor. The danger is that they may come to look for these hazards whilst excluding other types of hazard from consideration, or may try to force other hazards to fit into these strict categories. These events may well occur since client organisations are likely to view proprietary health and safety software as providing expert guidance on proactive health and safety management tasks. This is an issue which will be returned to in Chapter 3. Further, the client organisation will be unable to adapt the list of hazards to match their own constantly evolving health and safety management needs. The list of hazards is set in stone unless WMB Limited choose to modify it, and if they do so, any changes may or may not suit the individual client organisation. The list of work activities from which the user can select when undertaking a risk assessment is similarly set in stone.

The risk assessment screen does not include a datafield to allow the user to record the name of the person who undertook the risk assessment. This is important information that should not be omitted from any health and safety assessment. The idea of a risk control database holds promise, and in Planning Supervisor the facility does allow the user to add their own risk control measures to the database, edit those which are already present and delete those which are not required. The facility is presented smartly and the user can decide whether or not to employ any of the control measures that are featured in the risk control database. However, there is no mention of how the risk assessment facility and the risk control database have been designed, of their health and safety management basis, of how they can aid compliance with the *CDM Regulations 1994*, or of the source of the information. Hence, users may believe that the information that is contained in the risk control database is definitive and comprehensive.

I would suggest that the above is not always the case. The difficulty with attempting to create a risk control database is that it assumes that risk control measures can be

provided for hazards at a broad level. In other words, it assumes that risk control measures can be provided for "Falls" or "Electricity" which will be relevant regardless of the specific circumstances of the hazard. The risk control database in Planning Supervisor proves that this is not an easy task to accomplish. For example, as a "Communal Control Measure" for "Rads, Chems and Metal splash" it only provides "Employ foundry boots" since "This shoe is ideal for working with molten metal". For "Avoidance" and "Control" control measures for the same hazard it only provides "Remove" or "Minimise cutting and welding". These recommendations are fine except that they only refer to metal splash in foundry work or during cutting and welding. They are clearly irrelevant for controlling "Rads and chems splash", yet this is by no means obvious from the risk control database. Similar examples include the "Avoidance" control measure "Avoid hot/cold areas" which is recommended for the hazard "Struck by mobile plant", and the "Avoidance" risk control measure for "Manual handling" of "Avoid in situ concreting". Whilst the idea of a risk control is appealing, it would need a sufficient depth of information to be of real value rather than a brief sentence to explain each control measure. There would also need to be sufficient guidance on how to use the risk control database, and general guidance on risk control as part of health and safety management.

Gee Publishing Limited's Health and Safety Lawbase features an on-line assessment facility and an assessment database. Ready-made assessments are provided for: risk assessment, control of substances hazardous to health assessment, display screen equipment assessment, manual handling assessment and accident report. The assessments typically consist of a sequence of screens that the user works through which feature explanatory text, illustrative graphics, and questions with either radio button answers options or datafields requiring completion. The process of completing an assessment is thus relatively simple. When an assessment has been completed it can be printed or saved in the assessment database. The latter allows completed assessments to be kept over the long-term, and to be accessed easily through a database search facility.

The on-line assessments facility has a major deficit in that the assessments can only be completed on-line in one go from start to finish. The user cannot print a paper copy of an assessment form to complete away from the computer and then enter the data into the program at a later time. Similarly, they cannot save an assessment midway through completion so as to search away from the computer for the information that they need to answer a particular question. This seriously limits the value of the Assessments facility in Health and Safety Lawbase. The question arises as to how users are supposed to undertake realistic risk assessments, COSHH assessments and manual handling assessments amongst others whilst confined to a computer. The main point of health and safety assessments is that the assessor should walk around the workplace examining its current state. The value of health and safety assessments is lost if they can only be completed by an assessor responding from memory at a computer desk. It would thus appear that Health and Safety Lawbase encourages the user to undertake health and safety assessments in an inappropriate and ineffective manner.

2.4.7 Auditing

Auditing is another key element of a proactive health and safety management system. On examining the various pieces of proprietary health and safety software, auditing would seem to be the easiest aspect of a proactive health and safety management system for which a specialist piece of computer software can be produced. Auditing involves the need to design audits, the need to complete audits and the need to analyse audit results. There is far less scope to go wrong than when designing risk assessment, active monitoring or reactive monitoring software. Three of the proprietary health and safety programs that I examined provided some type of audit facility. In the case of HASTAM Limited's S-CHASE and Ergosystems Limited's Safety Auditor, health and safety auditing is very much the main feature of the programs. In the case of Gee Publishing Limited's Health and Safety Lawbase, auditing features in terms of the provision of a compliance audit for health and safety legislation.

HASTAM Limited's S-CHASE is perhaps one of the more well known pieces of health and safety auditing software in the United Kingdom. It provides fairly substantial ready-made audits for a variety of areas. These audits are designed so as to be suitable

for any organisation in any industry. They are thus written at a broad level. The user can work through an audit on-screen. Each audit question is presented clearly on its own screen, along with basic answer options, and a notes facility to allow the user to expand upon their response. Each completed audit can be verified by a second independent person working through it, recording their own responses and notes. Analysis facilities are provided to allow audit results to be examined quantitatively, and to allow comparisons to be made. Client organisations can purchase extra audit modules for an additional fee and can purchase the right to produce their own audits for S-CHASE for a further fee.

As a proprietary health and safety program, S-CHASE was perhaps the piece with which the fewest flaws were identified during the software evaluations. The reason for this is perhaps that the program has kept to the limited scope of basic health and safety auditing, and has not tried to "throw in" extra features or accomplish anything too ambitious. Some of its largest deficits are related to it being a MS-DOS program, which results in it lacking an attractive user interface, a sophisticated help system, and so on. In terms of the auditing facilities in S-CHASE, the only deficits are that the ready-made audits may be too broad to provide a thorough examination of health and safety management in many organisations. General audits can only cover so much of each client organisation's health and safety management system. Only the areas of commonality can be examined by such audits, whilst the areas of difference, which may well be the most important, are omitted from analysis. Although users can design their own audits in S-CHASE, it is not easy to construct a large audit in a piece of software which has no spelling check facility, which does not allow any flexibility with regards to formatting and audit design, and which requires the user to think a great deal about dividing an audit into numerous levels of questions. Further, it is not easy for users to understand and remember the technical jargon which is used throughout the program such as "Modules", "Areas", "Evaluations" and "Verification".

The auditing facility that is provided in Ergosystems Limited's Safety Auditor takes a different approach to S-CHASE. Once again several ready-made audits are supplied which the client organisation can use. The Safety Auditor audits tend to be based around

specific pieces of health and safety legislation, such as the *Control of Substances Hazardous to Health Regulations (COSHH)* 1994 and the *Health and Safety (Display Screen Equipment) Regulations (DSE) 1992*. They are multimedia files which make use of impressive graphics for illustrative purposes. The files are intended to be used for simultaneous health and safety auditing, training and risk assessment. The user can set up an audit by completing an audit details screen which explains who is running the audit, when it will be conducted, which multimedia file it will be based upon, whether the purpose of the audit is training or risk assessment or both, and the number of employees who will complete the audit. The selected employees can then complete the files on-line, advancing through a series of screens which contain information and questions to which they must respond. As the employees progress they are being trained by virtue of working through the screens. The audit is deemed to have been completed when the required number of employees have worked through the multimedia file.

When the audit has been completed the results are analysed in the risk assessment part of the program. A grid is displayed here which is colour coded to indicate the level of risk that would generally be associated with each audit answer. The user can alter the number of colours which are used in the grid to adjust the level of risk categorisation, and can set a threshold limit for the level of risks which will be indicated in the grid. The user can also adjust the level of risk that is associated with different audit answers so as to suit better the specific circumstances of their organisation. They can even adjust the level of risk for a particular answer for a particular employee whose work circumstances may make the answer indicate a higher or lower risk than normal. The user can also set risk control measures where high risks are shown, and can then indicate the new level of risk. Safety Auditor also features a basic statistics facility and a facility which allows client organisations to create their own multi-media audit-training-risk assessment files. The statistics facility allows the user to examine in table or graph format the percentage break-down of the responses that have been given to a particular audit question. The audit-training-risk assessment creation facility is an original visual tool that lets the user enter explanatory text, pictures, sounds, question text, and answer options, onto a drawing board metaphor so as to construct new multi-media

audit-training-risk assessment files. These files can then be used for auditing, risk assessment and training purposes.

Although Safety Auditor is visually impressive, appears to feature many of the elements that are necessary for proactive health and safety management, such as health and safety policy creation, risk assessment, auditing, training, law reference, substance reference, and statistics, and has received the IOSH sponsored Safety and Health Product Innovation Award for General Safety in 1996, it is unfortunately based upon a very poor understanding of health and safety management. In health and safety management it is impossible to create one document to use for risk assessment, auditing and training purposes. This is because risk assessment, auditing and training are meant to achieve different purposes, and as such need to present different information, ask different questions, require different responses, and be designed in different formats. Yet Safety Auditor does not recognise the distinction that is made between risk assessment, auditing and training in proactive health and safety management. It assumes that the same multi-media documents can be used to accomplish simultaneously training, risk assessment and auditing. It misunderstands the meaning of "auditing" in proactive health and safety management, assuming that it means the keeping of administrative records regarding the completion of risk assessments and training. It also misunderstands the meaning of "risk assessment" in proactive health and safety management, assuming that risk assessment is a process which can be conducted upon audit results. The level of confusion that is evident within the program concerning the basics of proactive health and safety management can be seen in this advice from the on-line help system:

> *The Risk Assessment Drawer lets Health & Safety Officers manage schedule safety audits and carry out risk assessment on audit results - selecting this drawer will take you to the Audit Manager screen.*
>
> *The risk assessment allows the auditor to assign hazards and corrective measures*

Because Safety Auditor attempts to use the same ready-made set of multi-media documents for auditing, risk assessment and training purposes, the documents have

ended up without the necessary depth and detail for any of its purposes. In its current format, Safety Auditor is highly confusing when it is examined in the light of conventional health and safety knowledge, and it carries the inherent danger of being misleading for client organisations who are likely to believe that it is based on solid health and safety management foundations, that it caters fully for many of their health and safety management needs, and that it demonstrates the right way to undertake complex health and safety management tasks such as auditing, training and risk assessment.

Three interesting points were raised during the evaluation of Safety Auditor. Firstly, a proprietary health and safety program may *appear* to be of great value for health and safety management if it is competent from a software design viewpoint, even if its health and safety management basis is inaccurate. Whereas if a proprietary health and safety program has an accurate health and safety knowledge basis but is incompetent from a software design viewpoint, it is unlikely to appear to be of value. This is perhaps because it is easier for the average user to identify basic software design incompetencies within a computer program, such as the program carrying out the wrong commands, the program crashing, or the program operating slowly, than it is to identify basic health and safety management incompetencies, such as the wrong legislative reference being provided, a questionable approach to risk assessment being taken, or a poor definition of "hazard" being presented. Secondly, the evaluation of Safety Auditor highlighted that if there are fundamental errors in the health and safety basis of a piece of proprietary health and safety software, the program can be worse than useless, in that it is communicating misleading information. Thirdly, the evaluation of Safety Auditor found that despite the questionable health and safety management basis, the program demonstrates a promising route forward in terms of making use of the modern computer's multi-media capabilities to provide easily understandable auditing, risk assessment and training documents which incorporate text, pictures, sounds and films.

The compliance audit in Gee Publishing Limited's Health and Safety Lawbase provides an on-line auditing facility that allows the user to check the extent to which their organisation is complying with the legal requirements that are made by the *Management*

of Health and Safety at Work Regulations (MHSW) 1992. The compliance audit consists of a sequence of screens through which the user has to proceed. Each screen contains an outline of a legal requirement that is made by the regulations and presents the user with a question which they must answer by choosing between two or three answer options. Convenient hypertext links throughout the compliance audit allow the user to check readily the meaning of a term or a regulation about which they are unsure. The user also has the option of printing a checklist for compliance with the *MHSW Regulations 1992.* Finally, when the user has completed the compliance audit, Health and Safety Lawbase generates a report based on the users answers. This report is supposed to highlight areas where there may be compliance problems and to suggest what should be done to rectify the situation. The report can be saved or printed.

Although a computer-based compliance audit designed to check an organisation's compliance with health and safety legislation could be a useful tool for health and safety management, there are several limitations to the Health and Safety Lawbase compliance audit. Firstly, the program only provides a compliance audit for the *MHSW Regulations 1992.* This limits the scope of the compliance audit tool considerably. Secondly, as the user completes the compliance audit, they can only select the set "Yes/No/Some" answers, and cannot record any notes to expand upon those answers. This means that the program does not encourage the user to *think* beyond the program boundaries by making notes to expand upon the minimalist answer options. It also means that a vital source of insightful information is lost which could have added considerable value to the auditing process. Thirdly, the sequence of screens in the compliance audit does not change according to the user's earlier responses. This means that the program can appear unintelligent and the compliance audit can be time-consuming to complete. Fourthly, the text that is displayed on the compliance audit screens is often poorly presented, with very long sentences, sentences which end without punctuation, and sentences with inadequate alignment and spacing. Fifthly, several of the questions in the compliance audit are incorrectly written so that they check whether a particular regulation has application to a client organisation rather than check whether the client organisation is complying with the regulation. Sixthly, the compliance audit is neither comprehensive nor systematic. Several important aspects of the *MHSW Regulations*

1992 are omitted from the compliance audit, whilst others are checked inadequately. For example, the only question related to training checks merely whether the designated competent person has been trained sufficiently; there is no mention of the training requirements for the rest of the workforce.

Once the user has completed the compliance audit, they will encounter further problems which reduce its value. The user cannot print or save their answers to the compliance audit; they can only print or save the report that Health and Safety Lawbase produces based upon their answers. This is frustrating since the report does not include the original question text or provide the user's answers to the compliance audit. The answers are thus lost and cannot be examined by the client organisation for themselves. Health and Safety Lawbase takes over the audit evaluation task for the client organisation without giving the latter the opportunity to develop their own solutions to the weaknesses that are indicated by the compliance audit answers. The client organisation is thus confined to the solutions recommended by the program. When the compliance audit report is saved, no administration details are saved with it. Thus it does not save information concerning the date and time when the compliance audit was undertaken and the name of the user who undertook the audit. This makes it very difficult to save and compare different compliance audit reports over a period of time.

Further, the checklist and compliance audit report feature many obvious spelling and grammatical errors which make them appear less than professional. This problem is compounded by the very poor presentation of the compliance audit report when it is printed, for example, with no left margin, no page numbers, inconsistent bullet formatting, and headings which are not distinguishable from normal text. The printed report is only headed "Management Action Plan", with there being no mention that the report concerns the results of a compliance audit for the *Management of Health and Safety at Work Regulations 1992,* that the report was created by Health and Safety Lawbase, of the date when the report was produced, or of the user who completed the compliance audit. At no point in the compliance audit report is it explained that the report refers only to compliance with the *MHSW Regulations 1992;* the absence of this context makes the report imply that it refers to health and safety legal compliance as a

whole. This is clearly misleading. The compliance audit report is written with unclear, confusing sentences and poor referencing to pieces of legislation. Further, many of the terms that are used throughout the report assume that the reader is the same person who completed the compliance audit; this means that the report is only understandable by those who are familiar with the software. Even for those who are familiar with the software, the compliance audit report is confusing because it bears no relation to the on-line compliance audit. It does not feature the same headings, the same explanatory text, or the same ordering. It is very difficult to attempt to relate the report's recommendations with the compliance audit.

The advice which is provided by the compliance audit report is shallow, vague and confusing. The recommendations are often made in a manner which implies that they are the only course of action to take or that they are legally required. The advice is thus misleading. An example is as follows:

> *Risk assessment is fundamental to the implementation of the strategy as it is the starting point to any documentation designed to inform employees of the risks inherent in the workplace.*

Moreover, the compliance audit report concludes with a highly misleading statement:

> *Once the above have been put into action you are well on your way to achieving compliance with health and safety requirements.*

2.4.8 Forms

Several of the programs that were examined aimed to provide client organisations with ready-made forms which they could use for health and safety management tasks. HASTAM Limited's Microsafe provides the user with an on-line version of the HSE's F2508 incident reporting form. As the user enters the details of a particular incident into the system, they can opt for a copy of the F2508 form to be completed from the supplied information. They can then check the form's contents and print a copy to send to the HSE or local authority. This is a very useful idea, although with the form menu option labelled "F2508" on the incident record screen, I suspect that many users will not recognise the term and thus will not realise the facility that the option provides. Further,

users may not realise that Microsafe does not have the ability to distinguish which incidents should be reported to the Health and Safety Executive or local authority; it will agree to complete the F2508 form for any incident if the user selects the option. The value of the facility is somewhat negated because Microsafe does not include any information or guidance concerning the incident reporting requirements of the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations*, or concerning how the on-line F2508 form should be understood and completed.

As the user completes the form they receive no interactive feedback, and are not queried if they enter details which fall outside the scope of the requirements that are made by the *RIDDOR Regulations*, such as reporting a road traffic incident. Overall, the points raised mean that users are likely to waste their time completing the form for incidents which do not need to be reported, and waste the Health and Safety Executive or local authority's time by sending them F2508 forms for incidents that did not need to be reported. Finally, Microsafe does not keep records of whether F2508 forms have been sent to the Health and Safety Executive or local authority, and if so, when and by whom. Users may thus complete the form and forget to send it to the Health and Safety Executive or local authority, or may send more than one copy not realising an earlier copy has been sent.

WMB Limited's Planning Supervisor features a proformas facility which allows the user to print a form to use for data collection for each type of data that is required by the program for a construction project to achieve compliance with the *Construction (Design and Management) Regulations (CDM) 1994*. The proformas are nicely designed, are consistent with the datafields that exist on the associated program screens, and are easy to print. When the proformas are printed, the printed versions are extremely well presented and are easy to complete. It appears that a lot of care has been taken in their creation. The proformas demonstrate how computer software can be used to provide ready-made, well-constructed forms for health and safety records and assessments. They also highlight how much the quality of proprietary health and safety software can be raised by ensuring that it produces high quality, readily understandable, printed output which is consistent with what the user views on the program screens.

On the negative side, only one copy of a proforma can be printed at a time, which makes printing multiple copies of a proforma a slow process, and although there is a special facility where the user can select proformas for printing, this facility does not allow the user to view the proformas before they send a print order. As a final point, although it is useful to have high-quality, ready-made proformas within a piece of proprietary health and safety software, the facility in Planning Supervisor is limited in that it does not allow the user to modify existing proformas or create new proformas. The design of the proformas is fixed, which means that client organisations cannot adapt them in any way to include datafields for the collection of organisation-specific data, to account for changing health and safety management needs, or to suit better their own presentation preferences. If organisations purchase Planning Supervisor, the program strictly dictates to the last detail what they should do to achieve compliance with the *CDM Regulations 1994*. The program does not provide client organisations with even the slightest possibility for individual variation.

Gee Publishing Limited's Health and Safety Lawbase features a form manager facility that provides the user with several ready-made forms and notices. These can be printed and used by client organisations. Whilst the idea of providing client organisations with ready-made forms and notices to aid compliance with health and safety legislation is good in principle, there is a host of problems with the forms which are provided. Firstly, the forms are completely different to the on-line assessments in the program even when they cover similar areas, such as the *Control of Substances Hazardous to Health Regulations (COSHH) 1994* or the *Health and Safety (Display Screen Equipment) Regulations (DSE) 1992*. This is awkward and confusing for the user. Secondly, the forms and notices are isolated from the rest of the program. Several cover aspects which are not mentioned anywhere else in the program, such as a food hygiene notice and two cleaning checklists. The assessment forms and checklists can be printed and completed, but there is no facility for entering the results into Health and Safety Lawbase and thus no facility for analysing the results.

Thirdly, there is no guidance in the help system or elsewhere concerning how the forms and notices are to be used and analysed to aid compliance with health and safety

legislation. Fourthly, the forms cover a peculiar spectrum of topics, which is far from comprehensive, and bears little relation to the areas covered elsewhere in *Health and Safety Lawbase.* For example, there are two cleaning checklists and two display screen equipment assessment forms, but no fire, electricity or manual handling assessment forms. Fifthly, the forms are so poorly designed that it is difficult to know how some of them are meant to be used, and many fail to feature basic administration datafields for date of assessment, time of assessment, assessment location, name of assessor, position of assessor and signature of assessor. Sixthly, the notices that are provided are written in an unclear and repetitive manner. Seventhly, many of the forms and the notices are designed in a way which strongly suggests that they were produced specifically for one company and are now being presented as general documents. This means that it will not be easy to apply them to many organisations. Eighthly, the forms and notices are poorly titled, they often fail to state clearly the piece of legislation for which they are designed, and do not state that they are the product of Health and Safety Lawbase. Ninethly, many of the forms and notices confusingly state that they were designed by Personnel Health and Safety Consultants in 1992 and 1993, and hence were not designed by Gee Publishing Limited specifically for Health and Safety Lawbase. This explains many of the identified problems. Finally, no facilities are provided to allow the user to modify the forms and notices so that they suit better their organisation, or to create new forms and notices to meet changing health and safety management needs.

2.4.9 Substance Database

Three of the pieces of proprietary health and safety software that were examined aimed to provide the user with a substance database facility. Additionally, another piece of software aimed to provide rudimentary substance information. In principle there are good possibilities for using computer technology to present important information concerning substances which are used in the workplace.

HASTAM Limited's MicroCOSHH features a substance database which is intended to contain data on a large number of substances which may be used in the workplace. The substance database is provided to help organisations to make adequately informed decisions when seeking to comply with the *Control of Substances Hazardous to Health*

Regulations (COSHH) 1988. Users can search the substance database by entering any name by which they know a substance, be it a chemical name, product name or company name. This is a very useful feature since it means that users do not have to recall the particular name that is used in MicroCOSHH when they wish to find information for a particular substance. They are then presented with several screens of substance data which can be easily navigated through by selecting from clearly labelled menu options.

Whilst the MicroCOSHH substance database has several good features, it also has a number of drawbacks. Firstly, the software does not make any distinction between different types of substance names, such as product name, chemical name or company name. This could be a source of confusion, especially when users are searching for a particular type of name for a substance, such as its chemical name. Secondly, only users with certain security system rights can access the context-dependent help for the substance database. This program flaw means that many users cannot obtain this help. Even those users with appropriate security access rights face a cumbersome process for obtaining help in the substance database. Thirdly, the datafield labels and associated data in the substance database is presented in the form of abbreviated codes. This means that the user either has to remember the meaning of the codes or keep checking the code reference screens. This is inconvenient and time-consuming.

Fourthly, the data that is contained in the Substance Database is extremely minimalist. Short phrases and lists of items are presented to the user, without any explanatory text or guidance. For example, MicroCOSHH may describe the personal protective equipment that is required when working with a substance as: "Gloves, mask, boots". This is near to useless information since it does not explain when these items should be used, what type of each item should be used, how the items should be stored, or how the items should be maintained. It can surely sometimes be worst to provide poor or minimalist information than to provide none at all. If information is presented in proprietary health and safety software it is likely to be acted upon by organisations, and it may be viewed as comprehensive and authoritative by users, particularly if they are

health and safety novices. Minimalist information is misleading, it suggests that "This is all you need to know". It also makes complex tasks appear trivial and unimportant.

Finally, the substance database in MicroCOSHH has not been updated by HASTAM Limited since it was first produced for the *COSHH Regulations 1988*. This means that the information that it contains would have become out-of-date within a short time of its release on the commercial software market unless organisations took it upon themselves to research accurately and update the database at regular intervals. Thus there is a very real danger of organisations acting upon increasingly incorrect information in the substance database. The manner in which the informational content of MicroCOSHH would have rapidly deteriorated within a few years means that the value of the software would similarly have deteriorated. The idea that MicroCOSHH could provide long-term information and data storage to aid compliance with the *COSHH Regulations 1988* was thus incorrect.

WMB Limited's Planning Supervisor and ErgoSystems Limited's Safety Auditor incorporate what is basically the same substance database. The substance database is attractively designed, with clearly presented data. It is also easy to operate, and prevents a complex area from appearing daunting to the user. A relatively sophisticated search facility allows the user to search the substance database for information concerning a particular substance or particular substances. The user can search the substance database according to substance name, index number, EEC number, CAS number, CHIP symbol or CHIP phrase. They are rapidly presented with a list of substances which match the search criteria, and can select from this list to view the full data for particular substances. The substance database has some flexibility in that it allows the user to enter data for user-defined substances. This means that client organisations will be able to use the substance database to record the details of substances that they use but are not already featured in the database.

On the negative side, the data that is featured is minimalist. The substance database features far less information than that in MicroCOSHH. It does not provide basic chemical details for the substances, does not provide Maximum Exposure Limit (MEL)

or Occupational Exposure Standard (OES) data, and only provides the short, vague *CHIP Regulations 1994* risk and safety phrases to describe substance use and control, such as: "Wear suitable protective clothing and gloves"; "This material and it's container must be disposed of in a safe way"; and "After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer)". The *CHIP Regulations 1994* phrase codes are listed separately to the associated phrases in the substance database, which makes it difficult to link the phrases with the appropriate codes. Overall, the substance database for Planning Supervisor and Safety Auditor lacks sufficient depth to be of real value to the health and safety expert or novice. It is only of use for checking the EEC code for a particular substance, or for checking whether a substance is toxic. There is not enough information to allow risk assessments to be undertaken and control measures to be developed. The *CHIP Regulations 1994* risk and safety phrases by themselves are extremely minimalist, and without explanatory text and guidance tell the user little about how hazardous substances should be used and controlled. Health and safety experts would not rely on this information alone when undertaking a risk assessment process for the use of hazardous substances in the workplace. The substance database seems to imply that this is all the information that is needed for such tasks.

Gee Publishing Limited's Health and Safety Lawbase provides the user with a rudimentary substance data facility when they are undertaking on-line COSHH assessments. At a certain screen in the assessment, the user can choose to utilise the facility to obtain basic Maximum Exposure Limit (MEL) or Occupational Exposure Standard (OES) data for particular hazardous substances. Whilst the idea of incorporating basic substance data into the on-line COSHH assessment has merit, the manner in which this has been accomplished leaves much to be desired. One problem is that the information can only be accessed when the user is in the on-line COSHH assessment. This means that the information is not available as a general reference source within the program, and cannot easily be referred to when the user is undertaking a paper-based COSHH assessment using the supplied COSHH assessment form.

Even when the user is undertaking an on-line COSHH assessment, they can only access the OES and MEL data from one screen amongst a sequence of assessment screens. Although the user can move backwards through completed assessment screens to utilise the facility, any data that they have entered on the screens is permanently lost and will have to be re-entered from scratch. The facility itself does not allow the user to copy or print substance information, so they must either resort to copying the data by hand or to consigning the data to memory. The only data that is available for substances is the MEL or OES exposure limits. There is no information concerning the nature of different substances, the dangers that are associated with them, how they should be used, or how they should be controlled. The MEL and OES data is presented in a highly technical manner that would be extremely off-putting to the health and safety novice. Technical health and safety abbreviations such as *PPM*, *TWA*, and *EH40* are used without explanation. The program does not explain how the data should be interpreted and used in managing hazardous substances in the workplace.

2.4.10 Law Reference

Three of the health and safety programs that were examined featured a separate law reference facility. Presenting complex health and safety legislation in an attractive and easy to examine format is a task which computer software could undertake well. Ergosystems Limited's Safety Auditor and WMB Limited's Planning Supervisor both feature what is essentially the same law reference facility. The facility is structured according to the Microsoft Windows standard for on-line help systems. This makes it immediately familiar and understandable to anyone who is used to the Microsoft Windows environment. The law reference facility presents the user with a list of health and safety legislation from which to choose. This list is reasonably impressive, with nine pieces of legislation featured, as well as a "Health and Safety Booklist" option.

When the user selects a piece of legislation, they are presented with a list of the constituent regulations, schedules and appendices. If one of these is selected, the original text is presented clearly on-screen. The law reference facility provides the user with common Microsoft Windows help system options such as "Print", "Copy", "Annotate", "Bookmark", "Hypertext" and navigation commands such as "Back" and

"History". The booklist presents the user with a list of health and safety books for reference. The law reference facility in Safety Auditor and Planning Supervisor provides a good format for presenting health and safety legislation. To be of greater use though, it should cover more legislation, rectifying, for example, the notable omission of the *Health and Safety at Work etc. Act 1974*. It should also ideally contain more that just word-for-word copies of health and safety legislation. There should be information from guidance notes and approved codes of practise to elaborate upon the legislation, and a glossary of terms. Finally, the booklist should feature more than merely a list of references. It needs to provide a short description of each text so that the user can more easily use the facility.

The main purpose of Gee Publishing Limited's Health and Safety Lawbase is to provide an interactive law reference system for health and safety. This is accomplished through the program's Interactive Law Library. The interactive law library is a topic-based reference facility. The user can search for information regarding health and safety legislation by selecting a topic such as fire, electricity, or manual handling. They can then select from a list of areas relevant to the topic, such as training, competence and record keeping. Then they are presented with a series of screens which present explanatory text which includes hypertext links, and sometimes features questions which require a "Yes" or "No" answer. For each health and safety topic that is covered, the user can also access an index which lists all of the constituent topics and hypertext links.

Whilst the interactive law library in Health and Safety Lawbase is promising, there are questions regarding its design. It has several major limitations. The first limitation is that it is entirely topic-based. This means that the user cannot directly choose to examine a particular piece of legislation, or a particular regulation in a piece of legislation. It also means that the user cannot examine a piece of legislation in the interactive law library as they could a paper copy. They cannot read through the legislation in its written order. The topics-based approach means that each screen contains information from several regulations within a piece of legislation or within several pieces of legislation. This is similar to the approach taken by the *Tolley's Health*

and Safety at Work Handbook (Dewis, 1995). The difference is however that the latter is intended for the health and safety specialist only, whilst the former is intended as a clear guide for the health and safety novice as well as the expert. Although the topics-based approach is useful, in the instance of Health and Safety Lawbase it is confusing and lacking in depth.

The latter points are exemplified by the fact that the interactive law library does not include the original text from health and safety legislation. Instead only summaries of the legislation are provided. This means that the user has to rely upon the software company to have correctly interpreted and paraphrased the legislation. It also means that the user has no means of readily checking the exact wording in a piece of health and safety legislation. It limits the value of the software as a reference tool for the health and safety expert and as a learning tool for the health and safety novice. Organisations surely need to be able to view the original text when attempting to comply with health and safety legislation, rather than rely on paraphrased versions alone, particularly when those versions are far from comprehensive.

Although the interactive law library allows the user to move directly to individual screens in a topic without viewing the screens in sequence, the information screens have not been designed so as to be independent. The information screens are poorly titled, often assuming that the user will remember which piece of legislation they are examining rather than including this information on the screen, or using an abbreviation or paraphrase for a piece of legislation in the title. The information screens are also poorly referenced. Regulations are referred to without making it clear to which piece of legislation they are related, vague references are made to "the ACOP" and "the statute", and information is provided without explaining its source. On occasions the text in the interactive law library is written in a very confusing manner. The interactive law library does not encourage the user to look outside the system for further information. It does not provide any lists of texts to which the user could refer and it does not provide full reference details for the legislation which it describes. Again, these points limit the value of the software as a reference tool for the health and safety expert and as a learning tool for the health and safety novice.

2.4.11 Help System

HASTAM Limited's three health and safety programs featured reasonably good help systems. The help systems contained a large quantity of information concerning program operation, relevant health and safety legislation, and health and safety management theory. The help systems also explained the meanings of many of the technical health and safety terms that are used throughout the programs. The help system contents were thus excellent, apart from the fact that they were considerably out-of-date because the programs had been designed some years ago and had never been updated. Without regular program updates the help systems would have become out-of-date within a year or so of the software's release on the commercial market. From then on they would have contained increasingly incorrect information concerning health and safety legislation and health and safety management theory should organisations have continued to use them. This poses potential problems since if organisations act upon this incorrect information when undertaking health and safety management tasks there may be negative consequences.

The structure of the help systems in the three programs was far from impressive. It was standard context-dependent MS-DOS help, without the comprehensive style of help system which computer users are now used to with Microsoft Windows programs. The user thus has no control to search for the help information which they require, as they can only view the help information that is available for the particular screen that they are viewing. The help text also lacks the high quality presentation of that which is generated for Microsoft Windows, and does not feature the numerous convenient navigation options which are available to the user in the latter. Further, the help option is often not visible to the user on program screens. Although they can still access help by selecting the F1 key on the keyboard, users, particularly computer novices, are likely to forget this and feel that they have been stranded without help. This was common in many of the health and safety programs that were evaluated.

The opposite problem was found to exist with the Microsoft Windows health and safety software. In ErgoSystems Limited's Safety Auditor, WMB Limited's Planning Supervisor and Gee Publishing Limited's Health and Safety Lawbase the help system

structure was excellent. Each provided the user with a variety of options including hypertext, history navigation, back navigation, search, copy, annotate, print and bookmark. However, the standard of the help contents was generally very poor. Safety Auditor's help system contained extremely minimalist information. It often failed to describe adequately how to use various program facilities and was far from comprehensive. Whilst it is certainly a good idea for software to be designed so as to be self-explanatory and so that the user does not have to refer to the help system, the help system should still be comprehensive and detailed for the occasions when the user does seek guidance. In contrast, Health and Safety Lawbase's help system did explain clearly how to use the software, although a few software aspects, such as the ready-made assessment forms and notices that are available in the form manager were not explained.

Both Planning Supervisor and Safety Auditor's help systems failed to explain the health and safety management basis for the programs, and failed to link explicitly program facilities to relevant health and safety legislation. Health and Safety Lawbase's help system did provide some explanation of its health and safety management basis and its link to health and safety legislation. However, it failed to explain how the form manager facility is to be used to aid legal compliance. The help system in Health and Safety Lawbase clearly provided full technical support contact details for the user, whilst in Planning Supervisor a telephone number is provided which the user can call to find out about support details. It is essential for help systems to include advice on obtaining technical support for software. Safety Auditor's help system does not include contact details for technical support, which is even more surprising given that it is a fairly complex program to operate.

Neither Planning Supervisor nor Health and Safety Lawbase include a glossary to provide the user with their definitions of the health and safety terms that are used throughout the program. This is a deficit since it is important for the user of health and safety software to understand how key terms have been interpreted by the software designers. There is as yet no consensus in the field of health and safety as to how key terms should be understood, so every health and safety program will probably take a slightly different stance as does every health and safety text. If users cannot easily

access a glossary in the help system, they cannot examine how terms have been defined and discover the extent to which they agree or disagree with the definitions. Further, the health and safety novice will have no easy method of checking the meaning of health and safety terms which may seem commonplace to those in the field of health and safety but are likely to be baffling to those outside the field. Safety Auditor includes a glossary of terms, but the list only contains seven items, and fails to cover many relevant terms such as "risk" and "risk assessment". Further, the definitions which are provided are often poor. The issue of the provision of suitable definitions for key health and safety terms in proprietary health and safety software will be returned to in Chapter 3.

The version of Safecode Limited's IRIS that was examined does not yet feature a help system. This aspect was still under development at the time of the software evaluation. Thus organisations which have bought the software will not have any help facilities to which they can refer. All health and safety software should be sold with a complete help system included.

2.4.12 Backing-Up Data

Microsafe III, MicroCOSHH and S-CHASE from HASTAM Limited are all designed to include a facility to allow the user to make easily back-up copies of the data that they have recorded in the program. This is important to prevent data from being lost due to corruption, computer viruses, computer theft, flooding or fire. One of the ideas behind health and safety software is that it is intended to allow an organisation to store health and safety information over the long-term. For information to be stored safely over a period of years it needs to be possible to produce regularly back-up copies. The back-up data facilities in the three programs were relatively easy to understand and operate. However, the back-up data option tended to be obscured in a sub-menu in Microsafe and MicroCOSHH, making it likely that users would forget to back-up data. In S-CHASE the back-up option is provided on various screens, but the user can only back-up files one at a time. This is highly inconvenient and time-consuming. Further, although a reminder is provided in all three programs to inform the user of the need to back-up data regularly, this reminder is not presented until the user has exited the

system. At this point it is too late as the user is unlikely to re-enter the system just to back-up data.

WMB Limited's Planning Supervisor includes a facility to allow the user to back-up data. The facility is easy to understand and operate. As with HASTAM Limited's Microsafe and MicroCOSHH, the back-up option is not easy to find, being in the "Options" menu item under the "File" menu on the main menubar. The user is not reminded of the importance of backing-up data before they exit the system, and although the program records the date and time when data was last backed-up, it does not keep a record of the user who last performed the operation. However, a nice feature is included which allows the user to set a reminder in the program so that they will be reminded of the need to back-up data at whatever regular interval of days the user selects.

It was surprising to find that Gee Publishing Limited's Health and Safety Lawbase, Safecode Limited's IRIS and Ergosystems Limited's Safety Auditor do not feature a facility for backing-up data. If anything, the Microsoft Windows proprietary health and safety software is larger and more sophisticated than the equivalent MS-DOS software. The expectation is presumably that users will find their own method of backing-up the whole of the software from the hard disk. This is a task that will require client organisations to possess cutting-edge data back-up systems such as Iomega Jaz drives, Iomega Zip drives, CD-Rs, CD-RWs, or computer networks. Further, as increasing numbers of files are stored in the health and safety software over a period of years, the back-up task will become more and more difficult. Needless to say, many potential health and safety software users will not have the level of computer competence to undertake this type of task regularly. Moreover, many potential users will probably not even realise the need to make and keep back-up copies of the software's data. More damning than the absence of a back-up facility in the new generation of proprietary health and safety software is the failure to even mention the need to back-up data to users in either program manuals or on-line help systems.

2.4.13 Security System

A security system is an essential feature for health and safety software. It allows a client organisation to control access to the software and thus to the data contained therein. This is important because much of the data which is recorded in health and safety software is likely to be confidential in nature, such as incident reports, medical records, monitoring results, risk assessments, and personnel data. HASTAM Limited's three proprietary health and safety software programs feature security systems which are easy to set-up and operate. A system administrator has to be designated by the client organisation, and they are responsible for providing other individuals with user IDs, passwords and varying access rights. The one weakness is that only basic user access rights can be set by the system administrator, when organisations may wish to have a greater degree of sophistication to control exactly which data and facilities each user will be able to access.

Surprisingly none of the Microsoft Windows proprietary health and safety software that was examined featured a security system. It is thus possible for any computer user to access ErgoSystems Limited's Safety Auditor, Gee Publishing Limited's Health and Safety Lawbase, Safecode Limited's IRIS, and WMB Limited's Planning Supervisor, by simply selecting the relevant icon in Microsoft Windows. The programs do not feature any facilities to allow client organisations to set-up a security system. Despite this, all of the programs are designed to allow important health and safety information to be recorded within them which organisations would want to keep confidential. For example, incident details can be recorded in IRIS included the names and addresses of witnesses; reports can be recorded in Health and Safety Lawbase which highlight where an organisation has failed to comply with health and safety legislation; audit and risk assessment results can be recorded in Safety Auditor; and personnel and business contact details can be recorded in Planning Supervisor. The absence of a security system must be considered as a large deficit for these programs, particularly when it is so easy with modern computer technology to print or electronically transfer data within seconds.

2.4.14 System Stability

Good system stability is vital for any computer software, and is even more important when that software is designed to store important health and safety information which needs to be protected from data corruption. HASTAM Limited's S-CHASE and Gee Publishing Limited's Health and Safety Lawbase were found to have excellent system stability as they did not crash once during the whole software evaluation process. Further, they never, as far as is known, malfunctioned or produced data errors. I would like to stress how rare this is, since in over 10 years of experience with hundreds of computer programs, I have found that most programs will crash or produce errors from time to time. The key in software design is to minimise the chance that this will occur and to design control measures such as warning screens to alert the user if system stability is threatened.

HASTAM Limited's MicroCOSHH and Microsafe programs did not have the same high level of system stability. Both crashed on numerous occasions during the software evaluation process due to errors in the programming code. Although both of the programs can be accessed in MS-DOS through Microsoft Windows, I found that problems arose when other Microsoft Windows applications were operated simultaneously. Neither program presents the user with warning screens to inform them of poor system stability, and thus they do not give the user any control to close safely the program. Safecode Limited's IRIS crashed many times during the software evaluation process. It would crash if data was entered by the user which the system was unable to handle, or if certain options were selected. It would also regularly crash if more than one other application was running simultaneously in Microsoft Windows. IRIS does not present the user with warning screens to inform them of poor system stability, and thus does not give the user any control to close safely the program.

Safecode Limited's Safety Auditor and WMB Limited's Planning Supervisor also had system stability problems. Both appeared to require a great amount of computer resources for operation, and thus were liable to become unstable if operated simultaneously with other applications in the Microsoft Windows environment. However, they were superior to the previous three programs in that although they would

become unstable at times they rarely crashed. Instead in the case of Planning Supervisor the high quality graphics would fail leaving a confusing combination of images on screen. The user would not receive a warning but would be able to exit safely from the program following their own intuition. When system stability was threatened in Safety Auditor, the user would be presented with a clear warning message, and be able to rectify the problem by exiting the program or freeing up system resources. However, both programs were easily thrown into confusion if incorrect data was entered at certain points, such as the project plan in Planning Supervisor and the risk assessment cost data in Safety Auditor, then the computer would take ages to produce a nonsense chart or graph, and sometimes crash in the attempt.

Chapter 3: Exploring Health and Safety Software

Beware of false prophets, which come to you in sheep's clothing, but inwardly they are ravening wolves.

The Bible Societies (1976) *The Good News Bible,* Matthew 7:1[33].

In this chapter I intend to examine in greater detail many of the issues that were uncovered whilst evaluating the current range of proprietary health and safety software. The first issue that will be examined is the nature of the proprietary health and safety software market. I will then advance to considering the foundations of proprietary health and safety software, with particular attention devoted to health and safety definitions, the imbalance of adaptation which exists when people use this type of software, the set route that it offers for health and safety management tasks, and the added value that users have to supply in order for the software to operate effectively. Lastly in this chapter I will consider whether proprietary health and safety software promotes or demotes thought, whether it encourages the right type of thought, whether users are likely to assume that it has more competence than is actually the case, what the consequences of system failure may mean for this type of software, and its questionable use of legal disclaimers.

3.1 The Proprietary Health and Safety Software Market

The starting place for exploring the value of proprietary health and safety software is the nature of the commercial market for this product. Whilst proprietary health and safety software can be evaluated in isolation to examine the extent of its software design competence and its health and safety management competence, as was demonstrated in Chapter 2, to determine the *value* of the software one has to advance beyond this to consider its commercial context. This context includes the suppliers and purchasers of proprietary health and safety software, the relationship between these parties, and the manner in which the software is marketed and sold. One of the crucial questions which arises when considering the value of proprietary health and safety software is the extent

[33] Quotation from original source.

to which this software differs in relation to proprietary office software. When I commenced this research project, although I believed that proprietary health and safety software was in some way distinctive from other proprietary office software, I did not fully appreciate the extent to which this was so.

I have divided the analysis into several areas so as to examine the manner in which proprietary health and safety software is purchased, and more specifically, the manner in which its associated manuals, training and product updates can be purchased. Throughout the analysis a useful comparison is drawn with the equivalent purchases for proprietary office software. The recurrent theme of the analysis is the distinctive nature of the proprietary health and safety software market, and the unique relationship that exists between health and safety software companies and their client organisations. This theme is developed further in an analysis of the problems that exist in the long-term for organisations who purchase proprietary health and safety software, and an examination of the problems that the distinctive nature of this type of software poses for its suppliers.

3.1.1 The Purchase of Proprietary Health and Safety Software

Most organisations utilise a range of proprietary office software in their everyday operation. When an organisation purchases proprietary office software, the purchase typically involves paying a set fee for a copy of the software, a software manual and a software license. The software can normally be bought from a range of vendors, including a large number of independent software retailers as well as the software company who created the software. Once an organisation has purchased a piece of proprietary office software, they can install it in their offices and use it for as long as they wish, without needing to make further payments to continue usage or to acquire essential software updates[34]. This means that, with proprietary office software, the relationship between the client organisation and the software company normally ceases once the product has been purchased. Although the client organisation can choose to extend the relationship by contacting the software company's support services for advice and registering for information on product updates, they are under no *obligation*

[34] By "essential" it is meant that the software would not continue to operate effectively unless the software update was purchased.

to continue their relationship with the software company in order to continue to use the software. Proprietary office software is typically free-standing after purchase, so that it will continue to operate into the future, independent of the software company by whom it was produced.

Unfortunately, this is not the case with the majority of proprietary health and safety software, as a more binding relationship tends to exist between the software companies, their software products and their client organisations. When an organisation purchases proprietary health and safety software, the purchase typically involves paying a set fee for a copy of the software and a software manual, and then being required to pay further fees for a range of extra software components and services. They may have to pay a separate fee for each *module* of the software that they require. They may have to pay an additional charge for each extra copy of the software that they require. They may have to pay a further fee for an annual software license. They may have to pay a higher sum if that license is to cover use of the software on a computer network, with the exact sum tending to be on an increasing scale according to how many individuals will use the software on the network. They may have to pay an additional charge for each extra copy of the software manual that they require. They may have to pay an annual fee to obtain access to software support services. They may have to pay for the software company to train members of their organisation how to use the software. The true cost of a piece of health and safety software is thus often obscured.

At the time of writing, there has been an escalating trend in the proprietary health and safety software market towards the software companies requiring client organisations to purchase annual software licenses. An annual software license for proprietary health and safety software can cost over £1000 and has to be purchased each year by the client organisations if they wish to continue to use the software. In other words, with the annual software license, organisations have to purchase the right to use proprietary health and safety software one year at a time. This is on top of the normal costs which are associated with the purchase of the software. The annual software license is significantly different from the software license that is included in the basic cost of proprietary office software which allows client organisations to use the software

indefinitely without further cost. The annual software license makes it likely that upon purchasing a piece of proprietary health and safety software, an organisation will become tied down for several years to the associated software company.

For example, if an organisation pays £2,000 for a piece of proprietary health and safety software complete with annual software license, then by the following year they will be faced with the choice of paying the next £1,000 annual license fee for the right to continue to use the software for another year, or the choice of failing to renew their annual software license, which will essentially mean writing-off the investment that they have so far made in the program. If the organisation wished to change to a different piece of proprietary health and safety software at this point, they would have to pay a large set of start-up fees and purchase an annual software license from the new software company. When the annual software license expires for the organisation's previous software, either the program will no longer be kept up-to-date and support will be withdrawn so that it will soon become unusable, as in the case of Gee Publishing Limited's Health and Safety Lawbase, or the software will cease to operate on the date that the annual software license expires, as in the case of Safecode Limited's IRIS. Either way, if the organisation does not buy a new annual license for the software, the data that they have previously entered into the system will probably be lost, since it will not be transferable to other proprietary health and safety software, and it may not be possible to transfer it in a meaningful format to proprietary office software.

The annual software license for proprietary health and safety software thus holds the client organisation to a continuing relationship with the software company. It gradually increases the organisation's financial commitment to the piece of software that they have purchased, and to the associated software company. Further, it makes it difficult for the organisation to retract on their investment decision. The chances are that they will purchase the next annual software license and stay with the "devil they know", regardless of whether or not they are entirely satisfied with the software, rather than having to terminate the investment and investigate alternative solutions.

3.1.2 The Purchase of Manuals for Proprietary H&S Software

When an organisation purchases proprietary office software they would normally expect it to arrive with a manual. If they wish to purchase more manuals, they can contact the software company for additional copies of the standard manual at a set price or they can visit a computer or office retailer where they can select from a range of alternative manuals for the product. The standard manual will cater for one level of expertise and one level of financial resources. In contrast, the alternative manuals will cater for different levels of expertise and financial resources. The alternative manuals will also often include a multi-media CD-ROM to assist the organisation in learning how to use the software. Essentially because proprietary office software is widely used, organisations that purchase the software are not solely dependent upon the software company for the provision of manuals, and can thus remain in a position of control where they can select the best out of a set of options to suit their own particular needs.

With proprietary health and safety software, organisations can only purchase the standard manual from the software company. Because the commercial market for this type of software is small, there will not be alternative manuals for the software that can be purchased elsewhere. This means that organisations which purchase proprietary health and safety software are dependent upon the software company for software manuals, and have no alternative options available. They have no choice but to accept the price level that the software company sets for copies of their manuals, and to accept the level of expertise which is catered for by the manuals.

3.1.3 The Purchase of Training for Proprietary H&S Software

When an organisation purchases proprietary office software, they may wish to receive training concerning how to use the software. Whilst they may be able to contact the software company for training, they can also choose from a range of alternative options. These options include hiring a software training company or an independent consultant to undertake the task, attending external training courses, purchasing training videos and CD-ROMs, or developing their own internal training courses. Because there is a range of choices, the organisation is in no way dependent upon the software company for the provision of training.

With proprietary health and safety software the organisation has far fewer choices with regards to training. They can either purchase training from the software company or learn how to use the software themselves and then develop their own training courses. However, since many organisations would find the latter option difficult, it is likely that they will at least purchase some initial training from the software company regardless of its price or quality. Because proprietary health and safety software has such a small commercial market, there will be no alternative training courses or materials available for purchase. Organisations who invest in this type of software are thus entirely dependent upon the software company for their training needs.

3.1.4 The Purchase of Product Updates for Proprietary H&S Software

As was mentioned earlier in this chapter, when organisations purchase proprietary office software they are essentially purchasing a software license that allows them to use that software for as long as they desire. The initial purchase cost is the only expenditure that the organisation need to make, since they do not need to purchase any product updates in order for the software to work correctly. Proprietary office software will continue to operate at the same level from the day it is purchased to the day the organisation no longer wish to use it. Although with time it will no longer possess the latest features, its performance will not deteriorate from its original level if it is not upgraded. The software will only become unusable if information technology advances to the point where it can no longer be operated on the computers which are used in the workplace.

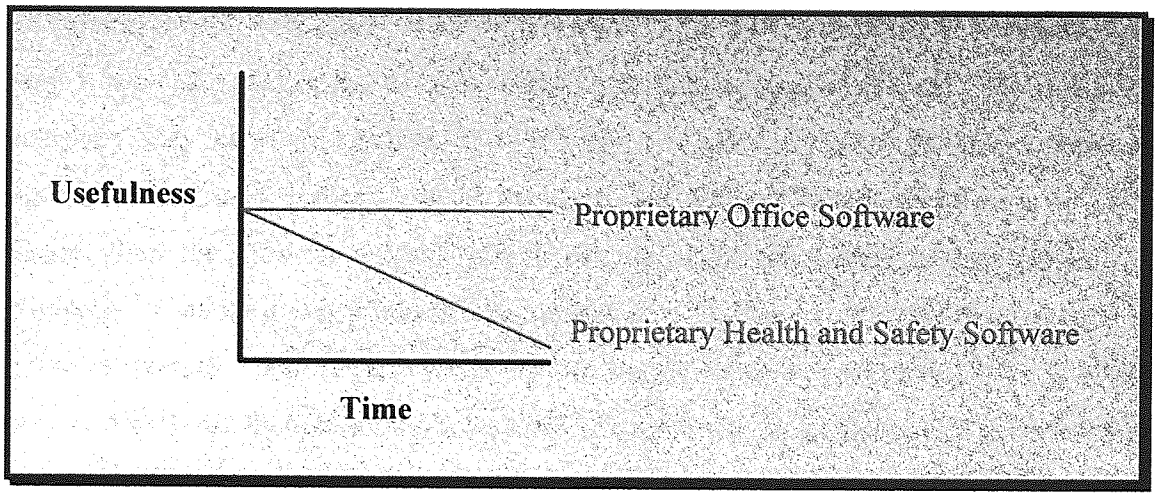
Though with time upgrades will become available for the majority of proprietary office software, client organisations can decide for themselves whether they wish to purchase an upgrade and if so, when. Thus a client organisation can purchase an upgrade when they have the finances to do so or can skip upgrades in the series, for example they could upgrade from version 2 of a word-processing program to version 4 skipping version 3. As well as the possibility of easily upgrading to a newer version of the same office software, organisations also have the choice of investing in any one of a range of alternative pieces of office software. If they choose to invest in an alternative program they would expect to be able to use their old files within it. This basic compatibility

between different pieces of proprietary office software means that the organisation can store data for as long they require.

In contrast, with proprietary health and safety software, client organisations are typically required to purchase an annual software license and renew it every year if they wish to continue using the software and receive software updates. With the high outlay costs that have to be paid to purchase initially a proprietary health and safety software system, client organisations are likely to feel obligated to continue renewing their annual software license. If they fail to renew the license, the software will no longer be updated and will rapidly become out of date. Whereas proprietary office software will over time continue to operate at the same level without being updated, if proprietary health and safety software is not updated, the level at which it operates will deteriorate markedly with time because it will contain increasingly out of date information. The information that is contained in proprietary health and safety software is time-dependent in a way that the information in proprietary office software is not. This is true for all proprietary health and safety software, even basic incident recording programs are time-dependent in their relation to the *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995* and incident recording practise. Figure 3.1 demonstrates this phenomenon.

The deterioration of the usefulness of proprietary health and safety software with time gives the software companies a degree of power over their clients that proprietary office software companies do not hold. Proprietary health and safety software companies have a captive market once organisations have made an initial investment in their software. This is because client organisations are dependent upon them to keep the software up-to-date and to prevent it from deteriorating in usefulness. Organisations can only purchase upgrades for their proprietary health and safety software from the one software company regardless of the price or quality of those upgrades. Organisations cannot choose to skip upgrade stages according to their financial position or personal preference. For the software that they have invested in to remain useful they have to purchase each annual software license in turn and progress through the provided upgrades in sequence.

Figure 3.1: The Deterioration In Usefulness Of Proprietary Health And Safety Software Compared To Proprietary Office Software With Time



Unlike proprietary office software, it is difficult for an organisation to change from one piece of proprietary health and safety software to another. If an organisation were to attempt such a change, they would effectively have to write-off the investment that they had made to date in their previous piece of proprietary health and safety software because it would rapidly become out-of-date and thus unusable once they ceased to renew its annual software license. Furthermore, the organisation would be faced with the prospect of paying another set of large initial outlay costs for a new piece of proprietary health and safety software to which they would again be held captive. The problems would continue even after the organisation has purchased a new piece of proprietary health and safety software, since they would find that the data that they had recorded in their old software is incompatible with the new software. The organisation's existing health and safety data would be trapped in their old software and as the software becomes out-of-date and unusable, the data that it contains would become unusable too. This means that health and safety data can only be stored in a useful format in proprietary health and safety software for as long as the software remains up-to-date. Therefore, proprietary health and safety software is unlikely to provide a suitable medium for the long-term storage of important health and safety data.

3.1.5 Long-Term Problems with the Purchase of Proprietary H&S Software

Because of the high degree of dependency between client organisations and their proprietary health and safety software company, there are a number of problems that may affect the usefulness of the software in the long-term. Firstly, the software company may cease to operate. If a proprietary office software company cease to operate, client organisations can continue to use their software for as long as they desire, since the software will continue to operate at the same level independent of the company by whom it was produced. In contrast, if a health and safety software company cease to operate, client organisations will no longer receive product upgrades, and the software will rapidly deteriorate in its level of usefulness. Its contents will soon become out-of-date and incorrect. If the client organisations continued to use the software there is a danger that they would act on incorrect information and this could have negative consequences for health and safety.

Secondly, the software company could cease to produce upgrades for the software. In the case of proprietary office software this would not be so important, since the software would continue to operate at the same level into the future, and client organisations could purchase alternative software at a later date to obtain the latest features. The alternative software should be compatible with the data which was stored in the old software, so that previously recorded data will continue to be accessible and useful into the future. In contrast, if a software company should cease to produce upgrades for a piece of proprietary health and safety software, the level at which the program operates will deteriorate with time, and it will soon become out-of-date and unusable. The client organisations could invest in alternative software but would probably find that it is incompatible with the data that they had stored in the old software, and that this data would soon become unusable.

Thirdly, a software company could change its software so that it no longer meets the needs of some of its client organisations. If a proprietary office software company did this, affected client organisations could choose to stay with the previous version of the software which did match their needs, or to find a new piece of software in which to invest. If they chose the latter option they could be fairly certain that the new software

would be compatible with the data that was stored in the old software, so that previously recorded data will continue to be accessible and useful into the future. If a proprietary health and safety software company changed its software so that it no longer met the needs of some of its client organisations, affected client organisations would find that they could either move to the updated software that no longer matches their needs, or could stay with the existing software which will rapidly deteriorate in usefulness. Alternatively, they could seek to invest in alternative software and risk facing the problems that were outlined previously.

Fourthly, a software company may be irregular in their production of product updates, developments and other programs which were intended to make up a software suite. If a proprietary office software company did this, client organisations would still be able to utilise the software that they had bought at the same level of operation as before. They could seek alternative software from more reliable companies if and when they wished. If a proprietary health and safety software company did this, client organisations would find themselves held captive whilst they waited for the items. If program upgrades and developments were delayed, the proprietary health and safety software's level of operation may deteriorate and its informational content may become out-of-date. Client organisations would be in a difficult position since changing to alternative health and safety software could result in data from the previous software rapidly becoming unusable, whilst remaining with the existing software would be equally problematic.

With regards to these four possibilities, since proprietary office software companies are generally larger and more stable than small proprietary health and safety software companies, they are more likely to continue trading in at least the medium term. Conversely, small proprietary health and safety software companies are more likely to cease operation. The larger proprietary office software companies are more likely to continue supplying a range of software products, and can fund those which have smaller or less stable markets with the profits that are generated by those which have large, stable markets. The smaller proprietary health and safety software companies are more likely to have only a limited range of products of which they must pursue those which offer the best financial stability. If a product proves unprofitable or difficult to continue

with, a small proprietary health and safety software company is likely to cease production and eliminate the product from their range. This may occur fairly quickly in the case of financial difficulties.

Proprietary office software tends to be broad and multi-purpose in nature, in that it does not dictate to the user how they should perform particular tasks, whereas proprietary health and safety software, as was illustrated in Chapter 2, is relatively rigid, narrowly specialised and dictatorial. This makes it more likely that proprietary health and safety software will be modified by the software company in a way which no longer matches certain client organisations' needs than proprietary office software. Further, the larger proprietary office software companies are more likely to supply product upgrades, developments and related programs as stated, whereas the smaller proprietary health and safety software companies may find themselves subject to any number of unexpected delays.

The high level of dependency between client organisations and proprietary health and safety software companies can be seen vividly when one considers the nature of the dependency. When an organisation purchases a piece of proprietary health and safety software, they are not only purchasing a product but are commencing a relationship with the software company that makes them reliant upon the latter. At the simplest level they are relying upon the software company to provide a product which is competent from a software design angle and a health and safety angle, in terms of it containing health and safety knowledge and tools which have correct and up-to-date proactive health and safety management foundations. At a slightly more complex level, they are relying upon the software company to help them to fulfil the responsibilities that are placed upon them by health and safety legislation.

At a more complex level still, because proprietary health and safety software will deteriorate in usefulness over time if it is not regularly updated, an organisation that purchases this type of software is relying on the software company to continue to provide suitable updates for it over the next few years. This means that they are relying on the software company to continue operation during that time, and to continue to

develop the software that they have purchased. Further, they are relying on the software company to develop the software in a manner that continues to match their evolving health and safety management needs, and continues to be up-to-date with the latest information technology, computer operating systems, office software, health and safety legislation, health and safety management theory, health and safety practise, business practise, and industry practise. Furthermore, they are relying on the software company to develop the software in a manner that continues to be competent from a software design viewpoint and a health and safety viewpoint, and which continues to enable them to fulfil the responsibilities that are placed upon them by health and safety legislation. This is a considerable degree of reliance that client organisations are willing to place upon small proprietary health and safety software companies in order to manage successfully health and safety and achieve compliance with health and safety legislation.

3.1.6 The Suppliers of Proprietary Health and Safety Software

> *It eluded us then, but that's no matter - to-morrow we will run faster, stretch out our arms further ... And one fine morning ...*
> *So we beat on, boats against the current ...*
>
> F. Scott Fitzgerald (1926) *The Great Gatsby*[35].

Given the previous points which have been made, an interesting question which arises is whether small software companies are best able to provide proprietary health and safety software. As was explained earlier in this chapter, this type of software necessitates a unique relationship between software companies and their client organisations. Client organisations are completely dependent upon their software company to keep the proprietary health and safety software that they have bought up-to-date and usable. Yet as was described in the previous section, attempting to keep proprietary health and safety software up-to-date is no easy matter. It is a vast task, and one which puts

[35] Quotation from original source. The quotation is relevant here because it refers to the tendency to attempt to reach a goal which is beyond our grasp, fighting against the current as we do so. This is similar to small software companies hoping to supply sophisticated health and safety management software, but never being able to achieve and sustain this goal, because they are fighting against the current of constant change in technology, legislation, work practises, and health and safety practise. No sooner does a health and safety software product reach the consumer market, than progress renders it out-of-date or obsolete within a short while.

proprietary health and safety software companies on a treadmill continuously chasing after the harsh pace of change that has been set by technological society. That these software companies will always be several steps behind the times seems inevitable.

In comparison, software companies who produce proprietary office software do not face such a fight to keep their products up-to-date. Proprietary office software has only to keep up-to-date with changes in business practise, information technology, computer operating systems and other office software. Despite these lesser demands, even the largest software companies in the world, such as Microsoft, can only produce updated versions of their software every two years. Even then, the updated software is often rush released onto the market later than was hoped, with difficulties unresolved, and sometimes containing considerable flaws.

The majority of proprietary health and safety software that is released on the commercial market is already behind the times in one way or another by its release date. This is because it may take as long as 18 months for a small software company to plan, design, create, test, produce and market a piece of proprietary health and safety software. For example, if at the start of the design process, Microsoft Windows '95 and Microsoft Office '95 have just emerged on the commercial market, a forward-thinking software company may seek to design their proprietary health and safety software to operate in conjunction with these. However, by the time their software is released on the commercial market, it will probably be closely followed by the release of Microsoft Office '97 and then the release of the Microsoft Windows '98 operating system. Proprietary health and safety software is thus likely to appear to be behind the times within a few months of its release. This is in effect a "no win" situation for the small software companies that seek to produce proprietary health and safety software and for their client organisations.

Unfortunately, the example that I have provided is very much a best case scenario. Most proprietary health and safety software companies do not have the capacity to be able to update their software every two years. Proprietary health and safety software will often tend to fall three or four years behind the times, if not more, before it is updated to any

great degree. When I commenced this research project in 1994, the proprietary health and safety software that I first viewed was Microsoft DOS-based, and had not been substantially updated in some years. In 1995, the majority of the proprietary health and safety software that was being marketed through health and safety literature, such as the *Safety and Health Practitioner*, was still MS-DOS-based, even though the Microsoft Windows operating system had been dominant for five years. Only with the advent of Microsoft Windows '95 and Microsoft Office '95 was proprietary health and safety software developed to operate in the Microsoft Windows environment. Even then, much of it was only designed to rudimentary standards for Microsoft Windows 3.1 or failed to take advantage of the Microsoft Windows environment[36]. The proprietary health and safety software that was developed during 1995 arrived on the commercial market during the summer of 1996 and throughout 1997. By which time Microsoft Office '97 had been released, and Microsoft Windows '98 was anticipated.

Because it is often several years before a software company produces a new version of their proprietary health and safety software, it is more difficult for them to ensure that there is backwards-compatibility between previous versions of the software and the new version. As an example, there is a large gulf between computer software which is designed to operate in MS-DOS and that which is designed to operate in Microsoft Windows '95. It will be difficult for proprietary health and safety software companies to ensure that their new Microsoft Windows '95 software is backwards-compatible with its previous MS-DOS incarnation. The problem of backwards-compatibility is worse for proprietary health and safety software than for proprietary office software, because of the larger time gaps between new software versions and because of the integral need to be able to store health and safety data over the long-term. If it cannot reliably store health and safety data over the long-term its value is significantly diminished.

The extent of the difficulties that exist with small software companies supplying proprietary health and safety software, is even greater when one considers that most of these companies attempt to produce and keep up-to-date several pieces of this type of

[36] See, for example, Chapter 2 of the thesis, for a discussion of how the seven proprietary health and safety programs which were evaluated as part of the research fared in terms of their operating system.

software, which are often intended to comprise an integrated software suite for health and safety management. It is difficult for a small software company to attempt to keep one piece of proprietary health and safety software up-to-date, and competent from both a software design and a health and safety angle, but the task is likely to be all the harder when they attempt to accomplish this with two, three, four or five pieces of software. In the latter case, the time span between updated versions of the programs is inevitably lengthened, and the chances of at least one of the programs falling considerably behind the times, or being eliminated from the product range, are increased.

When proprietary health and safety software falls behind the times, as with any commercial proprietary software, client organisations have no legal rights to modify the software themselves. This is perfectly understandable from a software producers point of view. However, proprietary health and safety software differs from proprietary office software in that it will not only become out-of-date from a software design viewpoint, but its health and safety informational content will also become out-of-date. Because of the extremely rigid, fixed design of the majority of pieces of proprietary health and safety software, client organisations will be unable to adapt their software by up-dating its informational content or its approach to health and safety management tasks. With this type of software, client organisations do not have the power to adapt their health and safety management system to match their unique, constantly evolving proactive health and safety management needs. This is a theme which will be returned to later in this chapter[37].

3.2 The Foundations of Proprietary H&S Software

> *... a wise man ... built his house on rock. The rain poured down, the rivers overflowed, and the wind blew hard against that house. But it did not fall, because it was built on rock.*

[37] It could be argued that it is far more difficult to attempt to keep proprietary health and safety software up-to-date since the advent of Microsoft Windows. The previous MS-DOS operating system was dominant in IBM-compatible PCs for 10-12 years, during which time it changed only marginally between versions. Software which was designed for MS-DOS could therefore remain up-to-date from a software design viewpoint for a longer period. In comparison, Microsoft Windows has evolved enormously through its various incarnations, and the software market has changed so that within a couple of years programs become out-of-date from a software design viewpoint.

> *... a foolish man ... built his house on sand. The rain poured down, the rivers overflowed, the wind blew hard against that house, and it fell. And what a terrible fall that was !*
>
> The Bible Societies (1976) *Good News Bible,* Matthew 7: 24-27[38].

> *'Then you should say what you mean', the March Hare went on. 'I do', Alice hastily replied; 'at least - I mean I know what I say - that's the same thing, you know.' 'Not the same thing a bit !' said the Hatter. 'Why, you might just as well say that "I see what I eat" is the same thing as "I eat what I see!"'*
>
> Lewis Carroll (1865) *Alice's Adventures in Wonderland*[39].

For a software company to create a valuable piece of proprietary health and safety software, they need to base that software upon solid proactive health and safety management foundations. The software needs to take an acceptable approach to health and safety management tasks, to contain correct and up-to-date health and safety knowledge, and to provide health and safety management tools which allow the user to undertake suitably tasks such as auditing, active monitoring, reactive monitoring and risk assessment. Put simply, proprietary health and safety software can only be as good as its health and safety management foundations. Yet, as was emphasised in Chapter 1, the important task of ensuring that proprietary health and safety software is built upon solid health and safety management foundations usually falls to a small number of individuals within a small software company, who will differ greatly in the level of their health and safety knowledge, experience and qualifications.

In Chapter 2, in reviewing the findings of the proprietary health and safety software evaluations, attention was drawn to a number of areas where the health and safety management basis of the seven programs could be called into question. The exact problems varied greatly, and included amongst others: the inadequate explanation of health and safety legislation, inadequate referencing for health and safety information, unsuitable approaches to auditing and risk assessment, over-simplification of complex health and safety management tasks, poorly devised assessment forms, and a general lack of flexibility and user control over how health and safety management tasks are

[38] Quotation from original source.

[39] Quotation from original source.

undertaken. The problems stood alongside many promising ideas for the use of computer software in health and safety management. One of the valuable points to emerge from the software evaluations is that with proprietary health and safety software, no matter how good and correct the majority of a program, if there is an error in the health and safety knowledge that it contains, or if it takes a questionable approach to a health and safety management task, the positive value of the program is lost, and the program instead carries the danger of disseminating incorrect health and safety knowledge or inappropriate health and safety practise. Proprietary health and safety software can thus serve as a double-edged sword in a manner in which proprietary office software cannot. This is an issue which will be returned to later in this chapter.

One of the greatest benefits that proprietary health and safety software can bring to health and safety management is the ability to represent in a readily understandable, visual working model the foundations of health and safety management which are often only otherwise presented in the form of complex technical detail and abstract theory. Health and safety management is not an easy subject to learn, and perhaps does not instinctively appeal to many people. Unfortunately, in the UK there are few conveniently priced health and safety management texts that are well researched and written in a manner which is accessible to the average person in the workplace. Even though an increasing number of health and safety management courses are now available, they are still likely to fall outside the range of affordability for the managers of small to medium businesses. Yet unlike many other academic subjects, health and safety management has a strong practical basis, and affects every member of the nation's workforce.

Whilst recent health and safety legislation, such as the *Management of Health and Safety at Work Regulations 1992*, has placed legal requirements upon employers to perform complex proactive health and safety management tasks such as risk assessments, many organisations are understandably unsure as to how to undertake these tasks. It is not easy to learn how to perform auditing, reactive monitoring, active monitoring and risk assessment from health and safety management texts. When attempts are made to describe practical tasks in words, it is difficult not to lose

something in the translation. It is difficult to describe practical tasks clearly, to use distinct terminology, to provide enough detail, and to provide complete, independent descriptions which can be readily understood by those with little previous knowledge of health and safety management. When experts in any field attempt to describe practical tasks in words, their descriptions are rarely complete, since much of the surrounding knowledge is left implicit, and is taken for granted as assumed knowledge.

When it is hard to understand risk assessment, auditing, reactive monitoring, active monitoring and health and safety legislation from health and safety texts, it is easy to see why organisations without health and safety experience may look to proprietary health and safety software to show explicitly them what to do. The personal computer's capabilities for utilising text, pictures and sound to convey information offer far more scope for learning than words on paper alone. Proprietary health and safety software can, in theory, show organisations *how* to accomplish proactive health and safety management tasks in a way which text books cannot. It can, in theory, reach and interest those for whom conventional health and safety educational methods are unappealing, difficult to understand, and difficult to act upon.

In practise, however, the current range of proprietary health and safety software tends to offer little as a learning tool. It is often designed in a manner whereby the user is already assumed to possess a great deal of health and safety management knowledge, where technical terms and abbreviations are left unexplained, where the program's health and safety management basis is sometimes inadequately explained, where knowledge is presented as gospel without an explanation of its source of origin, where the user is not informed of the software's limitations, and where the user is not encouraged to look outside the software's boundaries. When this is added to the problem of proprietary health and safety software often carrying incorrect information and inadequate health and safety management tools, and often carrying a high price which puts it beyond the reach of those for whom it could be of most benefit, the value of the software is far less than what it could be in an ideal world.

Yet one must consider the possibility that the reason why organisations are driven towards purchasing proprietary health and safety software is to some extent the same reason why the software fails to live up to its highest potential. In other words, organisations may look to proprietary health and safety software to clarify the complex and confusing field of health and safety management, yet in this software the failures, contradictions and confusions of health and safety management are made manifest[40]. Software companies who seek to design proprietary health and safety management software can only attempt to represent explicitly current health and safety management knowledge and tools. Failures in proprietary health and safety software may thus provide a good guide to where failures lie in health and safety management knowledge and tools, or perhaps, where failures lie in the *communication and explanation* of health and safety management knowledge and tools. To pursue this issue further, I will examine one area in more detail, that of health and safety definitions, and in particular those for the central terms "hazard" and "risk".

3.3 Health and Safety Definitions

> *And thus here, as in all other cases where we use words without having clear and distinct* ***ideas****, we talk like children who, being questioned what such a thing is which they know not, readily give this satisfactory answer, that it is something ...*
>
> John Locke (1690) *An Essay Concerning Human Understanding*, Book II, Chapter XX111, 2.[41]

> *Expert consultants ... invent their own jargon. They use words in a way which nobody has heard before, or conjure up a new word, thus underlining once again separateness from their clients. The consultant is not only a creature from another world, he actually* ***speaks*** *a different language.*

[40] As an example of the contradictions and confusions in health and safety management, a recent text by Wallace (1995) *Developing Effective Safety Systems* reverts to describing accident causation in terms of the Domino Model, where *hazards are caused by unsafe acts.. or by unsafe conditions*, and *hazard identification is a fact-finding process to identify the components of a hazard under these two headings.* Wallace's list of unsafe acts is extremely out-of-date, including items such as *riding on hazardous equipment* and *horseplay*. Unfortunately the text would appear to be competent and authoritative to most readers since it is published by the Institution of Chemical Engineers, and Wallace was an expert witness to the Piper Alpha enquiry.

[41] Quotation from original source.

> *The technique for inventing jargon is simple enough. The trick is to take a noun in common use, and turn it into a verb; or, to reverse the procedure. Loathesome, but impressive-sounding words emerge in this barbarous manner. Profit can spawn 'profitalise'; merchandising can develop 'merchandisation'. And so on. The humble words 'up' and 'down' can be joined in new, surprising and revolting ways e.g. 'In this way, we can seek to 'up-bottom-line'.*
>
> Nigel Viney (1986) *Bluff Your Way in Consultancy*[42].

When the proprietary health and safety software was evaluated for this research, it was found that the software companies often avoided providing definitions for key health and safety terms, or only provided definitions for one or two of these terms. When definitions were provided, they were of varying quality and tended to be difficult to locate in the on-line help system for the associated software. The programs which failed to provide health and safety definitions tended to claim that this was intentional so as to benefit their client organisations, since the latter would then be able to decide for themselves how the key health and safety terms are to be interpreted. Contrary to this view, I would suggest that it is important for health and safety software to include clear definitions for every key health and safety term which they utilise. These definitions should be easily accessible in both the software manuals and the on-line help system. The reasoning behind this suggestion is as follows.

In order to create software for health and safety management, software designers must first have a clear idea of how they are going to interpret key health and safety terms such as "hazard", "risk", "safety", "accident" and "incident". It would be impossible for them to produce a meaningful, consistent health and safety program if they did not possess a distinct understanding of these terms. If the definitions that are used during the software design process are not made explicit to the software users, there is a potential for confusion since the software users may interpret the terms differently to the software designers. This could cause difficulties when software users initially learn and later use the software. Software companies that shy away from providing health and safety definitions may feel that to do so gives their program a broader appeal; that it prevents potential customers from being lost because of differences in opinion over key

[42] Quotation from original source.

health and safety terms. However, in order for the software users within a client organisation to understand fully a piece of health and safety software, to be able to *add value* to the software so that it can meet their organisation's needs[43], and to be able to optimise their interactions with the software, they need to know how key health and safety terms have been interpreted by the software designers. An organisation cannot otherwise recognise and work around any potential differences.

Although it is essential for software designers to include key health and safety definitions in their health and safety software, it is equally vital that when such definitions are provided, they are constructed well. If the software contains poor definitions this can present as many difficulties to client organisations as software which provides no definitions. The reason being that poor definitions may confuse and misinform their audience. Many potential users of proprietary health and safety software, such as members of small to medium businesses and health and safety novices, may look to the software that they purchase to explain key health and safety terms in a definitive manner. They are likely to assume that the software is created by health and safety experts, and that it is competent in terms of its health and safety knowledge base. They are likely to take the health and safety definitions that it provides at face value, and assume that they are correct and authoritative.[44]

In the majority of cases where proprietary health and safety software does provide definitions for key health and safety terms, it does not make clear the sources of the definitions. Thus it is often impossible to determine whether a given definition has been created by the software company, taken from health and safety legislation, taken from health and safety literature, or taken from specific client organisations. It is likely however, that client organisations will assume that the provided definitions are taken directly from relevant health and safety legislation[45] and literature. Occasionally, the definitions which are provided are constructed poorly so as to not make sense when

[43] The issue of to what extent the users of proprietary health and safety software have to *add value* to that software in order for it to be useful is examined later in this chapter.

[44] The issue of user's assuming competence in proprietary health and safety software is examined in more detail later in this chapter.

[45] This assumption is perhaps particularly likely when the software is designed to aid compliance with a particular piece of health and safety legislation.

examined outside the confines of the program. To avoid this problem, it is surely logical for all health and safety definitions to be written clearly in a manner which makes them independent of the particular program.

The failure to provide clear and consistent definitions of health and safety terms is not confined to proprietary health and safety software, since the same disease pervades health and safety literature. This is perhaps not surprising since the definitions that are proposed by proprietary health and safety software companies are largely inspired by those that are expressed in health and safety literature. For each of the main terms of health and safety, such as "hazard", "risk", "accident", "incident" and "safety", a myriad of definitions abound, amongst which there are not even generally agreed upon definitions. This has produced a number of problems, such as the continuing confusion amongst health and safety specialists and the general public over how the key terms of health and safety are to be understood and how they are to be used practically in health and safety management.

As with proprietary health and safety software, many health and safety texts try to avoid entirely the issue of providing health and safety definitions, no doubt assuming that the reader will already be familiar with the mentioned terms. The two mediums tend to assume frequently that their audience possesses a high level of health and safety knowledge and thus often fail to explain the basic tenets of their health and safety management theories. When this occurs it makes them inaccessible to the novice, and difficult for even the expert to understand and evaluate.

When health and safety definitions are provided in health and safety literature, it could be argued that many of them are in some way flawed. Those contained in the HSE's 1991 publication *Successful Health and Safety Management,* are not easy to locate since they are buried amongst the text and a comprehensive glossary of terms is not provided. They are also extremely abstract and circular in nature, giving the impression of explaining everything to the reader yet on analysis offering little which is concrete. It would be extremely difficult for the reader, for example an employer of average

education and intelligence, to translate these definitions so that they can be applied to practical health and safety management in the workplace.

In other health and safety texts, the writer often takes the "blunderbuss approach" of peppering the reader with an infinitesimal variety of definitions from a wealth of sources. The idea behind the blunderbuss approach is that by providing a variety of definitions for a key health and safety term, the reader will somehow come to understand the general concept, even if they will be unable to clearly define it in words themselves. Examples of this approach include Thygerson (1992) and Stranks (1996a, 1996b, 1996c, 1997). For example, Stranks (1996a) defines "hazard" as[46].:

- *A situation of risk or danger*
- *A situation that may give rise to personal injury*
- *The result of a departure from the normal situation, which has the potential to cause injury, damage or loss.*

and defines "risk" as:

- *A chance of loss or injury*
- *A chance of bad consequences*
- *To expose to a hazard*
- *To venture*
- *To expose to a mischance*
- *To expose to chance of injury or loss*
- *The probability of harm, damage or injury*
- *The probability of a hazard leading to personal injury and the severity of that injury.*

[46] The extent of the confusion caused by the blunderbuss approach to health and safety definitions is all the greater in the case of Strank's texts, since they each tend to include a slightly different list of definitions for "hazard" and "risk". For example, *The Law and Practise of Risk Assessment* (Stranks, 1996b) includes only the third definition of "hazard" that is presented on this page along with the definition of "hazard" from the HSE (1991); the text also includes only 4 of the above definitions of "risk", one of which is rephrased, along with a new definition of "risk", and the definition of "risk" from the HSE (1991).

This is perhaps a similar approach to that employed by the leading English dictionaries, which of course present their own variety of definitions for the key health and safety terms (see for example, Pearsall and Trumble, 1996).

Another problem with the health and safety definitions which are provided in health and safety literature is that the term "hazard" is defined differently in the context of health and safety management than in the context of safety technology. Whereas health and safety management attempts to provide a somewhat broad definition of a hazard as, for example, *"a situation with the potential to cause harm"*, safety technology tends to define a hazard as a particular *type* of harm. Thus, the text *Safety Technology* (Stranks, 1996) provides a long list of hazards for maintenance work, which includes amongst others the following: "entanglement", "ejection", "electrocution", "explosion", and "dust". Whilst this approach is exemplified in the British Standard *BS5304 Safeguarding of Machinery* (British Standards Institute, 1988), it is difficult to reconcile how these hazards match the definitions of "hazard" that are proposed in health and safety management. The problem with the dual use of the term "hazard" in health and safety has been succinctly summarised by Erickson (1996, p13):

> *The term hazard is sometimes used to define a source of potential harm or injury and, sometimes, the potential harm or injury itself. Thus, a silo containing plastic chips or grain or any other raw material may be said to be a hazard, because, having entered the silo, a worker might become engulfed and subsequently asphyxiated. Or the hazard may be defined as the engulfment or asphyxiation. This double meaning of the word hazard (i.e. the silo itself or the dangers that exist within a silo) often results in a confusion of cause and effect.*

If the reader is interested in pursuing the difficulties that exist in providing health and safety definitions, a valuable discussion can be found in *The Evolution and Design of Safety Management Systems* by Kingston-Howlett (1996). This discussion focuses in depth not only upon the definition of "hazard" and "risk", but also upon the definition of "accident", "incident", and "safety".

3.4 The Imbalance of Adaptation

> *In considering the interaction between computer programs and human beings one is considering a relationship between an entity which has proved itself supremely capable of adaptation and one which has yet to demonstrate any significant capacity for adaptation. The likely outcome of the interaction will therefore be that the human adapts to suit the computer rather than vice versa. What one would expect to occur in an interaction between a human being and a computer, therefore, is that the human would adapt quickly and maybe even unknowingly to the demands of the computer, while the computer failed to adapt to any significant degree.*
>
> Blay Whitby (1988) *Artificial Intelligence: A Handbook of Professionalism*[47].

Beyond the question regarding the accuracy of the knowledge base for proprietary health and safety software, lies the question of how the software can influence the manner in which health and safety management tasks are undertaken. When proprietary health and safety software is created, as with any software, it is designed to be rigid, consistent and reliable. Although many pieces of commercial computer software have some flexibility incorporated into them, this is usually of a limited variety. Neither the modern computer nor modern computer software yet possess the ability for self-adaptation: the ability to change themselves to match better the requirements of their environment. In stark contrast, humans are characterised by an innate ability to adapt themselves to their environment, and to shape their environment to suit better their own capacities. This includes being able to adapt themselves to the technological environment and in turn adapt the technological environment so that it becomes more yielding.

Whitby (1988) has observed that this is due to the mental, as oppose to the physical, abilities of humans. Whitby highlights the human mental capacity for adaptation with the everyday example of people being able to venture into new environments, analyse the novel requirements of those environments and devise creative solutions to those requirements. Through the evolutionary process of natural selection, humans have developed so as to be able to adapt easily to their environment. Whereas, in stark contrast, computers do not undergo such evolutionary processes, but instead have to be

[47] Quotation from original source.

adapted over the course of years by human computer programmers. Computers have no innate capacity for adaptation and our interactions with them suffer for it.

Whenever a human interacts with computer software, because the human has the ability of adaptation which is lacking in the computer, they are likely to find themselves adapting to match the granite requirements of the software. The computer software itself cannot adapt and the human usually has no means of adapting it to match better their own needs beyond selecting amongst minor pre-set customisation options. If there are any difficulties, confusions or conflicts during the interaction, it is the human that has to adapt in order to make the computer software work. Moreover, the user has to learn to accomplish the tasks that the computer software is designed to perform according to its dictates. Over the last two decades proprietary office software has advanced remarkably, moving from being completely dictatorial with rigid command-line interfaces that forced the user to accomplish tasks by proceeding through a set sequence of actions, to being somewhat more flexible with user-driven interfaces that present the user with all of the options at once and allow the user to select whichever options they want to perform, in whichever order they desire.

Despite the advances in proprietary office software, proprietary health and safety software has remained extremely dictatorial to the user in terms of how they should accomplish particular health and safety management tasks. For example, proprietary incident recording software tends to tell the user what information they should record concerning incidents, how this information should be set out and divided in an incident record, what headings there should be within an incident record, how much detail should be given, and even, as in the case of Safecode Limited's IRIS, the strict order in which data should be entered. Further, proprietary incident recording software tends to tell the user what type of analyses they can perform on the incident data, and what kind of graphs and reports they can produce. This means that the way in which the user accomplishes the task of incident recording and analysis has to be adapted according to the proprietary health and safety software. The software makes little or no allowance for individual variation, and the way it is designed means that it can rarely be adapted by the software designers to match the individual client organisation's needs.

The intolerant treatment of individual variation by technological society has drawn analogy with the *procrustean bed* (Whitby, 1988). In Classical Greek mythology the hero Theseus encountered a robber called Procrustes who tortured his victims by placing them on a bed and then either stretching them with a rack or cutting off their legs so that they fitted the exact length of the bed (Hope Mancrieff, 1907). The same threat to individualism is present when an individual interacts with a piece of proprietary health and safety software that serves as a procrustean bed. The individual is stretched or confined to match the software. They are either stretched beyond their knowledge and abilities in order to use the software or find that only a fraction of their knowledge and abilities can be utilised with it. The individual has to adapt their method of performing a task to match that which is set out by the computer software. The computer software provides a set minimum limit of what the user must undertake in order to complete a particular task and a set maximum limit which they cannot progress beyond. In other words, the user no longer has the freedom to choose how to perform the health and safety management tasks for which the proprietary health and safety software is designed, nor the freedom to change how those tasks are performed whenever they desire. The loss of these basic freedoms takes away one of humankind's most fundamental abilities - the ability to manipulate the environment (Smith and Layton, 1989).

In practical terms, the suggestion is that because proprietary health and safety software is so inflexible, it is the user who has to fit the software and not the software which has to fit the user. This type of software does not provide the user with even minor customisation options which may give the latter the power to adapt the software somewhat to match better their needs. It is a very difficult task for inflexible proprietary health and safety software to be designed so as to match the needs of all potential users, regardless of their level of computer competence or health and safety competence. The task is even more difficult when one considers that it is not only the user who is placed on a procrustean bed by the software, but also client organisations. Client organisations have to fit themselves to the software rather than the software having to fit them. If they depend upon proprietary health and safety software for health and safety management tasks, they will find themselves either stretched beyond what they would like to do to

accomplish those tasks, or forced to undertake those tasks in a more limited manner than they would like. With this type of software, no user or client organisation can ever undertake health and safety management tasks *exactly* how they would wish.

3.5 A Set Route

> *We are merely the stars tennis-balls, struck and banded*
> *Which way please them ...*
>
> John Webster (1623) *The Duchess of Malfi*[48].

Because the current range of proprietary health and safety software is so inflexible and dictatorial, it can only offer client organisations a single set route for performing health and safety management tasks. This means that for as long as a client organisation use a piece of proprietary health and safety software, the software will specify how health and safety management tasks are to be performed rather than the organisation. Although over time the unique health and safety management needs of each client organisation will constantly evolve, proprietary health and safety software cannot adapt itself to the changing environments around it. This would not be such a problem if the software was designed to allow the user considerable flexibility in the manner in which they accomplish health and safety management tasks, and the control to change how they use the software to perform those tasks over time.

However, from a software design viewpoint it is difficult and time-consuming for small software companies to produce such flexible software, and so the current range of proprietary health and safety software cannot adapt to its changing environment unless it is modified by the original software company. Thus although in theory, if a client organisation wishes to change the way they perform a particular health and safety management task, they could ask the software company to tailor the program that they have purchased to match better their changed health and safety management needs, in practise this is unlikely to yield a result with most proprietary health and safety software companies since such product tailoring is beyond the scope of their resources. This leaves client organisations with two alternatives when their health and safety

[48] Quotation from original source.

management needs evolve: they can either continue using the proprietary health and safety software which no longer matches their needs, or they can cease to use this software and seek an alternative solution[49]. The point is that proprietary health and safety software puts its client organisations in a straight-jacket in terms of how they can perform health and safety management tasks. It prevents client organisations from having the power to adapt regularly their proactive health and safety management system to meet best the constantly changing needs of the environment.

If an organisation have purchased a piece of proprietary health and safety software which they fully evaluated to ensure that it was competent from a software design perspective, competent from a health and safety perspective, and matched their health and safety management needs at the time of purchase, they may expect that it to continue to match their needs for the next year or two. Some organisations may find that a piece of proprietary health and safety software will continue to match their health and safety management needs over a longer period. This instance may exist if a client organisation's health and safety management needs have not changed with time or if they have been fortunate enough to have purchased proprietary health and safety software which has been developed with time so as to continue to match their needs. I would suggest that these examples encompass the minority of client organisations of proprietary health and safety software, since the majority are likely to find that their health and safety management needs will constantly evolve with new health and safety legislation, new health and safety management theory and practise, new business and industry practise, new employees, new work tasks and new technology. If an organisation invests in proprietary health and safety software they are restraining their capacity to adapt to the changing environment that surrounds them; they are restraining their own creativity and ingenuity.

In general, proprietary health and safety software lacks the flexibility and versatility of proprietary office software. It normally consists of rigid data structures with set datafields and set datafield labels which the user has no means to modify in the slightest. The user typically cannot alter the arrangement of these datafields, cannot

[49] The problems that are associated with the latter option have been outlined earlier in this chapter.

rephrase the datafield labels, cannot include new organisation-specific datafields, cannot delete unwanted datafields, cannot change screen colours, cannot alter text font or size, cannot expand or reduce window sizes, cannot drag and drop items, cannot work in multiple windows at the same time, cannot format the presentation of reports and illustrations, cannot create toolbars, and cannot change icons. In other words, the user of proprietary health and safety software frequently cannot customise it in any way. Above all else it is this lack of flexibility with the software which constrains the user, and the client organisation, and offers them no feeling of control. The lack of flexibility means that proprietary health and safety software eliminates the possibility of client organisations changing their health and safety management system rapidly and regularly in response to the changing demands of their unique environment.

It is ironic that when deregulation was advocated for health and safety, the driving concept was to place the responsibility for health and safety management upon organisations and to remove the bonds that had restrained organisations from adapting freely to their evolving health and safety management needs. Health and safety legislation confined the manner in which organisations allocated health and safety resources and undertook health and safety management tasks. Organisations had to comply with the dictates of prescriptive health and safety legislation, and could rarely opt to venture outside those dictates, regardless of whether or not they best matched their health and safety management needs. It proved impossible for legislators to adapt prescriptive health and safety legislation fast enough to meet the changing demands of the environment since it would rapidly become out-of-date and obsolete. Now that the compulsory shackles of prescriptive health and safety legislation have been removed from organisations, many organisations have sought to place themselves captive to the equally inflexible dictates of proprietary health and safety software. Instead of looking to prescriptive health and safety legislation to explain how to manage health and safety, they are now looking to proprietary health and safety software for this type of detailed step-by-step guidance. This perhaps suggests that whilst deregulation is a significant advance for health and safety management, it has left a gulf in terms of the detailed guidance that many organisations feel that they need to move through this transitionary

period because they do not yet possess the necessary knowledge and skills to pursue confidently and competently proactive health and safety management for themselves.

3.6 Added Value

> *'What you are saying', said Black, 'is that the inadequacy of a robot must be made up for by the ingenuity and intelligence of a man ...'*
>
> *'... Exactly so young man, exactly so. Robots have no ingenuity. Their minds are finite and can be calculated to the last decimal.'*
>
> Isaac Asimov (1955) *Risk,* p151-153[50].

The next question to consider is to what extent proprietary health and safety software succeeds in catering for the health and safety novice who may look to the software for detailed guidance. In order for any computer software to work effectively within an organisation, it is necessary for the human users to *add value* to it. Computer software does not exist in isolation, it is only understandable and usable because of the framework of knowledge and the wealth of skills that the user brings to the system. Often the human knowledge and skills which have to be added to a piece of software in order for it to work are *culturally invisible*, to use a phrase coined by Schaffer (1996). Because the application of human knowledge and skills that is necessary for computer software to work is culturally invisible, it often means that competence, expertise and intelligence are attributed to the computer software itself, whilst the vital contributions of the human users is all but forgotten. Schaffer has observed that this phenomenon has occurred since the earliest days of human interaction with machines. Amongst a variety of fascinating examples, he cites the free trader William Cooke Taylor' description of a Manchester spinning mule in his industrial report *A Tour in the Manufacturing Districts of Lancashire* in 1842:

[50] Quotation from original source.

> *[It] recedes and then returns so gracefully that I was almost going to say the effect was picturesque. I can assure you that the brightness of the machinery, which looks like steel, and the regularity of its motions, produce a tout ensemble which has a novel and striking effect. It seems to me that machines can do everything but speak.*

The example illustrates the attribution of intelligence and expertise to the machine itself, and demonstrates the way in which machines are often viewed as complete and perfect in isolation from everything that surrounds them. It is easy to view modern computer technology and computer software in this manner. The workings of the computer and its software are increasingly hidden from the view of the user. The computer appears to be a magical, all powerful black box, into which data is entered and from which results emerge. Computers and computer software appear to be independent and meaningful in their own right.

Yet this is clearly not the case. Even the most advanced computer software can only offer a minimalist reduction of human knowledge and skills. Computer software typically takes one aspect of human knowledge or one human skill and attempts to reproduce it in a limited version inside a vacuum. The limitations of the computer software have to be countered by the ingenuity and flexibility of the human users. Computer software can only work if the users add computer competence to their interactions with it. Even the most impressive computer software is still a long way from being transparent and intuitive. A person with no computer experience could not easily understand and operate computer software. To utilise effectively computer software, the user has to bring to the software an understanding of the strengths and limitations of computers, a technical understanding of the software's operating system, the wile and wherewithal to recognise software and operator errors, and the ingenuity to correct these errors and overcome these limitations.

For as long as symbol processing computers are in operation, computer software is likely to remain rigid, inflexible and incapable of self-adaptation. Because of these inherent weaknesses, when an individual encounters errors whilst interacting with a piece of computer software, they have to learn how to correct them or how to avoid generating them in the future. If the individual fails to do so, the software will become

rapidly unusable. The intelligent, experienced software user learns how to react when a piece of software crashes so as to avoid data loss. They learn how to overcome the poor quality of printing that is available in one program by transferring data into a word-processing program or graphics program which is capable of high quality printing. They learn to refer to paper textbooks for explanations of the jargon and terminology that is used within a computer program. They learn what will make a particular computer program unstable and how to avoid it. They learn to apply general knowledge and common sense to the operation of a computer program. They learn when to seek help from colleagues in the workplace and from software support.

Proprietary health and safety software requires more from the user than many other types of commercial software, such as proprietary office software. In addition to requiring computer competence from the user, proprietary health and safety software requires the user to be able to add a wealth of health and safety knowledge to the software. The user has to have an understanding of health and safety management, health and safety terminology and jargon, and health and safety theory and practise. The proprietary health and safety software that was evaluated for this research was far from comprehensive and self-explanatory. This was the case even with those pieces of software which are intended primarily for the health and safety novice. The software does not start at square one with health and safety knowledge and skills, since it implicitly assumes that the user already possesses these missing dimensions to add to the software and make it whole. Although proprietary health and safety software often attempts to reduce health and safety management to a more widely consumable form, the programs are designed by computer experts and health and safety experts who take many understandings for granted. Unless the user already possesses the necessary knowledge and skills to be able to add to the software so as to make it work, they will encounter considerable difficulties.

A recent book called *Artificial Experts* by the sociologist Collins in 1990 (cited in Schaffer, 1996, p80) focuses upon the vast amount of collaborative work that is required from human beings to make the machines with which they interact appear to have expertise and intelligence. He has emphasised the point that humans need to add

value to machines, in the form of knowledge and skills, in order for them to work effectively, by providing the example of a calculator:

> *One of the reasons we tend to think a calculator can do arithmetic is the natural way we help it out and rectify its deficiencies without noticing. All the abilities that we bring to the calculation - everything that surrounds what the calculator does itself - are so widespread and familiar that they have disappeared for us.*

One of the great dangers of failing to recognise the extent of the value that users have to add to computer software in order for it to work, is that the human contribution may be undervalued whilst the computer contribution may be overvalued. Thus users may come to believe that the computer software is a comprehensive authority with regards to a particular skill or area of knowledge. They may come to feel that there can be no alternative way to perform a task, or that a task can no longer be accomplished without the use of specialist computer software. They may come to believe overwhelmingly in the competence and expertise of the computer software. They may come to over-depend upon the computer software for decision-making. They may come to believe that the computer software is far better than it actually is and may cease to see its limitations. They may come to believe that the computer software is always right.[51]

Another danger is that by underestimating the amount of added value that users have to bring to a piece of proprietary health and safety software, organisations may purchase such software only to find that their members do not have the prerequisites that are necessary for it to be used effectively. The many individuals who are novices in the field of health and safety management or who lack computer competence, may find that they do not have the knowledge or skills that they need in order to be able to add value to a piece of proprietary health and safety software and make it work effectively. At present the majority of the workforce in the United Kingdom have not received formal training in information technology, or in health and safety management. Although the numbers of trained workers in both fields are now increasing, it will take a considerable period of time before the changes become evident on a large-scale in the workplace.

[51] These issues are discussed further later in this chapter.

Organisations who believe that proprietary health and safety software offers a complete solution to proactive health and safety management tasks, may therefore invest in software which they find themselves unable to use properly. This is perhaps particularly likely with small to medium businesses who are looking for proprietary health and safety software to bring in their entirety the knowledge and skills that they need for proactive health and safety management. A question mark is thus raised as to the value of proprietary health and safety software for the health and safety novice. The commercial market for this type of software would appear to be confined to those who already have a practical understanding of computer software, and at least a broad knowledge of proactive health and safety management. Those who do not already possess these qualities, must first acquire them before they can utilise the software.

3.7 The Promotion or Demotion of Thought

> *Someone once asked Issac Newton how he managed to reach solutions to problems that others found impenetrable. He answered, "By thinking and thinking and thinking about it."*
>
> Isaac Asimov (1990) *Ideas*[52].

Since proprietary health and safety software offers a set route for performing health and safety management tasks, another question which arises is whether this type of software serves to promote or reduce the amount of thought that organisations devote to health and safety management. My initial view prior to undertaking the software evaluations which were discussed in Chapter 2, was that for people with little knowledge of health and safety management, computer software may offer a convenient medium for enlightenment. It is always difficult for individuals to attempt to learn new knowledge in an area for which they have no existing mental models. Given that this is the case, it could be argued that computer software may aid such individuals since it can provide strong visual representations of health and safety management tasks. As was discussed earlier in this chapter, in theory proprietary health and safety software could provide a working model of a risk assessment or auditing process, which could serve as a practical demonstration of what an organisation needs to do to manage proactively

[52] Quotation from original source.

health and safety. The potential value of such computer software for health and safety novices is increased because of the lack of health and safety texts which are reasonably priced, well written, up-to-date and easy to acquire. The latter frequently fail to offer a route into the area for the novice, and in many cases seem intent on catering for the expert alone.

Although in principle proprietary health and safety software could serve as a catalyst to initiate interest and promote thought in health and safety, on the whole this is not accomplished by the current range of software. One of the main problems with the prescriptive health and safety legislation that has been revoked in recent years was that it led organisations to grudging compliance without real interest or commitment in health and safety management (Booth, 1993c). The downfall of the prescriptive legislation was that organisations were not required to *think* about health and safety management for themselves, and to develop their own plans for how to manage best the risks that they faced in their unique environment. Organisations could simply follow what was written in the legislation without thought or effort. In this respect the current range of proprietary health and safety software is similar to the prescriptive health and safety legislation. It appears to offer a ready-made off-the-shelf solution that eliminates the need for organisations to think about health and safety management, and to plan, design and implement their own health and safety management systems.

The greatest benefit that the new non-prescriptive health and safety legislation, such as the *Management of Health and Safety at Work Regulations 1992*, confers is that it encourages people within organisations to think about and research health and safety management who would not have done so in the recent past. Encouraging people within organisations to think for themselves is surely the key aspect of the new legislation. Yet, as the changes in health and safety legislation have placed the burden of thought back onto organisations, many organisations have sought to dispatch the burden of thought onto small software companies who produce proprietary health and safety software. Thus it is the latter who are relied upon to undertake the difficult thinking and planning that is needed for proactive health and safety management, which used to be the province of prescriptive legislators, with organisations simply purchasing the finished

product. The benefits that could be accrued from encouraging organisations to think for themselves are thus lost when they choose to turn the burden of thought over to small software companies.

Whilst an off-the-shelf piece of proprietary health and safety software can provide a working model of a health and safety management task, it only provides a rigid, limited model of one way in which the task can be performed. The software that was evaluated for this research had a limited scope and constrained its users to thinking within that scope. If organisations invest in proprietary health and safety software they may assume that it offers a complete model of health and safety management and expect it to cover all of the points that they need to consider. The software that was evaluated for this research did nothing to discourage this view, and did not attempt to warn the user of its possible limitations, or to inform the user that they should think beyond its scope. The opposite was often true, with many of the programs providing statements which would seem to imply that they offer a complete solution for a health and safety management task by themselves. The following statements from the on-line help systems and product brochures of proprietary health and safety software emphasise the point.

- *Planning Supervisor is a complete system for the management of CDM.*

  Planning Supervisor by WMB Limited (WMB Limited, 1996)

- *CDM is serious news. Failure to comply could cost you a heavy fine or even put you behind bars. With CDM competence now a job requirement, at the very least it could cost you a tender. Now there is a system to keep you a step ahead.*

  Planning Supervisor by WMB Limited (WMB Limited, 1996)

- *Its a range of easy to use Microsoft Windows programs that produce all the paperwork you need to comply with the Construction (Design and Management) Regulations. They guide you through your duties and produce reports at the touch of a button.*

  Planning Supervisor by WMB Limited (WMB Limited, 1996)

- *It helps you stay within the law. It saves you time and money, letting you get on with the job. It helps you work more safely. And with safety competence now required as standard, it helps you win more work.*

  Planning Supervisor by WMB Limited (WMB Limited, 1996)

- *Health and safety lawbase is a unique management tool that allows you to carry out detailed health and safety assessments, and through a series of simple question and answer sequences leads you logically to compliance.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (on-line help system).

- *The interactive law library is a simple yet comprehensive guide to health and safety law, regulations and approved codes of practise.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (on-line help system).

- *The system contains a complete reference library of health and safety legislation.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (Gee Publishing Limited, 1996)

- *Everything you need to know is within the program. There's no need for you or any member of your staff to be absent from work on an expensive health and safety course.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (Gee Publishing Limited, 1996)

- *Now you have the power to comply with European health and safety legislation in a single morning.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (Gee Publishing Limited, 1996)

- *The unique new management tool that ensures total compliance at minimum cost.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (Gee Publishing Limited, 1996)

- *As a manager, the overall responsibility for the health and safety of your employees and visitors is yours. Using Health & Safety Lawbase you can be sure that you have complied with every element of the legislation - without any specialist expertise whatsoever. In as little as a morning, you'll be able to provide documentary proof of you're company's compliance.*

  Health and Safety Lawbase V 1.0 by Gee Publishing Limited (Gee Publishing Limited, 1996)

- *Safety Auditor is the complete auditing system. No separate modules or software are required.*

  Safety Auditor by ErgoSystems Limited (on-line help system).

- *Safety Auditor: The Ultimate Risk Assessment and Training Software Package. A One-Stop Solution to Health and Safety.*

  Safety Auditor by ErgoSystems Limited (ErgoSystems Limited, 1996a).

- *Safety Auditor 5.0 really is a one stop solution to health and safety. The easy to use program has all the tools necessary for auditing, training, and carrying out quantitative risk assessments.*

  Safety Auditor by ErgoSystems Limited (ErgoSystems Limited, 1996a).

- *Safety Auditor is the only health and safety software package you will ever need. Incredibly auditing, training, risk assessment and chemical and legislation databases are included in the one package covering all major European legislation and more.*

  Safety Auditor by ErgoSystems Limited (ErgoSystems Limited, 1996a).

- *ManHand is the complete risk assessment and training package which deals with the European Directive (90/269/EEC) on manual handling. The program also examines all areas where upper body trauma can occur in several different sections.*

  ManHand by ErgoSystems Limited (ErgoSystems Limited, 1996b).

- *ManHand is like having a full time consultant offering training, risk assessment, data collection, medical surveying and ergonomic work redesign on line.*

  ManHand by ErgoSystems Limited (ErgoSystems Limited, 1996b).

The great danger is that organisations which use proprietary health and safety software may be unlikely to think beyond the limiting boundaries that are imposed by the software for health and safety management tasks, and may therefore miss aspects that should be considered given their unique environment. Often the limitations that proprietary health and safety software imposes on thought can be seen vividly in the restricted manner that it attempts to undertake a health and safety management task. An example of this can be found in Safecode Limited's IRIS, where when the user

completes an incident record, they are asked to select a single checkbox to indicate the one underlying cause of the incident from a set list of ten broad items:

- Inadequate information
- Inadequate ongoing training
- Inadequate staffing
- Inadequate maintenance
- Inadequate plant/equipment
- Inadequate induction training
- Inadequate supervision
- Inadequate policy/procedure/work instruction
- Inadequate facilities/work environment
- Personal factors
- Other.

This set list approach is an inadequate way in which to attempt to tackle the complex issue of incident causation. The list encourages the user to take a simplified, naive approach to incident causation and to attempt to fit the incident into a pre-defined incident causation category. Thus every incident which occurs in an organisation that uses the software, no matter how minor or how severe its consequences, must have been caused by one of the 11 vague factors. The approach is fundamentally incorrect. Rather than encouraging a client organisation to take an incident and work backwards to identify its causal factors, the software asks the client organisation to take the incident and force it to fit into one of the set "underlying cause" categories. The problem of broad classification is exacerbated because the software fails to offer the user the flexibility to enter a different cause to those listed, and only allows the user to make brief explanatory comments regarding their response. Thus not only does the IRIS program narrowly confine the way in which the user can approach incident causation, but its lack of flexibility prevents the user from venturing outside its scope. IRIS serves to limit thought about incident causation rather than promote it.

Another example of how proprietary health and safety software can serve to limit rather than promote thought is when it offers one set health and safety policy template that organisations can use to produce their own quick and easy health and safety policy. This type of facility is becoming increasingly popular on the commercial software market with numerous programs existing which claim to help organisations to produce a range of fast, do-it-yourself specialist documentation. ErgoSystems Limited's Safety Auditor program features this type of facility to allow the client organisation to produce their own health and safety policy. The user simply has to proceed through five screens, filling small pieces of information into the blank datafields that are presented, to generate in a matter of minutes an eight page health and safety policy which looks impressive and would appear to suggest that they have devoted a significant amount of time and effort to its creation.

Whilst the idea of proprietary health and safety software attempting to help organisations to produce well presented health and safety policies has some value, the attempt to eliminate thought and individual variation from the task is worrying. If an organisation does not devote the time and effort, the thought, to developing their own health and safety policy, the document is likely to be poorly understood by their members and to receive little commitment. Once more it is surely the thought process which is involved in creating a health and safety policy which is the most important aspect. Is it not better for an organisation to develop their own health and safety policy, however basic, which their members fully understand and which is completely tailored to their organisation, than to purchase a ready-made, generic health and safety policy ?

3.8 The Right Type of Thought

> *Sir: In your otherwise beautiful poem "The Vision of Sin" there is a verse which reads - "Every moment dies a man, Every moment one is born." It must be manifest that if this were true, the population of the world would be at a standstill ... I would suggest that in the next edition of your poem you have it read - "Every moment dies a man, Every moment 1 1/16 is born". ... the actual figure is so long I cannot get it onto a line, but I believe the figure 1 1/16 will be sufficiently accurate for poetry. I am, Sir, yours, etc. Charles Babbage.*

A letter from Babbage to Tennyson 1851.[53]

Given that the current range of proprietary health and safety software is rigid and dictatorial, particularly in terms of how client organisations undertake health and safety management tasks, the question arises as to whether health and safety management can be adequately represented in computer software. In other words, does proprietary health and safety software promote the *right type of thought* with regards to health and safety management. I pose this question because health and safety is in many ways a unique field, which involves constantly searching for and identifying new problems, and applying lateral thinking, problem solving techniques, ingenuity, intuition and the skills and knowledge of many different fields to solve those problems. In many cases the problem identification and problem solving have to be accomplished on the spot. Hence it is perhaps likely that the constraints that proprietary health and safety software places upon health and safety management tasks, with its scientific, reductionist, computational approach may mean that some of the best aspects of health and safety management are limited or lost, because proprietary health and safety software is by its very nature oblivious to them and unable to cater for them.

In fairness, many health and safety texts in their attempts to describe the technical aspects of health and safety management, the legislative details, the mechanics, fail to communicate clearly the true essence of health and safety theory and proactive health and safety management tasks. In the wide variety of health and safety texts that have been published over the years, it is difficult to recall any describing hazard identification and risk assessment in terms of them being complex visualisation exercises which involve identifying potential problems and applying problem solving techniques to prevent those problems from materialising. Broader issues which have relevance for health and safety management, such as risk perception, attitudes to health and safety, communication and employee participation, have only recently sneaked into health and safety literature in the attractive guise of "safety culture". These are important and distinct aspects which should be considered in their own right, and should not have to be covered by a catch-all phrase, however popular it may have become.

[53] Quoted in Spufford and Uglow (1996) *Cultural Babbage: Technology, Time and Invention.*

3.9 The Illusion of Competence

> *Risks can be magnified because people take computers seriously. For many people information takes on an air of respectability if it comes from a computer. Computer-generated reports tend to be emphasised, often at the expense of other sources of knowledge. Executives use worksheets to make decisions involving hundreds of jobs and millions of dollars. Politicians decide the fate of military weapons and endangered species based on summaries of computer simulations. Doctors use computer models to make life-and-death decisions involving new drugs and treatments. All these people, in some sense, are placing their trust in computer simulations. Many of them trust the data precisely* ***because*** *it was generated by a computer.*
>
> George Beekman (1994) *Computer Currents: Navigating Tomorrow's Technology*[54].

Boden (1987) in the text *Artificial Intelligence and Natural Man* identified the *illusion of competence* as a particular problem that may plague the interaction between humans and computer systems. The core of the problem is that users are likely to assume that computer systems have more competence than is actually the case. Taking a futuristic view, she suggested that as expert systems are developed with natural-language processing front-ends, there will be an increasing danger that users will believe that the systems have more competence than they actually do, simply because they are interacting in the language of the user. With the relatively basic computer programs that were available at the time when the text was published, it is perhaps understandable that Boden saw the problem as one for the future when more sophisticated computer hardware and software had been developed.

However, with the massive leaps forward that were made during the Information Technology Revolution of the late 1980s and early 1990s, the majority of computer software is now highly sophisticated. Computer programs have impressive graphics, operate at vast speed, are large in size, offer the user an array of functions, provide multi-media sound and vision, are interactive, contain immense amounts of knowledge and information, produce numerous forms of output and offer a wide choice of communication methods. The future is already here and it has not taken the might of artificial intelligence to bring forth its arrival. A whole spectrum of computer software is now being produced to provide users with the knowledge, skills and tools that were

[54] Quotation from original source.

once the exclusive domain of the professional expert. This software rarely takes the form of artificial intelligence expert systems, but instead appears as multi-media software or specialist computer software that is commercially available and runs on standard operating systems such as MS-DOS and Microsoft Windows for IBM-compatible PCs.

Amongst this sophisticated specialist software is that made for the field of health and safety. Although health and safety software does not strictly make use of natural language processing front-ends, the majority of the interaction between the computer systems and the users is in the human language. With modern software, the technical computer code is buried beneath the visual imagery of the graphical user interface. The user operates the software by selecting commands from menus that are written in the human language, they receive information, feedback and guidance in the human language, they receive output from the software in the human language. Whilst the text is all pre-set and presented according to user selections, it appears on the surface to be responsive to the user, to be authoritative, to be competent. The days of command language interaction, of obscure command syntax and coded error messages, are long gone for most computer software. Computer users no longer have to possess expert technical knowledge and understand how the machines work, in order to use the latest software. They can view the computer as a black box that simply takes input and produces sophisticated output.

So, in analysing the proprietary health and safety software that is currently available on the commercial market, I felt that the illusion of competence was worth consideration. Proprietary health and safety software offers a range of knowledge and tools to the user, who may or may not be a computer expert or a health and safety expert. There is auditing software that can receive input from the user and produce an analysis of their organisation's health and safety compliance, and risk assessment software that can receive input from the user and inform them of the risk level and offer suggestions for appropriate control measures. There is also incident recording software that instructs the user how to record and analyse incident details, and legal compliance software that

guides the user through the legislation relevant to their organisation, helps to assess their organisation's level of compliance and makes recommendations for improvements.

Having evaluated seven pieces of proprietary health and safety software I feel that there is a very real danger of users succumbing to the illusion of competence. The software looks impressive, appears knowledgeable, comprehensive, and authoritative. Ideally, of course, this is exactly what we may wish health and safety software to be. But the inherent danger is that users will come to take the software as gospel, come to over-depend on it, assume that it is always correct and always knows best. This is particularly likely given that the users will probably view the software as having been carefully constructed by experts in information technology and health and safety management. Beekman (1994) has identified this problem as the *Illusion of Infallibility* and has strongly argued that it applies to all human interactions with computers. He has observed that while computer programs can be invaluable decision-making aids, the risk is that people who make decisions with computers will *"turn over too much of their decision-making power to the computer"*.

Allowing computer programs to guide decision-making is fine in principle, and is perhaps a very important service that they can perform for their human counterparts. But there are dangers. If the software contains programming errors it may produce incorrect output. If it contains errors in knowledge it may present poor advise and recommendations to the user. If it is based on poor foundations, it may teach the user to accomplish tasks in a poor manner. If the computer software with its inevitable limitations contains omissions in knowledge or fails to cover all of the factors that an organisation needs to consider in a particular area of health and safety management, the user may also come to omit these elements from the decision-making process. The user who relies too much upon the competence of the computer software, and who does not thoroughly evaluate the software's output before acting upon it, is in danger of making poor decisions. In the field of health and safety, such poor decisions could have very serious consequences.

The *illusion of competence* makes an interesting point of comparison between proprietary health and safety software and other commercial software. If proprietary office software is considered, users may assume the presence of software design competence in programs such as Microsoft Word and Microsoft Excel. They also may assume that the former program is competent in providing a range of word-processing tools to allow the user to produce complex documents. However, it is unlikely that users would assume that Microsoft Word has any expert writing competence in the tasks of actually writing documents. With proprietary health and safety software, not only is the user likely to assume the presence of software design competence, but they may also assume expert health and safety competence. This is because whilst Microsoft Word does not tell the user how to draft a letter, or write a thesis, or even string a sentence together, proprietary health and safety software does tell the user how to undertake audits, how to accomplish risk assessments, interpret legislation, record incident statistics, decide on risk control measures, create health and safety policies, and discern which information is important and which is not. Proprietary health and safety software does attempt to provide expert health and safety knowledge, whether it is represented explicitly or implicitly, whether is correct or not.

A further interesting comparison can be drawn between proprietary health and safety software and multi-media encyclopaedias. Multi-media encyclopaedias are designed to carry a wealth of expert knowledge about the world, and users would expect them to possess software design competence and to contain correct and accurate information. However, the knowledge that is contained in multi-media encyclopaedias is essentially static, in that the user can view it and listen to it, but it does not form a basis for undertaking practical tasks. This is in stark contrast to proprietary health and safety software, where the expert knowledge which it attempts to encapsulate is intended to be applied to practical health and safety management tasks.

The distinct nature of proprietary health and safety software makes the illusion of competence a very real and dangerous phenomenon. When a user operates this type of software, it is necessary to some extent for them to assume that the software is competent and contains expertise. When an organisation invests in proprietary health

and safety software, they are presumably relying upon the health and safety knowledge that the program is based upon to be correct. They are relying upon the means that it provides to accomplish health and safety management tasks to be suitable, reliable and valid. The inherent danger is that the user may view the software as having more competence, expertise and authority than is actually the case. This may be particularly likely with people who are not particularly knowledgeable about information technology or health and safety management.

Boden (1987) has suggested two counter-measures to the problem of assumed expertise. Firstly, people could be made aware of the limitations of computer software by playing with different pieces of software. One of the computer programs which can most emphasise the way in which users can be deceived by the apparent competence of a computer system is ELIZA (Weizenbaum, 1966). ELIZA is a rudimentary artificial intelligence program which passed the famous Turing Test for machine intelligence (Turing, 1950) despite being extremely limited. The program interacts with the user in what would seem to be natural language, simulating the role of a Rogerian counsellor[55]. The user is rapidly drawn to believe that they are holding a genuine conversation with a counsellor via the computer terminal. ELIZA was so convincing that users would discuss a wide range of personal problems with it, and would often ask Weizenbaum to leave the room so that they could continue their conversation in private (Covington, 1994). Further, many psychiatrists viewed ELIZA as a practical way to deliver counselling. Weizenbaum was horrified to realise the extent to which people were deceived by ELIZA and has since turned his attention to discussing the potential problems of a technological society[56].

If users were to interact with a program such as ELIZA and then be shown how the program works, it may make them aware that they should not attribute too much competence to computer software. Boden's second suggestion is that users could be

[55] See for example, Thorne (1990) for a comprehensive account of Rogerian or person-centred therapy.

[56] For a brief explanation of how the ELIZA program works via basic pattern-matching techniques and of how it fits into the context of using artificial intelligence to model natural language comprehension in humans, see Garnham (1988), Greene (1986), and Allen (1995). Greene (1986) is particularly useful as it has a chapter which summarises the main programs which have been developed within this context.

reminded of the knowledge that a particular piece of software is based upon, and of the software's limitations, by on-screen messages. For example, when a computer system makes a calculation or a conclusion, it could inform the user of the factors that it has not taken into account as well as those which it has. Whilst these are useful suggestions, unfortunately they are not likely to be willingly adopted by commercial software designers. As far as health and safety is concerned, the best solution to the problem of the illusion of competence is perhaps to ensure that enough accurate information is made available concerning the evaluation, selection, implementation and maintenance of computer software for health and safety management tasks. This information would need to be communicated in health and safety magazines and literature, and be incorporated into health and safety training courses. Although the best method of teaching others about the nature of proprietary health and safety software, about its good and bad points, and about its limitations and boundaries, is to have an individual with information technology expertise and health and safety expertise who is familiar with proprietary health and safety software, to demonstrate practically different pieces of this type of software.

3.10 System Failure

> *The highly publicised 1974 Club of Rome study summarised in the book "Limits of Growth" used the most powerful computers available at the time to model the environmental and economic impact of human activity on Earth. Months after the study was released, a researcher discovered a misplaced decimal point in one key equation that threw many calculations off by a factor of ten ! ... Bad input in a complex simulation can come from a number of sources, and "garbage in, garbage out" is a basic rule of simulation.*
>
> George Beekman (1994) *Computer Currents: Navigating Tomorrow's Technology*[57].

[57] Quotation from original source.

But remember, please, the Law by which we live,
We are not built to comprehend a lie,
We can neither love nor pity nor forgive.
If you make a slip in handling us you die !

Rudyard Kipling, *The Secret of the Machines*[58].

Whitby (1988) has observed that if an expert system fails, the failure may only be recognised by humans who are themselves expert in the same domain as the system. Whitby provides an example of a medical expert system that is designed to make diagnoses. If the system were to fail and make an incorrect diagnosis for any medical ailment that is not common, it is likely that while those with a high degree of relevant knowledge may detect the error, people without specialised medical knowledge may not be able to detect the fault. In other words, an incorrect conclusion from a sophisticated piece of software may not be obvious to users. This problem is not confined to expert systems. Whereas until recently most computer software failures resulted in systems blatantly crashing out, with the recent advances in information technology it is possible for systems to fail in more subtle manners. Rather than simply failing to operate, they may make incorrect calculations, present data incorrectly, or corrupt data.

The proprietary health and safety software that is currently available on the commercial market is intended for use by both experts in health and safety and non-experts, such as managers of small to medium businesses. If a piece of this software were to fail in this manner, the failure may not be recognised by non-expert users. Even expert users may not identify the failure if it is relatively subtle or if they are over-confident in the competence of the software. Such a failure may mean that the proprietary health and safety software would produce incorrect risk assessment calculations, or suggest the wrong control measure for a particular risk, or corrupt the data in old incident records or calculate audit scores incorrectly. Further, the non-expert user may fail to identify fundamental design flaws in a proprietary health and safety software system. They may not recognise if the health and safety knowledge in the software is faulty, or if the tools that it provides to accomplish health and safety management tasks are inadequate. With

[58] Quotation from original source.

proprietary health and safety software failures of any type are likely to have worse consequences than failures in other types of commercial software.

Whitby (1988) has commented upon the problem as follows in the context of expert systems:

> *In order to manage the use of expert systems safely, in application areas where there are serious risks, it is essential that the primary user be a human domain-expert who can recognise serious errors. The problems of successfully and safely introducing them into the workplace are substantially similar to those of employing human expertise.*

I would suggest that the introduction of health and safety software systems in an organisation should similarly be considered with the same gravity as the introduction of human expertise. The problem of only experts being likely to recognise errors in sophisticated knowledge-based systems, throws a question mark over the development of health and safety software to enable the non-expert to undertake expert tasks for themselves. If a piece of software is well-designed, has a suitable health and safety management basis, and conveys health and safety knowledge and tools accurately, it may be of some service. But if it is based on flawed or partial knowledge, contains incomplete or misapplied tools, or serves to misinform and confuse the user, the consequences could be considerable. Instead of disseminating correct health and safety knowledge and tools, the software could instead pollute the knowledge and tools which it attempts to communicate. The thin line which exists between the dissemination and the pollution of knowledge has been addressed fittingly by Locke (1690), as the following quotations demonstrate:

> *For he that shall well consider the errors and obscurity, the mistakes and confusion, that is spread in the world by an ill use of words, will find some reason to doubt, whether language, as it has been employed, has contributed more to the improvement or hindrance of knowledge amongst mankind.*
>
> John Locke (1690) *An Essay on Human Understanding*, Book III, Chapter XI, 4[59].

[59] Quotation from original source.

For language being the great conduit, whereby men convey their discoveries, reasonings, and knowledge, from one to another, he that makes an ill use of it, though he does not corrupt the fountains of knowledge, which are in things themselves; yet he does, as much as in him lies, break or stop the pipes, whereby it is distributed to the public use and advantage of mankind. He that uses words without any clear and steady meaning, what does he but lead himself and others into errors ?

John Locke (1690) *An Essay on Human Understanding*, Book III, Chapter XI, 5[60].

Despite this software companies that produce inadequate health and safety software will often attempt to fall back upon the classic defence - the legal disclaimer that places all responsibility firmly upon the organisation that purchased the software and none upon the organisation that designed and produced it.

3.11 Legal Disclaimers

There is no other product that is commonly sold with such disclaimers as: 'The program is supplied "as is". Neither (name of software house) nor (name of distributor) make any warranty of any kind, either expressed or implied, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose. The entire risk as to the quality and performance of the program is with you. Should the program prove defective, you and not (software house or distributor) assume the entire cost of all necessary servicing, repair or correction. Neither (software house) nor (distributor) warrant that the functions contained in the program will meet your requirements or that the operation of the program will be uninterrupted or error free.' It is quite inconceivable that other products could be sold by respectable commercial organisations with such disclaimers.

Blay Whitby (1988) *Artificial Intelligence: A Handbook of Professionalism*[61].

If one behaves like a professional, one must expect not only a professional's rewards, but also a professional's risks - even if 'one' is hidden behind a computer.

Campbell, J. A. (1984) *The Expert Computer and Professional Negligence: Who is Liable?*[62].

[60] Quotation from original source.

[61] Quotation from original source.

[62] Quotation from original source.

The use of legal disclaimers has become commonplace in the computer software industry in an attempt to protect the software companies from any negative consequences which may arise as a result of organisations using their products. Unfortunately, software companies frequently employ dubious means to present legal disclaimers to the software users. They may, for instance, provide a legal disclaimer in the form of a small printed paragraph on the back of an envelope which contains their software disks, or in the form of a long statement that flashes past the user in the space of a few seconds on their program's title screen. The software disclaimer normally includes a line to the effect that if an organisation uses the software, they will be deemed to have accepted a legal agreement which states that the software company has no legal responsibility for any losses which arise as a result of the organisation using the software. Legal disclaimers can be found in proprietary health and safety software as readily as in other types of commercial software.

Amongst the seven proprietary health and safety programs that were evaluated for this research, two featured legal disclaimers. These programs are WMB Limited's Planning Supervisor and ErgoSystems Limited's Safety Auditor. Both present a legal disclaimer on the program title screen which alleges that use of the software will be interpreted as an acceptance of a legal agreement that the software company has no responsibility any losses which arise as a result of the organisation using the software. The exact wording of the legal disclaimers is as follows for WMB Limited's Planning Supervisor:

> *This product has been developed by Weston Martin Bragg Ltd in association with Lewis and Hickey. While both parties have taken all reasonable steps to ensure the accuracy of this product and the information contained therein, no responsibility for losses arising from its use, whether direct or consequential, is accepted. Use of the software shall be deemed to indicate the acceptance of the above.*

and Ergosystems Limited's Safety Auditor:

> *This product has been developed by ErgoSystems Ltd with support throughout the industry. ErgoSystems Ltd has taken all reasonable steps to ensure the accuracy of this product and the information contained therein. No responsibility for losses arising from its use, whether direct or consequential, is accepted. Use of the software shall be deemed to indicate acceptance of the above.*

From one perspective, it is understandable that when the software industry was in its infancy it pursued the idea of disclaiming responsibility for the failures of its own products because of the fear that immense litigation would otherwise follow. It is not possible to design perfect computer software, where every conceivable error in programming code or software design is eradicated before the product is released on the commercial market. It would take too long, cost too much, and delay the release of computer software products for so long that they may be out-of-date by the time they reach the consumer. Given that there will always be inherent failings in computer software, it is understandable that software companies wish to protect themselves. Many software companies would cease operation if they were held legally and financially responsible every time there was a malfunction in a computer program that they had designed. With such a high level of financial risk, without some form of legal protection, software companies may move out of the software market entirely, or at least out of its high risk areas. They may also hesitate over the development of new software products, particularly for challenging areas such as health and safety management.

Despite these conditions I would seriously question the extent to which software companies can completely exclude themselves from legal responsibility for their products. Does it mean that software companies can produce any software, no matter how poor in quality, no matter how factually incorrect, no matter how ill-conceived, no matter how error strewn, and be able to release it on the commercial market without fear of retribution ? I feel that this is incorrect, and that software companies should be legally obligated to produce software which is fit for its purpose; just as they would have to ensure that any other consumer product is fit for its purpose. Software companies should not automatically be immune to product liability laws. In the 1990s, when thousands of pieces of computer software are purchased daily, it should not simply be a case of "let the buyer beware" - particularly when by the very nature of computer software, problems and faults may not emerge or be recognised for months or even years.

Proprietary health and safety software differs from other commercial software in that its purpose concerns the well-being of employees in the workplace rather than the production of written documents, or the calculation of financial accounts, or record-keeping for product stock. Whilst software failures or incompetencies in other types of commercial software may very well lead to considerable confusion and even substantial financial loss for client organisations, there is no aspect of business which deals with the currency of human life as health and safety does. Failures or incompetencies in proprietary health and safety software may lead to injury or loss of life. They may even produce latent failures that could lie dormant within an organisation for several years before they are triggered, just as with any other failures or incompetencies in health and safety management or expertise. For example, proprietary health and safety software could inform the user that risk is suitably controlled for an operation when it is not, or incorrectly inform them that everything is in order as far as the results of a health and safety audit are concerned.

I personally do not think that proprietary health and safety software companies can be allowed to discharge entirely their responsibilities via a dubiously presented legal disclaimer. Nor do I think it appropriate for proprietary health and safety software companies to attempt to force client organisations to accept legal disclaimers by virtue of whether or not they access a piece of software, open an envelope, or press a button on a program title screen. A satisfactory solution needs to be developed within the field of health and safety for the problem of allocating responsibility for failures in health and safety software. With increasing use of computer software for health and safety management, it can surely only be a matter of time before a notable incident arises. It would be better to consider the legal implications of the use of information technology in health and safety management in advance of such an incident.

Chapter 4: Purchasing Health and Safety Software

> *As organisations grow increasingly dependent on computer application systems, the ability of the end-users of these systems to use them effectively becomes critical, in some cases to successful functioning of the whole organisation. If end-users find that the system actually interferes with, rather than enhances, their work, and if it causes them undue stress and frustration, then they may find it inefficient to use, and may actually cease to use it altogether.*
>
> Ravden and Johnson (1989) *Evaluating Usability of Human-Computer Interfaces: A Practical Method* [63].

In this chapter, I will apply the knowledge that has been discovered during the software evaluations and their analysis, to tackle the specific issue of organisations purchasing health and safety software. Every year, a large number of organisations consider whether to invest in health and safety software to help them to undertake proactive health and safety management tasks. As was explained in Chapter 1, health and safety software has been widely available from the 1980s, but it is only since the emergence of proactive health and safety management and the advent of the Information Technology Revolution that it has seemed to offer organisations a genuine panacea to the complex problems of health and safety management. Nevertheless, as the discussion of the software evaluations in Chapter 2 highlighted, there are many deficits in the pieces of proprietary health and safety software that are available on the commercial market, and these deficits can often be difficult to identify. On the surface the latest proprietary health and safety software can *appear* to be very impressive, with an attractive graphical user interface, an extensive array of functions, the ability to store and analyse a large quantity of data, and extensive reference information. This can make it easy to believe that this type of computer software is a vital health and safety management tool which no organisation can afford to be without.

Because there has been little research conducted in health and safety concerning the application of information technology to the field, there is sparse information available for organisations to draw upon to inform their decision-making process regarding the

[63] Quotation from original source.

purchase of health and safety software. Whilst there are occasional articles in health and safety magazines concerning the application of information technology in health and safety management, such as "*Getting to Grips with IT*" (Pantry, 1997), "*CD-ROM Review*" (Lilley, 1997), "*Assessing Risks in the Workplace*" (Leathley, 1997), "*Around the Internet*" (Pancucci, 1996), and "*Opening the Door on OSH Websites*" (Pancucci, 1997), organisations are left largely in the dark as to how they should approach the tasks of evaluating, selecting, implementing, and maintaining health and safety software systems. It would be easy in such circumstances for them to make poor purchase decisions which may prove costly from a financial, organisational, and health and safety viewpoint.

The importance of selecting the correct software should not be under-estimated as many studies within the field of human-computer interaction have demonstrated the high failure rates and difficulties which are associated with the purchase and implementation of new computer systems. Eason (1988), for example, found that just 20% of new computer systems which are implemented in organisations are successful in achieving their intended benefits, whilst 40% have only marginal success, and 40% are failures or are rejected. Bjorn-Anderson has produced several key articles examining the organisational impact of new computer systems (e.g. Bjorn-Anderson 1984, 1985, 1986a, 1986b), covering issues such as their effect on the quality of working life, their ideal characteristics based upon democratic and humanitarian values, their impact on tasks and job satisfaction, their impact on employee control and discretion of task performance, how they can change power and influence within an organisation, and how they can be implemented in a manner which avoids any negative effects. Shneiderman (1987, 1992) has also contributed significantly to this area, identifying a variety of serious problems which can be caused when a new computer system is implemented within an organisation, including personal anxiety, organisational fragility, invasion of privacy, and unemployment amongst others.

Hence, in this chapter, I intend to discuss how organisations can approach the tasks of health and safety software evaluation, selection, implementation and maintenance, and to highlight the main points that they should consider during the purchase

decision-making process. The discussion is based upon the ideas that I have developed throughout the research, and attempts to cover new ground, rather than merely re-iterating the findings of the human-computer interaction experts. The focus of the discussion is thus very much at the decision-making level, with attention devoted to the issues which are particularly salient within the context of purchasing health and safety computer software. I would refer the reader to Bjorn-Anderson (1984, 1985, 1986a, 1986b), Booth (1989), Eason (1988), Helander (1988), and Shneiderman (1987, 1992) for further information specifically concerning the organisational issues that are associated with software implementation which have been identified within the field of human-computer interaction.

4.1 Health and Safety Resource Allocation Process

The crucial point that an organisation has to address when considering the purchase of health and safety software is whether they have genuine health and safety management needs which can best be met by this particular solution. This is true for all health and safety software, not just the proprietary variety. As was discussed in Chapter 1, proactive health and safety management involves the continuous assessment of health and safety management needs within an organisation. This assessment essentially involves examining the current status of health and safety management within the organisation (with input from reactive monitoring, active monitoring, auditing and risk assessment), identifying health and safety management needs, prioritising these needs, identifying possible solutions to them, and evaluating the solutions to determine which are the best to employ. The purchase of health and safety software should be subject to this process, just like the purchase of any other piece of health and safety equipment.

Figure 4.1 shows an overview of a Resource Allocation Process model which I have designed to aid organisations when they are deciding whether to invest in computer software solutions to health and safety management problems. The process is somewhat similar to the review process in the HS(G)65 proactive health and safety management model (see Chapter 1), but is more stream-lined and is intended to operate at a broader, and higher, level. The aim is to demonstrate how the purchase of health and safety software fits in with the process of health and safety management, and how this in turn

fits in with the process of business management. In theory the method could be applied to any high-level investment, such as a new communications system within an organisation, a new fork-lift truck, or the development of new health and safety procedures.

At the highest level the model illustrates the process which organisations follow for the majority of the time when they make investment decisions. Thus they examine the current state of the organisation, identify organisational needs, and prioritise those needs. They then identify possible solutions to their needs, and evaluate the solutions using several criteria such as the level of business risk which the investment represents, its cost-effectiveness, implementation and maintenance factors, and possible side effects. The best solutions are then selected, implemented, maintained, and subjected to a regular review.

At an intermediate level, the model illustrates the process which organisations **should** follow for health and safety investment decisions. Because health and safety management is an integral part of business management, in theory health and safety investment decisions should also progress through the resource allocation process. Unfortunately, in practise, only a fraction of health and safety investment decisions are treated in this way. Figure 4.2 shows the model adapted specifically for health and safety resource allocation. Note that the only difference between this model and Figure 4.1 is the health and safety management context.

At a more specific level, the models in Figure 4.1 and Figure 4.2 illustrate the process which organisations **should** follow for health and safety software investment decisions. Unfortunately in practise, this process is followed even more rarely with health and safety software than for other items of health and safety investment. Nevertheless, to ensure that only sound investments are made in health and safety software, organisations should adhere to these resource allocation processes. In the context of health and safety software, the stages of Figure 4.2 should be understood as follows.

Figure 4.1: Resource Allocation Process

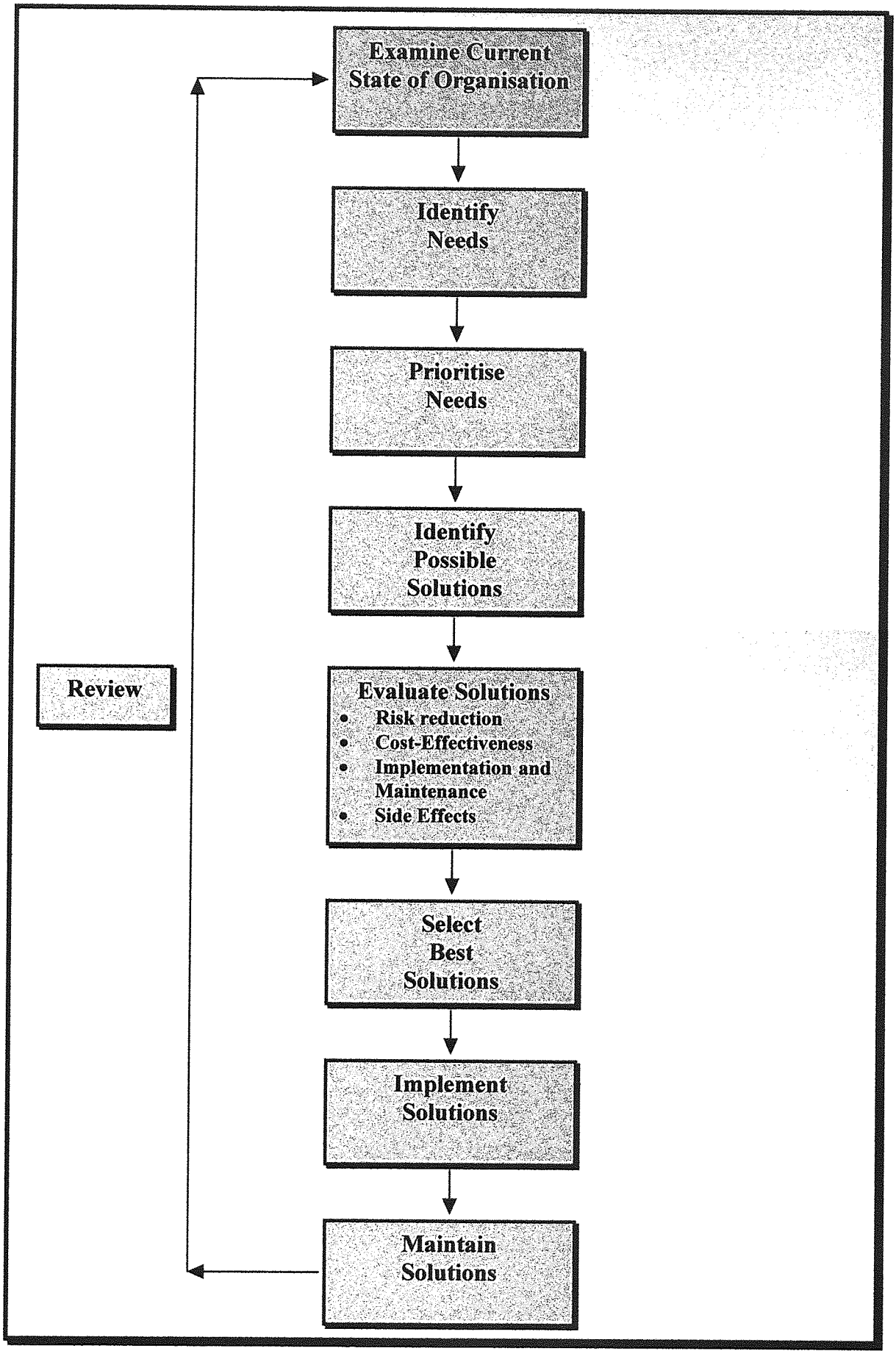
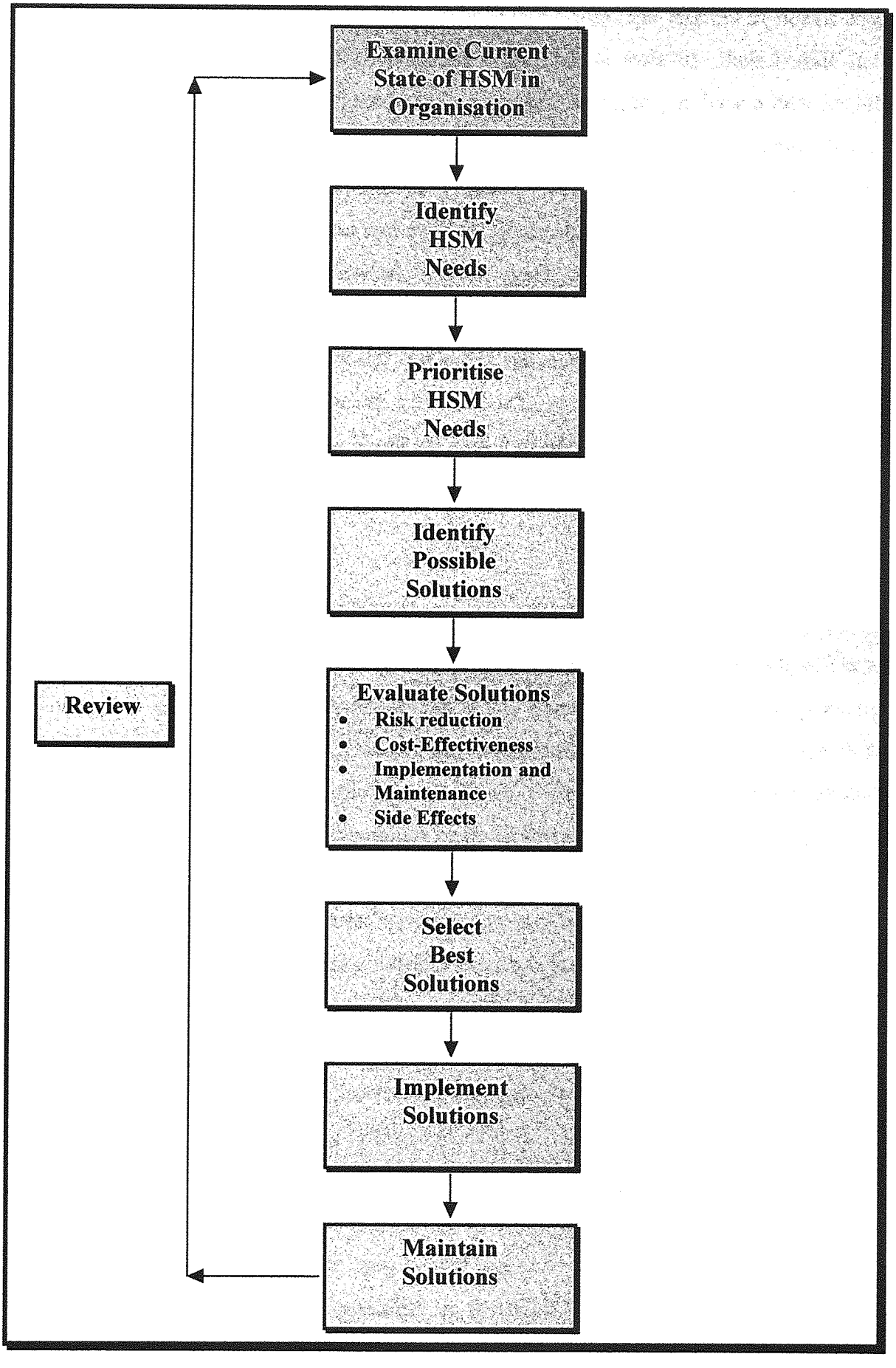


Figure 4.2: Health and Safety Resource Allocation Process



4.1.1 Examine Current State of HSM in Organisation

The first stage of the process is for the organisation to use the interest in health and safety software as an opportunity to examine the current state of their health and safetymanagement. Put simply, there is little point in rushing to purchase a new health and safety computer system without first examining what is in place. To accomplish this task, the organisation should look at their existing systems for reactive monitoring, active monitoring, risk assessment and auditing. They should consider how the systems are designed, operated and maintained, and the extent to which they are implemented properly and are effective. They should examine the information that these systems provide to consider the state of health and safety management as a whole. They should refer to external information sources such as health and safety legislation, guidelines and standards during this stage to check the extent to which they are meeting their legal obligations.

4.1.2 Identify HSM Needs

In this stage of the process, the organisation should attempt to identify their health and safety management needs, based on the analysis undertaken in the previous stage. They should try to identify **all** of their health and safety management needs at this point in time. This stage is essential because organisations are often too quick to decide that health and safety software offers the best solution to their health and safety management needs, and to move directly to selecting a piece of software for purchase, without ever having evaluated those needs in depth. It is all too easy for an organisation to believe that they need a new incident recording computer program, for example, and to act on this belief, without first considering whether there are perhaps more pressing health and safety needs to address.

Organisations should use their interest in computer software for health and safety management as an opportunity to examine all of their health and safety needs, however major or minor. Only by taking this broader view can the purchase of health and safety software be put into perspective. This stage of the process may lead to needs being identified which are more urgent than a new computer software system, such as the need to replace old machinery guarding, or the need to install a new local exhaust

ventilation system. It may also lead to needs being identified which will have to be addressed before a new computer system can be installed, such as the need for improved IT facilities for health and safety managers, the need to appoint a new member of health and safety staff, and the need for IT training amongst employees.

It is crucial that organisations consider the purchase of health and safety software with the same depth that they would consider any other health and safety management decision. For health and safety software to be of value, it needs to match the client organisation's health and safety management needs. A piece of health and safety software can be competent from a software design viewpoint and a health and safety viewpoint, but this is irrelevant if it does not match the organisation's health and safety management needs. If an organisation attempts to purchase a piece of health and safety software without first determining those needs, it is likely to be a case of hit or miss as to whether the software is suitable for them. Instead of starting with the assumption that health and safety software automatically offers the best solution, organisations need to follow the more logical route of first identifying their health and safety management needs, then prioritising these needs, and then searching for possible solutions.

4.1.3 Prioritise HSM Needs

In this stage of the process, the organisation should attempt to prioritise the health and safety management needs that they have identified. At a simple level, needs could each be assigned a priority rating from 1 (most important) to 5 (least important). Each health and safety need should be considered carefully before a priority rating is assigned. With some health and safety management needs it may be easy to assign a priority rating, based for example, on the level of risk that is posed by a piece of machinery which needs new guarding. With other health and safety management needs, it may be more difficult to allocate a priority rating. For example, many higher level needs, such as the need for a new incident recording system, may have numerous diffuse effects within the organisation. A new incident recording system may not directly lead to the reduction of the level of risk associated with a particular machine, but may improve the overall level of health and safety management, thus leading to marginal reductions in risk throughout the workplace.

By the end of this stage, the organisation should have a better idea of where the need for a new health and safety management system stands compared to other health and safety needs. It may prove to be the most urgent need, or a reasonably urgent need, in which case the organisation should progress to the next stage in the process. However, if it proves to be a low priority need, the organisation may be wise to delay investment until the more urgent needs have been addressed.

4.1.4 Identify Possible Solutions

Once the organisation has prioritised their health and safety management needs, they should identify possible solutions to the high priority needs. These solutions should be many and varied, including, for examples, solutions based around: information technology, management systems, organisational structure, machinery and work equipment, procedures, safety culture, quality, training and monitoring. At this stage of the resource allocation process, solutions should only be identified at a broad level. Thus if an organisation considers a health and safety management software solution to a health and safety management need, the solution should be listed as "health and safety software". The consideration of what type of software would be best and whether this offers the best solution will be considered in the next stage. This stage should essentially be a brain-storming effort, no solutions should be ruled out.

4.1.5 Evaluate Solutions

Once the organisation has identified possible solutions to their health and safety management needs, they should evaluate these solutions. This will involve considering in much greater depth the solutions which have been proposed, and applying formal evaluation methods where appropriate. Clearly, the latter should be selected specifically according to the particular health and safety management need which is being addressed and the individual solution that has been proposed. The way in which organisations should evaluate health and safety software solutions in particular will be discussed in the next section of this chapter. The topic requires greater attention than can be devoted during this overview of the health and safety resource allocation process.

Regardless of the particular evaluation methods that are employed for each health and safety management solution, there are four basic criteria which need to be applied to all solutions. These can either be incorporated into the evaluation method which is utilised, or left to be examined as extra points of consideration. The first criteria is the extent to which the solution will reduce risk within the workplace. As was discussed under prioritise needs, it needs to be born in mind that sometimes a solution may lead to a direct and obvious reduction in risk, as in the case of new machinery guarding, but on many occasions, such as with the development of a new health and safety induction training course, a solution may lead to a slight reduction of risk in several areas. The majority of health and safety software systems are likely to fall into the latter category rather than the former. The second criteria is the cost-effectiveness of the solution. A particular solution may be ideal but if it has an extremely high cost it may prove to not be the best investment. It may be possible for the organisation to implement two other solutions for the same cost which will lead to a greater overall improvement in health and safety. For example, purchasing an impressive new computer program for health and safety training may not be the most cost-effective solution to the organisation's health and safety training needs.

The third criteria is implementation and maintenance. Organisations need to consider in detail how they are going to implement and maintain the proposed solution. It may be that other items need to be purchased in order for the solution to be implemented. For example, a health and safety computer program for auditing may necessitate several employees undergoing training to use the new system. It may be that the organisation cannot implement a particular solution for several weeks or months, perhaps because of the finances involved. Maintenance issues focus on the long-term implications of the solution. Who will be responsible for the solution, what future investment will be required to keep effective the solution, what about repairs and maintenance. With health and safety computer software, unfortunately the implementation and maintenance issues are often over-looked, which can result in serious problems down the line. The fourth criteria is the possible side effects of the new solution. These can be both good side effects, such as improved employee morale, improved safety culture, improved

communications, and bad side effects, such as employee anxieties, new hazards, and hindrances to work.

4.1.6 Select Best Solutions

Once the health and safety solutions have been evaluated, it is time for the organisation to advance to selecting the best solutions. Ideally, the evaluation process will have enabled the organisation to rate the various solutions proposed. Some solutions may have been judged to not be feasible, given their cost perhaps, or implementation and maintenance difficulties. Other solutions may have been judged as being able to offer little improvement to the current state of health and safety management. It may be that one solution will answer the organisation's health and safety management needs, or that several solutions need to be employed.

4.1.7 Implement Solutions

When the best solutions to the organisation's health and safety management needs have been selected, the organisation should seek to implement these solutions. The considerations that were made regarding implementation during the evaluation stage can be applied at this point. Solutions should be implemented by individuals with suitable and sufficient training. The implementation process should be supervised and checked on completion. The organisation's active monitoring system may need to be extended to cover monitoring the effectiveness of the new solutions. In the case of health and safety software solutions, the individuals who undertake these tasks should ideally have competence in information technology and health and safety. If there are few employees who meet this criteria, the organisation may need to fund training in these areas. A piece of health and safety management software can be a useful tool only if it is implemented, used and maintained properly.

4.1.8 Maintain Solutions

The next stage of the health and safety management resource allocation process refers to the need to maintain the solutions for their lifetime of use. The considerations that were made regarding maintenance during the evaluation stage can be applied at this point. Individuals with suitable and sufficient training should be responsible for maintaining

the health and safety management solutions. In the case of health and safety software, these individuals should ideally have competence in information technology and health and safety. If there are few employees who meet this criteria, the organisation may need to fund training in these areas for the reason stated above.

4.1.9 Review

The final stage of the health and safety management resource allocation stage is the review. This involves the organisation regularly examining the solutions that they have implemented to check on their effectiveness, and the extent to which they are aiding health and safety management. Since health and safety management is a continuous process, the review stage leads back into examining the current state of health and safety management, to identify the next needs to address. As an example, with health and safety software solutions, the review stage may bring to light any problems that have arisen with utilising the software, and this insight can be used to inform the next examination of the current state of health and safety management.

4.2 Evaluating Health and Safety Software Solutions

The health and safety management resource allocation process provided an overview which can be followed to ensure that health and safety software is only purchased when it constitutes a sound investment decision. At the evaluation stage of the overview, it was explained that the evaluation methods employed need to be appropriate for the particular health and safety management solution. Now it will be considered in greater detail how health and safety software solutions can be evaluated.

There are a number of factors that the organisation needs to consider when they are evaluating health and safety software solutions. One of the health and safety management resource allocation process criteria which is of particular importance when evaluating health and safety software is cost-effectiveness. The organisation needs to consider carefully whether health and safety software offers the best investment for their precious health and safety management resources. As was mentioned in Chapter 1, health and safety computer programs vary greatly in price, ranging from perhaps just over a hundred pounds for the simplest program to over ten thousand pounds for

complex software suites. Further, as was discussed in Chapter 2 and will be expanded upon later in this chapter, when an organisation considers the costs that will be involved if the invest in a piece of health and safety software, they need to take into account a host of indirect costs as well as the initial purchase cost. The latter costs are likely to push the overall investment cost higher than the organisation may have anticipated.

For small to medium organisations, any piece of health and safety software is likely to constitute an expensive purchase; whereas for larger organisations, health and safety software may be viewed as requiring a smaller percentage of overall funds. Nevertheless, regardless of the size of the organisation, every purchase that an organisation makes has associated opportunity costs. These are the alternatives that have to be forgone in order to make the investment. If an organisation invests in health and safety software, it is at the expense of making other investments in health and safety management. In terms of the health and safety management resource allocation process these "other investments" can be clearly seen as other solutions to health and safety management needs. The opportunity costs may be highest for small to medium businesses, since if they choose to invest in health and safety software it may constitute the lions share of their annual health and safety resources, whereas a larger organisation may be able to purchase such a system and still make other substantial investments in health and safety management. The crucial question for any organisation to consider is whether health and safety software offers the best allocation of precious health and safety resources. A high technology health and safety management computer system may be a good purchase for some organisations, but there will be many organisations who would do better to address more glaring, and perhaps more basic, health and safety needs.

Figure 4.3 shows a health and safety software evaluation process which organisations can apply as a tool to help them to systematically consider health and safety software as a solution to their health and safety management needs. The chart caters for all types of health and safety management software, and provides guidance on the evaluation process for proprietary software, tailored software, custom-made software and in-house software. What follows is a description of how organisations should work though this

Figure 4.3: Health and Safety Software Evaluation Process

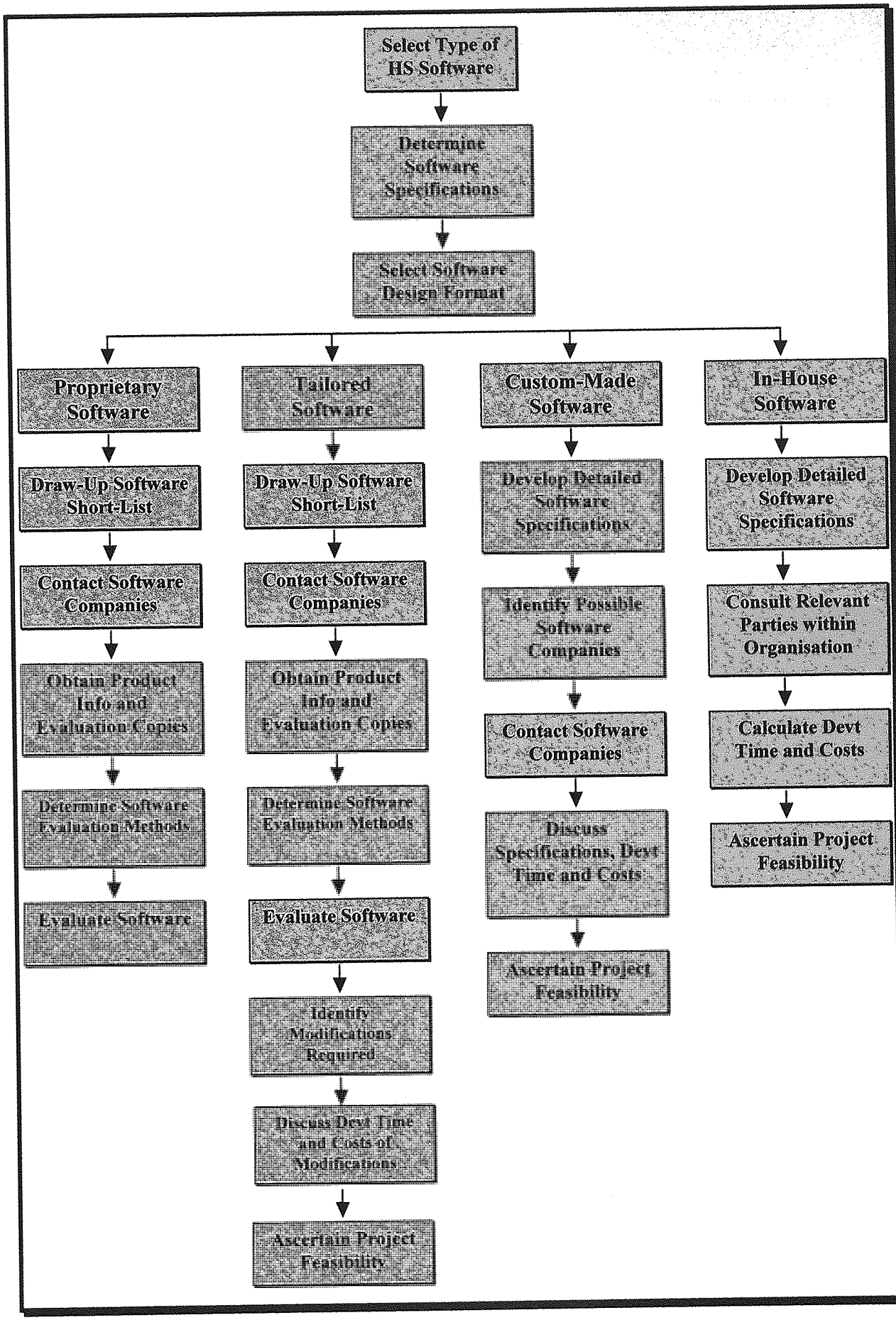


chart in order to evaluate health and safety software solutions.

4.2.1 Select Type of Health and Safety Software

The first task that the organisation needs to undertake is to select the type of health and safety software that they require. They need to decide whether they require health and safety software to perform certain proactive health and safety management tasks, such as reactive monitoring or auditing (task-specific); or to aid compliance with a particular piece of health and safety legislation (legislation-specific); or to meet the health and safety management needs of a particular industry (industry-specific). The organisation may seek legislation-specific software if they feel that complying with a particular piece of legislation will require extensive record-keeping and analysis on their part. An example of this could be a paint-spraying company who wish to have software for the *Control of Substances Hazardous to Health Regulations (COSHH) 1994*, or a construction company who wish to have software for the *Construction (Design and Management) Regulations (CDM) 1994*. The organisation may seek industry-specific software if they believe that their industry has specific needs which are both important and different from those of other industries. An example of this could be a medical establishment which requires health and safety software that can cater for the need to distinguish between clinical and non-clinical risks. Obviously, cross-over software may also be required, such as incident recording software for the railway industry.

4.2.2 Determine Software Specifications

The second task that the organisation needs to undertake is to determine the basic specifications that they require for the health and safety software. Essentially they need to identify the tasks that they would like the software to be able to accomplish, and how they would like it to accomplish them. At this stage the organisation should think in terms of what would be the ideal software. As an example, if an organisation requires a piece of health and safety software for reactive monitoring, amongst other things they should consider: how they want the system to define key terms such as "incident"; how they want it to approach the tasks of incident reporting, recording and analysis; what data they want to be able to collect and store within the system, and in what format and with what level of detail; what types of output they want to be able to produce from the

system; what type of security system they require to limit access to the software; how flexible and adaptable they want the software to be; what features the software will need in order to be compatible with their existing health and safety management systems; and with what office software they want it to be compatible.

For many organisations this may sound complex, perhaps particularly so for small to medium organisations who are unlikely to have health and safety specialists in their midst. However, the initial thought that the organisation devotes to developing software specifications is invaluable. It is only from this type of thought that the organisation can develop a good understanding of the health and safety management software that they require. Ironically, as was discussed in Chapter 3, one of the appealing aspects of health and safety software is that it offers to remove this thought process from organisations. The software can appear to offer organisations a ready-made health and safety management system where all of the creative thought process has been undertaken for them by the software company. If organisations view health and safety software in this manner, they are likely to encounter numerous difficulties.

If organisations do not know what they require from a health and safety software system, then it suggests that this type of software is not the best solution to their health and safety management needs. As this thesis has demonstrated, it is not easy to learn about proactive health and safety management from health and safety software, nor is it advisable to select a piece of health and safety software without thorough consideration and evaluation. Organisations who find themselves unable to determine the specifications that they require for health and safety software would perhaps gain more by investing their resources in sending their members on a reputable health and safety management course, or by hiring a reputable consultant to examine their health and safety management needs. Within any field, individuals always have to start by gaining a solid understanding of the basics before progressing from these foundations.

4.2.3 Select Software Design Format

The third stage requires the organisation to identify the software design format that they believe will best meet their health and safety management needs and their budget. I

have divided health and safety software into four broad categories of software design format. These are: proprietary software, tailored software, custom-made software and in-house software. Proprietary health and safety software has been the primary focus of this research project, and is usually designed so as to be generalised enough to suit the health and safety management needs of a large number of organisations. Tailored software may be proprietary software or software which has been designed for a particular company, which the software company are willing to modify for an additional cost so as to match better the organisation's health and safety management needs. Custom-made software is designed by a software company to match specifically the organisation's health and safety management needs. Finally, in-house software is designed by the organisation themselves to match their own needs. As one progresses through Figure 4.3 from left to right, the software design methods offer greater flexibility and organisational control.

4.2.4 Proprietary Software

If the organisation decides that proprietary health and safety software offers the best route forward, they should proceed through the following stages. They should begin by drawing-up a short-list of programs that may match the software specifications that they developed earlier. There are several sources of information which can be used to inform the creation of this list. These include advertisements and reviews in health and safety magazines; advertisements and reviews in industry magazines; and recommendations from other organisations, industrial bodies, professional societies, and personal contacts. Ideally a short-list of about six programs should be produced, as this provides a realistic number to evaluate. By evaluating several programs the organisation will be better able to make comparisons and contrasts, and thus better able to evaluate the quality of each program and judge how well they match their health and safety management needs. The organisation should try to stay open-minded throughout the evaluation process, even if they feel drawn particularly to one product or another. It is vital that all of the programs under consideration are evaluated from an even starting position.

Next the organisation should contact the relevant software companies to request product information and evaluation copies of the software. The latter may take the form of trial software or demonstration software. A personal presentation may also be available. Demonstration and trial versions of health and safety software normally consist of the full version of the software, with perhaps a few features disabled such as the "save" function[64]. Demonstration and trial software provides organisations with a good opportunity to evaluate the software in terms of its software design competence, health and safety competence, and the extent to which it matches the software specifications that they have developed based on their health and safety management needs. It needs to be born in mind though that the majority of health and safety software will look impressive on initial glance. Unfortunately, it is extremely easy to be impressed with health and safety software if demonstration or trial versions are only examined in a superficial manner. Thus it is essential that organisations use the evaluation opportunity in a constructive way so that they can gain a good understanding of the health and safety software that they are considering, which will enable them to make a more fully informed investment decision. Conversely, if they fail to do this it is easy to succumb to the trap of undertaking a superficial, incomplete evaluation of the software, which will result in shallow conclusions being made based upon the findings that the software *looks* good, it *appears* to accomplish the desired health and safety management tasks, and *seems* suitable.

Many software companies will offer to provide a personal presentation of their software for interested organisations. This provides the software company with the opportunity to present their software in its best light, and to attempt to influence positively the organisation's first impressions of their product. Whilst personal presentations can be a useful means of acquiring information about health and safety software, organisations should always remember that they are essentially a highly professional sales routine. Organisations should be careful to ensure that they are not too easily impressed by

[64] Demonstration and trial software are often very similar. Technically, the former term is often used to refer to software which may be the full version of the program with limited functions disabled or a smaller version of the program, with a larger number of functions disabled or only a fraction of the knowledge base provided, whilst the latter is often used to refer to software which is the full version of the program which will operate for a limited period of time only, for example 30 days, at the end of which it ceases to operate unless the organisation agree to pay the purchase fee.

personal presentations, as there can be a vast difference between the way that a piece of software looks during a presentation and its true quality. Understandably, the software company will attempt to highlight the strong points of their product whilst ignoring or playing down any weaknesses. They are also likely to emphasise the way in which they continuously develop their software, the number of other organisations who are already successfully using their software, the high quality of their software support services, and the way in which the software has been developed with the participation of health and safety experts. These points can seem impressive to the inexperienced, but they are merely part of the standard sales routine of software companies.

The value of the personal presentation is decreased significantly if the software company are unwilling to leave a demonstration or trial version of their software for the organisation to evaluate in detail. Organisations should never purchase health and safety software on the basis of a personal presentation alone. As with demonstration and trial software, it is too easy to jump to superficial conclusions regarding the quality of a piece of health and safety software, particularly since the majority of these programs will look good on initial viewing with their impressive graphics and stylised graphical user interfaces. Personal presentations can also be deceptive with regards to how easy a piece of health and safety software is to learn and use. It is essential to remember that with a personal presentation the software is being presented by a person who is highly skilled in the use of information technology, and who is completely familiar with the software. Therefore, most software presentations will run smoothly and the software will appear to be very easy to learn and use. However, a large difference will exist between the highly skilled manner in which the representative of the software company is able to use the software, and the way in which the average employee of a client organisation will be able to use it.

Similarly, during a personal presentation, health and safety software is likely to appear to be very comprehensive and competent, because the presenter will probably advance through the various screens and functions in a well-rehearsed routine. Organisations should note that there is a great difference between providing a presentation for a piece of health and safety software, and actually using it in the workplace to undertake health

and safety management tasks. With a personal presentation, health and safety software is being examined outside the work context. Any piece of software can appear to be impressive in an isolated demonstration, but the real test is the extent to which it can perform the tasks that the organisation requires in the way that they require under normal work conditions.

The evaluation of each piece of software starts at this point of initial contact. It is essential for the evaluations to be comprehensive, covering not only the software design competence and health and safety competence of the software, but also the quality of service that the software companies provide. This is because, as was discussed in Chapter 3, if an organisation purchases a piece of health and safety software, they will be entering into a relationship with the software company. There are a large number of factors which can be examined to judge each software company's quality of service, including: how long it takes to contact the software company by telephone; how easy it is to access relevant personnel; the level of software design and health and safety knowledge held by the software company's personnel; their helpfulness and informativeness; the speed with which they dispatch an evaluation copy of their software or arrange a personal presentation; the quality of packaging with any posted materials; and the quality of content and presentation with any written materials.

The next stage is to determine software evaluation methods. The organisation needs to consider how they will evaluate the six pieces of software in a manner which is systematic, comprehensive, consistent and fair. They will need to decide who is to undertake the evaluations, ideally a person or persons with knowledge of computer software and health and safety is required. They will need to decide how the pieces of software will be evaluated, whether it is in terms of giving ratings out of 5 to broad categories such as "software presentation", "software design competence", and "health and safety competence" allowing a simple quantitative total out of 15 to be produced for each program, or a checklist of the specifications that the organisation requires which is to be ticked off for each piece of software, or a more in depth form of analysis. The organisation will need to create evaluation forms where notes can be made during the evaluations to be kept as a permanent record. A more advanced generic health and

safety software evaluation method will be discussed later in the chapter. When the software evaluation methods have been determined, the organisation needs to progress to evaluate the software. It is suggested that the evaluators spend some time familiarising themselves with each piece of software before they commence the official evaluations. If any difficult questions arise during the software evaluations, the evaluators should contact the software company concerned to obtain the information that they need.

One difficulty that organisations often encounter when attempting to evaluate health and safety software is future product developments which are promised by the associated software company. The future developments may be discussed in the product literature or their may be mock-up demonstrations of them on the evaluation software. Such developments may include more sophisticated features for the software, long-term product development plans, designs for other health and safety programs to build up a software suite, and designs for an integrated health and safety management software system. It needs to be emphasised strongly that whilst it is good to find a software company who are committed to the future development of their products, very little weight should be placed upon future developments during the software evaluation. Essentially, the software company is not legally bound to ever provide these developments. They may or may not provide them at any future date depending upon their financial situation, the health and safety software market, their company direction, and their desire to continue with the product, amongst other factors. Most health and safety software companies will talk of future developments, maybe even providing very real timeframes for their appearance, such as "by the end of the year" or "early next year". However, an organisation can only evaluate a piece of health and safety software according to what is in place at the time, since that is the product which they would receive and have to work with if they made the investment. As Samuel Johnson so aptly stated, "*Promise, large promise, is the soul of an advertisement*" (Johnson, 1759)[65].

[65] Quoted by Partington, A. (ed) (1996) in *The Oxford Concise Dictionary of Quotations*.

4.2.5 Tailored Software

If the organisation decides that tailored health and safety software offers the best route forward, they should proceed through the first stages in Figure 4.3 in the same way that was described above. The only difference is that the software short-list should be compiled featuring software from companies who are willing to tailor their software. Once the six pieces of software have been evaluated, the organisation should identify what modifications they would require to each piece if it was to meet their specifications. They should consider what modifications they would ideally like to be made to the software. They should then hold discussions with the software companies concerned to ascertain the development time and costs for the desired modifications. Finally, they should ascertain the feasibility of tailoring the different pieces of software to match their specifications. It may be that some of the programs are ruled out because it would take too long to make the desired modifications, or because those modifications are not possible, or because they would cost too much.

4.2.6 Custom-Made Software

If the organisation decides that custom-made health and safety software offers the best route forward, they should proceed through the following stages. They should re-examine the software specifications that they had earlier created, and attempt to add greater detail to them if possible. They should then identify reputable software companies who will develop custom-made health and safety software. They should contact these companies and discuss the software specifications, development time and costs. Finally, for each software company they should ascertain the project feasibility. In other words, can the required software be produced by the software company within an acceptable time frame and for acceptable costs ?

4.2.7 In-House Software

If the organisation decides that in-house health and safety software offers the best route forward, they should proceed through the following stages. They should re-examine the software specifications that they had earlier created, and attempt to add greater detail to them if possible. They should consult with the relevant parties within the organisation to

discuss the software specifications, the development time and costs. Finally, they should ascertain the project feasibility.

4.3 Health and Safety Software Investment Traps

Finally, one crucial point that organisations should consider when they are deciding whether to invest in health and safety software, is *why* they are interested in software as a solution for health and safety management. This will require some honest analysis by those faced with making the investment decision, but it is important with any decision-making process that the individuals involved are clear as to why they are seeking a particular solution. Such analysis should allow organisations to make a more informed decision regarding the purchase of health and safety software. To help organisations with this analysis, I have identified a number of health and safety software investment traps that organisations may fall into at this stage which could bias the decision-making process and lead to a decision being made which has shallow foundations.

4.3.1 The Quick Fix Solution

> *The computer has long been a solution looking for problems - the ultimate technological fix which insulates us from having to look at problems.*
>
> Professor J. Weizenbaum (1983) *The New York Review of Books*, October 22[66].
>
> *The HSE have criticised computer systems as they have found that people were buying systems as a stock answer to COSHH.*
>
> Dr P. Lewis (1993, p124) *Health Protection from Chemicals in the Workplace*[67].

As was discussed in Chapter 1, the recent changes in health and safety legislation in the United Kingdom have led to new requirements being placed upon employers to undertake proactive health and safety management tasks such as risk assessment and training. For many organisations this will inevitably appear to be difficult and daunting, particularly if they feel that they do not yet possess the knowledge and skills to be able

[66] Quoted by Gill, K. S. (1984) in Crisis and Creation - Computers and the Human Future, in Yazdani, M. and Narayanan, A. (eds) (1984) *Artificial Intelligence - Human Effects*.

[67] Quotation from original source.

to undertake correctly proactive health and safety management. It is perhaps understandable that this may lead many organisations to look for easy, ready-made solutions to proactive health and safety management tasks. In the era of the Information Technology Revolution, computer software may seem the obvious source for quick fix solutions to proactive health and safety management.

If organisations are unsure how to undertake proactive health and safety management tasks such as risk assessment, reactive monitoring and auditing they may look to health and safety software to provide reliable working models from which they can learn. This may be particularly so given the short-comings that exist in the provision of practically-based, well-written, readily understandable guidance on proactive health and safety management. *"We'll get some software"* sounds like an intelligent, modern business decision: it sounds easy, it sounds quick, it sounds impressive. Yet as this research has demonstrated, this view is deceptive, since health and safety software is not a quick and easy solution which can just be plugged straight into an organisation, and it is not possible to take quick shortcuts to effective proactive health and safety management.

4.3.2 Technology for the Sake of Technology

> *Technology's gone robot happy. Any job has to have a robot, or the engineer in charge feels cheated. You want a doorstop; buy a robot with a thick foot.*
>
> Isaac Asimov (1955) *Risk*[68].

In Chapter 1, it was explained how the 1990s has seen the Information Technology Revolution sweep through the United Kingdom. Whereas in the 1970s and 1980s there was perhaps still a strong fear of information technology amongst the general public, now it has become commonplace, and is often viewed as being good, as being necessary, and as offering the only way to move forward. There is almost an unspoken view that all information technology is good information technology. Whatever the problem, whatever the field, it is often believed that information technology can help in some way. It can accomplish tasks quicker, more accurately, better. Many organisations want to invest in information technology, either to be at the cutting-edge of business, or

[68] Quotation from original source.

merely to attempt to keep up with rivals. When an organisation needs a new work or management system, the obvious action to take would seem to be to seek information technology solutions. I have termed this health and safety software investment trap "*technology for the sake of technology*". It represents the possibility that organisations will seek to purchase health and safety software simply because they want to invest in the latest information technology, regardless of whether or not this offers the best solution to their health and safety management needs.

4.3.3 Jumping on the Bandwagon

Another investment trap that organisations may succumb to is to seek to purchase health and safety software just because other organisations already have similar software installed. It may be that rival organisations, contacts within a particular industry or within the locality, or other branches or departments within an organisation claim to be using effectively the latest health and safety software. A common remark is likely to be that "*well, [company name] have got [health and safety program] and say that it's good*". Whilst information from these sources can be useful when deciding whether to invest in health and safety software, organisations must be careful not to give it too much weight.

It should be noted that a personal recommendation by a respected source is a very effective sales tool (see for example, Schiffman and Kanuk, 1991). Although such recommendations for health and safety software may well prove to be of value, it is essential that the organisation evaluates them in depth. There may be significant differences between the organisation and others who use a particular piece of health and safety software, for examples, the: type of organisation; size of organisation; types of work undertaken; types of hazard and levels of risk in the workplace; existing health and safety systems; level of health and safety expertise; level of computer competence; health and safety needs; health and safety budget; and organisation finances. The organisation has to consider what is best for themselves; this may not be what was best for another organisation no matter how similar they appear to be. The organisation needs to follow the health and safety resource allocation process to determine whether they should invest in health and safety software.

If they decide that they do need health and safety software, personal recommendations may well be of use in identifying or evaluating particular pieces of software. However, the organisation still needs to consider the following points: when the other organisations acquired the software (if it was 6 months to a year ago new products may have emerged on the market which are more suitable or are better); how the other organisation decided to buy the piece of software (did they systematically and open-mindedly evaluate a range of potential software, and invite the opinions of those who would use the software ?); and the qualifications of those who decided to invest in the software (are they informed with regards to both health and safety and computer software ?). The organisation may not know the answers to these questions, but thinking them through should help to determine the weight that such recommendations can be given. A common view is that "*the software must be alright if all of these other organisations are using it*". This is not necessarily true, as the other organisations may: not have noticed the software's limitations; have compared it to very poor software; not use it often; not like to admit that they have experienced any problems in using the software; or believe that any problems in operation are down to human error rather than poor software design.

4.3.4 Jumping a Step or Two

This health and safety software investment trap concerns organisations who want to jump straight to a high technology computerised health and safety management system from either a very poor existing health and safety management system or no existing health and safety management system. This can result in a number of problems, since the organisation may not have enough knowledge and experience to implement and operate such a system. It is surely better for organisations to progress gradually through more complex health and safety management systems, step by step, rather than to attempt to take a leap to a far advanced level. The step by step development of health and safety management systems can help to ensure that they are developed to match the organisations health and safety management needs, that any problems are identified and dealt with along the way, that the organisation learns gradually about how they can best manage health and safety, and that their health and safety management systems are only developed to the level of complexity that the organisation needs.

4.3.5 Out With the Old, In With the New

> *It may reasonably be argued that anything a manager wants to achieve in office information handling ... may now be achieved with computer support. Whether that support is the most cost-effective way of achieving corporate objectives, or if there may be better options than computerising a system which has already demonstrated its inability to cope, is a matter for another discipline ... which sadly seems to have disappeared ... in many recent waves of organisational cost-cutting.*
>
> Alan Paterson (1985, p9) *Office Systems: Planning, Procurement and Implementation*[69].

Some organisations may seek to invest in health and safety software because their existing health and safety management systems are not very effective, and they believe that a change to new computerised systems will resolve the problem. I have termed this health and safety software investment trap *"out with the old, in with the new"*. The danger is that many of the problems that surrounded the previous system and rendered it ineffective, may be transferred to the new information technology system and render it just as ineffective. Such transferable problems may include poor implementation, complacency, a poor safety culture, poor risk perception, a blame culture, inadequate training, poor communication, and a lack of employee participation in health and safety. To avoid this trap, the organisation needs to progress through the health and safety management resource allocation process (see Figure 4.2). This will help them to first diagnose what was wrong with the old health and safety management system, before they advance to identifying possible solutions.

4.3.6 Shifting Responsibility

Organisations may seek to invest in health and safety software, because they feel that it is a way to delegate some of their responsibility for health and safety management. They may feel that by buying ready-made health and safety software the responsibility for designing effective health and safety management systems and keeping them up-to-date has been taken out of their hands, and given instead to software designers. The organisation may seek to have an instant source of blame if there are any failures in their health and safety management: *"Well, I went along with this system ... I trusted the*

[69] Quotation from original source.

software company". From a legal viewpoint this stance is not correct. It is *always* the employers responsibility to ensure that health and safety is managed effectively in their organisation. Investing in health and safety software does not dispose of this responsibility elsewhere. Moreover, as was discussed in Chapter 3, the majority of software companies include legal disclaimers in their products which deny that they hold any legal responsibility regarding the design and operation of the software, and any negative consequences that may result from its use.

4.3.7 Rapid Decision

Another health and safety software investment trap occurs when organisations attempt to make a rapid decision regarding the purchase of health and safety software. They may believe that it is a decision that can be made within a couple of weeks, and which requires less thought and evaluation than other business decisions. They may feel that a rapid decision can be taken because the basic cost of a particular piece of software is inexpensive relative to their health and safety budget, and they feel that they can easily back out if the software proves unsuitable in practise. They may feel that they do not know how to evaluate the different pieces of software that are available and that it is simply a case of picking one from the range available, since all health and safety software must be good or it wouldn't survive on the market.

As was demonstrated earlier in this chapter, an investment in a health and safety software system needs to be thoroughly thought through. It should be thought of no differently than any other business investment, and the organisation should progress through the health and safety resource allocation process to determine whether or not to make the investment. A rapid decision will make it a case of hit or miss as to whether the software matches the organisation's health and safety management needs, is properly implemented and used effectively.

4.3.8 Reactive Response

> *During the last thirty years, the rate of change has become so great as to induce a kind of social vertigo. There seems no way in which we can plan any longer, for plans become outdated as fast as they are implemented. By the time we recognise a problem, action must be taken at once; and by the time we take action, it is too late; the problem has changed its nature and gotten away from us.*
>
> Isaac Asimov (1981) *The Influence of Science Fiction*[70].

As with any other health and safety measure, it is possible for an organisation to consider installing a high-technology piece of health and safety software in response to a recent accident or incident. The organisation may feel that this will appear to be an impressive response to the incident, that it will demonstrate a large investment in health and safety, that it is necessary to have specialist computer software to help to prevent a recurrence of the incident. As with other measures that are selected reactively, the organisation may find that they have not invested funds in the most effective way, they may find that they have invested in software that is too advanced for their needs, they may find that the software does not fit in with their existing health and safety management systems, and they may find that the software introduces new confusions and conflicts into the workplace.

4.3.9 Mind Set

> *We have a problem. We think of a solution. We are then so busy congratulating ourselves that we fail to see that there may be a better solution, that some evidence points the other way, or that our solution has unwanted side-effects. This is known as a "mind-set" or, if you prefer a more technical term, Einstellung.*
>
> Kletz, T. (1991, p65*) An Engineer's View of Human Error (2nd Ed.)*[71].

The individuals in an organisation who decide upon the purchase of health and safety software may make a poor decision because they develop a strict mind set early on in the process. They may rapidly decide that health and safety software is the correct solution for their problems, and be so convinced by this solution that they can no longer

[70] Quotation from original source.

[71] Quotation from original source.

see other possibilities. Alternatively, they may rapidly decide that a certain piece of health and safety software is the only solution, and may not wish to consider alternative computer-based or paper-based systems. Mind-set can render any evaluation processes superficial and ineffective. The individuals involved in the decision-making process may seek out information which supports the view that they already hold whilst dismissing contradictory evidence.

4.3.10 Groupthink

> *[Groupthink is] a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members strivings for unanimity override their motivation to realistically appraise alternative course of action.*
>
> Irving Janis (1972) *Victims of Groupthink*[72].

Groupthink is a psychological phenomenon, first identified by Janis (1972), whereby a decision-making group develop a way of thinking which blinkers the decision-making process and prevents them from making a properly evaluated decision. Very often the decision which is made turns out to be poor if not a serious error. Janis identified a variety of situations where serious errors in decision-making were made because of the groupthink phenomenon, including many government disasters such as the Bay of Pigs in Cuba and the escalation of the Vietnam war. At its simplest level, groupthink is the tendency for a group to seek concurrence. It can apply to all levels of decision-making, including decision-making within business, hence its relevance here.

Janis (1972) has identified five conditions which are likely to promote the occurrence of groupthink. They are when a decision-making group are highly cohesive, when they are making a decision in isolation from the judgement of qualified outsiders, when there is a lack of methodical search and appraisal procedures, when there is directive leadership, and when there is pressure to reach a decision and little belief that a better solution can be found than that which has been recommended by the group leader. According to Janis (1972), groupthink can result in defective decision-making where there is an incomplete survey of objectives, an incomplete survey of alternative solutions, a failure

[72] Quoted by Deaux, K. and Wrightsman, L. S. (1988) *Social Psychology (6th Ed).*

to examine the risks of the preferred choice, poor information search, selective bias in processing information, failure to reappraise alternatives and failure to work out contingency plans.

With the decision to purchase health and safety software, as with many other business decisions, it is possible for the decision-making group to strive for concurrence at the expense of a systematic, balanced decision-making process. In this context, it may be particularly likely for the group leader to bias the whole decision-making process by making their personal opinion known at an early stage. If the leader strongly advocates, either explicitly or implicitly, that they believe that specialist health and safety computer software should be purchased as a solution to the organisation's health and safety management needs, or that the organisation should invest in a particular piece of health and safety software, then this is likely to influence the thinking of everybody else who is involved in the decision-making process. The group leader can easily bias the decision-making process, including any software evaluations which are conducted, since others with input into the process may feel inclined to seek unanimity with the leader and avoid contradicting their stated opinion. In this case, the findings of any software evaluations that are undertaken may be inclined to veer towards the decision that the leader has already expressed.

Ideally, the decision-making process should be open-minded. Information should be actively sought out, considered and evaluated. Positive and negative opinions should be encouraged and thoroughly examined. The leader within the organisation should avoid making their personal opinion known until an appropriate stage in the decision-making process, when everyone involved freely expresses their personal view. Finally, it should be remembered that it is better to take the time to reach a sound decision regarding the purchase of health and safety software, than to be pressured into making a uninformed decision that may prove very costly to the organisation in the long-term.

4.3.11 Soft Option

Organisations may believe that choosing to invest in health and safety software is a soft option. They may believe that all they have to do is make a decision to purchase a piece

of software for a particular health and safety management task, act upon the decision, have the software installed, and then the software, and the health and safety management system, will take care of themselves. In other words, they may believe that purchasing health and safety software takes the majority of effort out of their hands, because all of the difficulties involved in designing a health and safety management system are taken on by the software company. This is an incorrect view which confuses health and safety management software with a health and safety management system.

Whilst the software company may be able to install the software and provide basic training in its use, the software itself is only one element of a health and safety management system. It will be up to the organisation to consider the long-term operation of the new health and safety management system which is to be based upon the software. It will be the organisation's responsibility to implement the health and safety management system, which may include tasks such as deciding how to maintain the software, determining how it is to be used to the greatest benefit, determining who is to use it, when it is to be used, and how it is to be kept secure, deciding how much resources are to be devoted to the system as a whole, identifying what procedures and documentation are needed for the system's implementation, and what else is needed for it to be effective. It will also be the organisation's task to integrate the new health and safety management system with their existing health and safety management systems.

4.3.12 Cheap Option

> *A number of indirect costs will be associated with the installation and running of any new system. Some of these will be apparent well in advance of implementation, others will be less predictable and the degree to which they occur or not will be very organisation-specific.*
>
> Alan Paterson (1985) *Office Systems: Planning, Procurement and Implementation*[73].

Organisations may believe that investing in health and safety software is a cheap option. They may think that for one basic cost they will be able to buy and implement a whole health and safety system. This cost may on the surface appear cheaper than that associated with designing their own computer-based or paper-based health and safety

[73] Quotation from original source.

system. Organisations are likely to look at the standard cost for the software and ignore the wealth of hidden costs that come with the software. Table 4.1 demonstrates some of the hidden costs that are connected to investing in a health and safety software system. They are both wide-ranging and extensive. The total cost of the investment is likely to prove to be greater than was initially anticipated. Health and safety software appears as a false economy in much the same way as personal protective equipment. Else (1981) in an excellent chapter upon the latter subject, explains how a measure such as personal protective equipment can appear to be a cheap option, but only because most of the costs are hidden rather than direct, and that in fact, contrary to general belief, it is an expensive option. It can be argued that the same is true for health and safety software.

4.3.13 Newest is Best

Another health and safety software investment trap that organisations may fall into is believing that they should get the newest software that is available because it is bound to be the best. This is not necessarily the case. As with all types of computer software, the latest products tend to vary widely in their quality. It is perfectly possible for a new piece of software on the commercial market to be inferior to one which was launched a year earlier. As an example, at the time of writing, the majority of organisations in the United Kingdom use Microsoft Word for word-processing, which is updated approximately every two years. In between the updates for Microsoft Word, numerous rival word-processing programs appear on the commercial market, but most organisations would agree that, in this instance, the existing Microsoft product is better than the new software. The same principle applies to health and safety software: the latest product may prove to be the best investment, but then again it may not. Organisations need to evaluate thoroughly any piece of health and safety software to determine whether it is of high quality and whether it matches their health and safety management needs. Only if both of these criteria are met should they proceed with the purchase.

Table 4.1: The Direct and Hidden Costs of Health and Safety Software

Direct Costs	Hidden Costs

• Initial software purchase cost
• Annual license fee
• Network license fee
• Installation fee
• Software manuals
• Registration for software support services
• Preliminary training from software company
	• Future product updates
	• Communication with software support services
	• Training the software users in:
	  • Computer skills
	  • Health and safety management
	  • The new HSM system
	• High quality, up-to-date anti-virus software
	• Prerequisite computer hardware upgrades
	• Prerequisite computer software upgrades
	• Maintenance of computer facilities
	• Printing on-line documentation and forms
	• Filing completed forms and print-outs
	• Media for backing-up system data
	• Storage of long-term back-up media
	• System administration and maintenance
	• System security
	• Integration with existing HSM systems
	• Support structures for the new HSM system
	• Data entry and analysis
	• Opportunity costs

4.3.14 Bigger is Better

Organisations may believe that the best pieces of health and safety software are those which appear to be the most comprehensive, feature the most functions, and be capable of accomplishing the most health and safety management tasks. Hence, they may believe that they should look for the largest piece of health and safety software that is available. This however is not necessarily correct. Organisations should consider their own health and safety management needs and evaluate health and safety software not only in terms of its software design competence and health and safety competence, but also in terms of whether it can match those needs. A large piece of health and safety software may include many functions that an organisation does not need or will not use; its functions may not have been designed to a consistent quality; it may require users to possess a high degree of computer competence; it may require users to possess a high degree of health and safety competence; it may take a long time for employees to learn how to use; it may appear daunting and off-putting to users; it may require high levels of maintenance and administration; and it may be capable of providing more information than their organisation could possibly use.

Organisations should always consider whether they truly need the health and safety software that they are considering, or whether they would be better with a smaller but high quality piece of software instead. As an example of the fallacy that bigger is better, one organisation purchased a large-scale £9000 *Microsoft DOS*-based piece of health and safety software in 1996, of which they were proud to announce that they had purchased every single part. When asked in 1997 about how useful they had found the software, they responded that it was very good, though they had only ever used one small part (Personal Communication with Jonathan Trimby, July 1997).

4.3.15 Fear of Getting Behind

Organisations may wish to invest in health and safety software because they fear that they will get left behind in the information technology revolution. In the last thirty years, the information technology industry has forged ahead with the production of new technologies and products at such a rate that within a short period of time organisations can feel that they have drifted so far behind that they are in danger of never being able

to catch up. This statement applies to the health and safety software market as much as to any other commercial software market. Thus organisations may feel that if they do not invest in health and safety software now, they will fall far behind and find it difficult to keep up with health and safety management. They may feel that they need to enter the health and safety software market before the software develops to such a degree of sophistication that it will be baffling to the uninitiated. Needless to say, the fear of getting behind is not in itself a valid reason for investing precious health and safety resources in a health and safety computer software.

It is important to bear in mind that the computer industry attempt to manipulate deliberately the market in this way so that products have a very short lifespan and everybody feels that they are in a race just to keep up. As numerous versions of computer programs come and go on the commercial market in a short space of time, it is easy for organisations to suddenly feel that they have fallen way behind: "*Safety Program Version 5 - I haven't even got Version 1 !!!*". Organisations should not let computer companies dictate when they should buy computer software and what types of software it should be. They should not be influenced by the rate of change, since it is pointless to attempt to keep up with each new development. Organisations should always remember that they can choose to purchase computer software at any time, when it best suits their own unique position, there is no hurry. Because organisations can opt to invest in a piece of computer software directly at whichever version number they require, the changing version numbers should not provide a great influence. On the contrary, benefits can accrue if organisations bide their time rather that attempt to rush to keep up, since with each month that passes, new computer software appears on the commercial market, and improvements are made to existing computer software.

4.3.16 Ignoring the Long-Term

Organisations may fail to consider the long-term implications of investing in health and safety software. At the beginning of Chapter 3, a host of problems were identified with the current proprietary health and safety software market which have serious implications for the long-term value of the software. Organisations should consider carefully the points which were raised, such as the relationship between the client

organisation and the software company, on-going investment costs in product updates and IT upgrades, the extent to which the software is time-dependent, whether data can be meaningfully extracted from the software at a future date, and the implications if the software company cease operation or discontinue the product. It would be extremely unwise for an organisation to invest in health and safety software without considering the long-term implications in depth.

4.3.17 External Must Be Better

Some organisations may wish to purchase health and safety software because they feel that an external organisation must be able to develop health and safety management systems better than they can. They may refuse to consider in-house solutions, whether they are paper-based systems or computer-based systems. They may believe that an external specialist organisation must be good because they are specialists. They must know more, understand health and safety better, understand computers better. This view neglects the problems of purchasing off-the-shelf products from external sources. A proprietary product may not match the organisations needs. It may cover some areas in too much depth, and other areas in not enough depth. It may not cover some areas at all. It may present health and safety in a manner that contradicts existing health and safety systems within the organisation. It is a product designed in isolation, outside the context of the organisation, that the organisation then attempt to plug in wholesale.

An external product cannot be fine-tuned to the organisation in the way that an in-house solution can be. The organisation are likely to understand an external product less well than one they have designed and created themselves. The organisation will also miss out on a positive health and safety task if they purchase an external product - that of constructing their own health and safety management systems, which would involve thinking through their needs, deciding how to match best these needs, obtaining information and training where necessary, and examining legal requirements. They will lose all of the learning that comes from developing an in-house solution. It is not true that external solutions *must* be better than in-house ones.

Chapter 5: The H&S Software Evaluation Chart

In this chapter of the thesis I will describe a software evaluation tool that I have developed to help organisations to evaluate health and safety software. The tool is called the health and safety software evaluation chart, and can be utilised by organisations when they undertake the health and safety software evaluation process that was described in Chapter 4. The chart was constructed based upon the insight that was gained during the evaluation of seven pieces of proprietary health and safety software in Chapter 2, and the analysis of the deeper issues which are associated with the use of specialist computer software for proactive health and safety management in Chapter 3. The chapter will first discuss the origins of the health and safety software evaluation chart, before advancing to discuss its more recent development and practical application. The full chart is itself included at the end of this chapter.

5.1 The Origins of the H&S Software Evaluation Chart

The health and safety software evaluation chart which is the focus of this chapter is a more comprehensive version of a software evaluation chart which I designed in 1996 when I was asked by the Occupational Health and Safety Department at the University Hospital Birmingham NHS Trust to help them to evaluate and select health and safety management software for incident recording. At the point at which I was contacted, the organisation had been examining evaluation copies of several pieces of proprietary incident recording software but had found it difficult to distinguish the differences between them and to identify comparative strengths and weaknesses. The main problem was that the task of evaluating health and safety software was entirely new for the individuals involved, which resulted in them being uncertain as to which software aspects they should examine and which investment issues they should consider. Basically, it is hard to evaluate something for which one has no mental model or relevant experience to guide the evaluation.

It was only through having spent a long time examining a range of health and safety software in detail that I had become able to recognise the points that should be considered by organisations in software evaluations. The question was whether the

knowledge that I had gained during the software evaluations could be encapsulated in the form of a practical tool for organisations to use when evaluating health and safety software. Initially, I developed a basic checklist of points to consider when evaluating a piece of proprietary health and safety software. The difficulty was that this checklist only covered the very basics of health and safety software evaluation, and lacked the necessary depth to guide a detailed evaluation.

I then considered developing a software evaluation chart, since this would allow a more structured, thorough approach to be taken to the software evaluation process. During the background research for this project, I had been impressed by the human-computer interaction software evaluation checklist that Ravden and Johnson (1989) had developed for evaluating the design of user interfaces in computer software. This checklist was presented partly in the form of a chart, where the user was asked various questions and required to tick a box to select their response to each question on an answer scale. Ravden and Johnson's software evaluation checklist had been constructed based upon human-computer interaction knowledge with which I am familiar, and in particular upon the following literature: Clegg et al (1988), Smith and Mosier (1986), Gardner and Christie (1987) and Shneiderman (1987).

Ravden and Johnson (1989) described their checklist for evaluating the user interface of software in this way:

> *It provides a structured and systematic tool, in the form of a checklist, with which to apply the knowledge emanating from software ergonomics research to evaluation of user interfaces. The method, and in particular the nature of the checklist, enables an interface to be evaluated by a variety of people, with differing expertise and backgrounds, including, for example, interface designers and other technical experts, and most importantly, representative end-users, who may, or will, actually use the system in practise.*

Their checklist was purely qualitative in nature, and was presented not as a solution to user interface design and evaluation, but rather as a tool which could be applied to examine a piece of software in depth to aid the identification of comparative strengths and weaknesses. This point is emphasised in the following quotation from Ravden and Johnson (1989):

> *The method does not aim to solve problems, or to enable a quantitative assessment of usability (e.g. by adding up scores). It provides a means of identifying problem areas, of extracting information on problems, difficulties, weaknesses, areas for improvement, and so on.*

Furthermore, Ravden and Johnson (1989)'s software evaluation checklist was purely focused upon the design of the user interface. What I wished to create was a tool which could be used to evaluate health and safety software, and which would be able to consider not only issues related to software usability in terms of the design of the user interface, but also many of the issues which were identified as crucial determinants of the value of health and safety software during the course of the software evaluations as described in Chapter 2 and their later in-depth analysis as discussed in Chapter 3. I adapted the idea of a software evaluation chart to produce an original software evaluation chart that was designed specifically to evaluate proprietary incident recording software for the health sector. This chart listed 89 different software aspects which were grouped together under appropriate headings.

Many of the software aspects concerned software design and human-computer interaction issues (such as user control, feedback, system administration, spellcheck, security, printing facilities, presentation), and the quality of service which is provided by the software company (such as software company reviews, support service, software development, training, and initial software cost). Both of these sets of software aspects would have been relevant for the analysis of a wide variety of computer programs, not just those designed for health and safety purposes. Other software aspects were specific to incident recording issues (such as reports, graphs, personnel details, vehicle details, incident investigation, and post-incident recommendations), and other software aspects were even more specific being related to incident recording in an NHS establishment (such as clinical incidents, clinical negligence incidents, and medical devices details).

The evaluator was required to work systematically through the software evaluation chart for each piece of software. They were required to assign each software aspect a rating on the rating scale shown in Table 5.1. The software evaluator was also required to expand upon the rating in the form of notes. Thus, it was not merely enough to rate the various aspects of the software, the evaluator was required to explain why they had

allocated the particular rating. This made the software evaluation chart of much greater value once it had been applied to several pieces of software, because meaningful comparisons could then be drawn to determine which software would make the best investment.

Table 5.1: Rating Scale for the Software Evaluation Chart for Proprietary Incident Recording Software for the Health Sector

Point on Rating Scale	Description of Software Aspect
0	Not present in software
1	Very poor
2	Poor
3	Average
4	Good
5	Very good

By providing quantitative ratings, rather than merely qualitative notes, it made it much easier to make comparisons between different aspects of the pieces of software under consideration. Thus it was possible to recognise that one piece of software had scored very low on system stability with a "1" whilst another had registered very high in this area with a "5". The different software aspects were all allocated the same weighting of "1", meaning that they were all considered to be of equal importance in determining the overall value of the proprietary incident recording software. In theory it would have been possible for certain software aspects to have been given a higher weighting than others if they were believed to be of greater significance in determining the overall value of the software for the particular organisation. The quantitative format of the software evaluation chart made it possible to calculate easily the total marks awarded for each piece of software that was evaluated, and to calculate a percentage rating based upon total marks awarded out of total marks available.

Two pieces of proprietary health and safety software were evaluated using this system by Jonathan Trimby, a health and safety advisor at the organisation, and myself. One of the programs was Safecode Limited's IRIS, which was discussed in Chapter 2. The software evaluations took far less time to produce using the software evaluation chart, than using the type of methods that were employed in Chapter 2, yet they produced a high level of detailed analysis. The structured, systematic approach of the software evaluation chart was highly effective, encouraging the assessor to consider carefully each point in turn and to check thoroughly the related software features. As the chart was completed it produced a smart, comprehensive software evaluation report. It highlighted the numerous deficiencies in the two programs under consideration, and resulted in them receiving overall percentage ratings of between 20% to 35%. Although these percentages are very low, the software under consideration was of a very poor standard, and in no way met the organisation's health and safety management needs, nor the software specifications that they had drawn up prior to the evaluations based upon these needs. The software evaluation chart was thus found to have produced highly accurate ratings in this case, and provided quantitative figures with detailed explanatory notes which could be presented to senior management to explain why the two programs were not suitable investments.

Following this Jonathan Trimby applied the software evaluation chart to three more pieces of incident recording software, two of which were proprietary and one of which had been designed for another medical establishment but could be tailored. The two pieces of proprietary software fared better in terms of overall rating than the previous programs, but the highest rating by far went to Chimera Limited's IRec software. In the latter's case, the structured software evaluation chart had allowed notes to be made concerning not only the quality of the various aspects, but also the modifications which would be required to adapt the software to the organisation. The feasibility, development time and costs were discussed with the software company, and eventually this was the solution chosen to meet the organisation's needs for a new incident recording system. At the time of writing, the tailored incident recording software has been in successful operation at the organisation for over a year.

5.2 The H&S Software Evaluation Chart

Having produced a software evaluation chart for incident recording software for the health sector, I then attempted to expand and generalise the chart so that it could be applied to any health and safety software for any industry. The result was the quantitative health and safety software evaluation chart that is presented in this chapter, which progresses in far more detail through the points that organisations need to consider when evaluating health and safety software. One of the most important benefits of the chart is that it can help organisations to understand what they should be looking for during a software evaluation, and encourage them to take a systematic approach to the evaluation and selection of health and safety software. The chart is not guaranteed to produce the perfect software solution, but is intended to highlight the relative strengths and weaknesses of pieces of health and safety software, and help to eliminate from contention those programs which have too many deficiencies.

As with the incident recording software evaluation chart, this chart considers each software evaluation aspect to have a weighting of "1". This provides the chart with a great deal of flexibility, since it can be applied "as is", to provide an overview of the software which is not biased by pre-conceptions as to what are the most important and least important features of the software. The organisation can later decide for themselves upon the relative importance of the findings, based upon the insight that they have gained during the software evaluation process. The possibility of utilising the software evaluation chart with different software aspect weightings will be discussed later in this chapter.

To use the software evaluation chart, the evaluator should progress through the questions one at a time, assigning a rating for each software aspect from the scale provided in Table 5.2. The reader will note that this rating scale is identical to that which was used for the original software evaluation chart which was designed for evaluating incident recording software for the health sector. This was because the six point rating scale was found to work particularly well when evaluating health and safety software. The possibility of using a larger rating scale, for example 0-10, was considered, but it was felt that this would be too broad, with it being awkward to

indicate clearly how each point on the scale should be interpreted, and that it would make the software evaluation process more difficult to undertake consistently[74].

Table 5.2 Rating Scale for the H&S Software Evaluation Chart

Point on Rating Scale	Description of Software Aspect
0	Not present in software
1	Very poor
2	Poor
3	Average
4	Good
5	Very good

The more time that can be allocated to the evaluation, the better the level of detail that will be produced. Whilst one evaluator with an understanding of both information technology and health and safety management will be able to undertake the evaluation, there is a great benefit to having two evaluators work together through the chart since they can discuss the questions that are asked and come to agreed upon ratings and explanatory notes. In the latter scenario, there is probably less chance of issues being over-looked or considered too swiftly. The questions in the chart are divided under various section headings, this means that the chart could be used if desired just to examine or re-examine specific aspects of the software. It also serves to make it easier to progress through the chart and to locate completed information at a later date. Evaluators should not feel limited in note entry by the size of the spaces which have been provided in the chart in the thesis. The original version of the chart was completed on-line in a word-processing program so that the notes could be as minimalist or expansive as was required. It is suggested that this is the ideal way in which to complete the software evaluation chart.

[74] In other words, with a larger scale such as an 11-point scale, it would be difficult to distinguish between what exactly would merit a rating of "6" rather that a "7", or a "3" rather than a "4". It would also be difficult for evaluation to provide consistent ratings for a particular piece of software, as there is far greater scope for subjective variation in aspect rating.

The software evaluator would then need to advance to the Health and Safety Software Evaluation Chart Totals page to obtain quantitative evaluation results. This page allows the evaluator to enter the total marks available and total marks awarded for each section of the software evaluation chart, and to obtain a percentage rating for each section. This helps the evaluator to identify the comparative strong and weak areas within the different pieces of software. To calculate the total marks available for a category, the evaluator would need to find the sum of the maximum aspect rating for each software aspect within the category. This will effectively be the number of software aspects within a category multiplied by the number 5 (the maximum mark which can be awarded for any software aspect on the 6 point rating scale). To calculate the total marks awarded for a category, the evaluator would need to find the sum of the aspect rating for each software aspect within the category. Percentage ratings of between 0% and 100% could then be calculated by applying the following basic formula:

$$\textbf{Percentage Rating} = \frac{\textbf{Total Marks Awarded}}{\textbf{Total Marks Available}} \times 100$$

This makes it easy to rank order the pieces of software which have been evaluated, and to gain an understanding of the magnitude of the difference between them.

5.3 Applying Weightings to the H&S Software Evaluation Chart

As was mentioned earlier in the chapter, if required it would be possible to give different weightings to the various software aspects which are listed in the health and safety software evaluation chart. This would allow aspects to be differentiated according to the their relative importance in determining the overall value of a piece of health and safety software. An explicit weightings system could be incorporated into the software evaluation chart by adding three more columns labelled "Aspect Weighting", "Maximum Weighted Aspect Rating" and "Weighted Aspect Rating" after the "Aspect Rating" column. When an organisation wished to utilise the chart to evaluate health and safety software, they would first need to work through it to allocate a weighting to each software aspect. Various weighting scales could be used in conjunction with the

software evaluation chart; one example of a possible weighting scale is given in Table 5.3.

Table 5.3: A Possible Weighting Scale f or Use with the Software Evaluation Chart

Point on Aspect Weighting Scale	Description of Aspect Importance Relative to Overall Value of Software
1	Low
2	Medium
3	High

When conducting a weighted software evaluation, the evaluator would need to progress systematically through the software evaluation chart, allocating a rating from 0 to 5 to each software aspect (as was described previously). Once the software evaluation chart is completed, the evaluator would need to calculate the maximum weighted aspect rating for each software aspect, by applying the following basic formula and entering the result in the appropriate column:

Maximum Weighted Aspect Rating = Maximum Aspect Rating x Aspect Weighting

Or, in other words, since for the software evaluation chart, the maximum aspect rating is 5, the formula can be re-written as:

Maximum Weighted Aspect Rating = 5 x Aspect Weighting

The software evaluator then needs to calculate the weighted aspect rating for each software aspect. This could be achieved by applying the following basic formula:

Weighted Aspect Rating = Aspect Rating x Aspect Weighting

The software evaluator would then need to advance to the Health and Safety Software Evaluation Chart Totals page, to enter the total marks available and total marks awarded for each software evaluation category. To calculate the total marks available for a category, the evaluator would need to find the sum of the maximum weighted aspect rating for each software aspect within the category. To calculate the total marks awarded for a category, the evaluator would need to find the sum of the weighted aspect rating for each software aspect within the category. Percentage ratings could then be calculated by applying the following basic formula:

$$\textbf{Percentage Rating} = \frac{\textbf{Total Marks Awarded}}{\textbf{Total Marks Available}} \times 100$$

This makes it easy to rank order the pieces of software which have been evaluated, and to gain an understanding of the magnitude of the difference between them.

5.4 Future Development of the H&S Software Evaluation Chart

The health and safety software evaluation chart can be applied to good effect as it is presented in this thesis. It should always be born in mind however that the chart is merely a tool to guide the evaluation of health and safety software, and to highlight many of the points which software evaluators should consider during the evaluation process. Although quantitative ratings are produced, this is simply to indicate relative strengths and weaknesses within a piece of software, and to provide a rough measure of how different pieces of software compare against each other. The software evaluation chart does not provide a guarantee that if a piece of health and safety software scores particularly high overall, it will be a successful investment for an organisation. However, it will help to identify potential problems with the software, areas where improvements are needed, areas which match the organisation's health and safety management needs, and areas which do not.

So far the software evaluation chart has been applied when evaluating a variety of proprietary health and safety software, tailored health and safety software, and

custom-made health and safety software. When the software evaluation chart is being applied, there are sometimes individual questions or sections which are irrelevant for a particular piece of software. When this is the case, the evaluator should explain at the appropriate point in the chart exactly why those questions or sections are irrelevant for the software. In all likelihood, this will occur when there are crucial differences between the piece of software which is being evaluated and a typical piece of health and safety software. These differences are likely to be essential in determining the value of the health and safety software, and it is one of the benefits of the chart that it will draw out many of these crucial differences and require the evaluator to examine and explain them.

As a final point before advancing to Chapter 6, where the work of Chapters 1 to 5 of the thesis will be brought together in the form of conclusions, it should be noted that the health and safety software evaluation chart will be subject to a process of continuous development. It has been under continuous development for over two years already, and during this time has progressed through three quite distinct incarnations. Therefore, the software evaluation chart will continue to be applied, tested, expanded and refined where necessary, rather than remain static in the form that has been presented in this chapter. The reader is welcome to contact the author, to obtain the latest version of the health and safety software evaluation chart in a paper-based or on-line format, and to contribute to the application, testing and refinement process.

Table 5.4: The Health and Safety Software Evaluation Chart

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
Acquiring the Software		
1. How easy is it to initially contact the software company ?		
2. How helpful are the software company on initial contact ?		
3. How well do the software company listen to your organisation's needs ?		
4. How knowledgeable are the software company about computer software ?		
5. How knowledgeable are the software company about health and safety management ?		
6. How easy is it to acquire demonstration or trial software?		
7. How promptly does the demonstration or trial software arrive ?		
8. How well is the demonstration or trial software packaged ?		
9. What condition are the software disks in when they arrive ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
10. How well are the software disks labelled ?		
11. If there is more than one software disk, how clear is the order in which they are to be used ?		
12. How well is the letter accompanying the software written?		
13. How well is the letter accompanying the software presented ?		
14. How clearly does the accompanying letter provide a contact at the software company ?		
15. How clearly does the accompanying letter provide the software company's address ?		
16. How clearly does the accompanying letter provide the software company's telephone number ?		
17. How clearly does the accompanying letter provide the software company's fax number ?		
18. How clearly does the accompanying letter provide the software company's e-mail address ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
Software Installation		
19. How clearly are the computer specifications for the software provided ?		
20. How well does the description of the computer specifications cater for the novice user ?		
21. How well do the computer specifications match your organisation's computers ?		
22. How up-to-date is the operating system that the software will run upon ?		
23. How clearly are the accompanying installation instructions written ?		
24. How well are the accompanying installation instructions presented ?		
25. How well do the instructions explain how to install the software ?		
26. How well is the explanation broken down into suitable steps ?		
27. How well does the explanation cater for the novice user ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
28. How easy is the installation process ?		
29. How good is the on-screen guidance for the installation process?		
30. How well is the user kept informed of the computer's activities during the installation process ?		
Software Manual or Instructions		
31. How well does the cover of the software manual identify the software name ?		
32. How well does the cover of the software manual identify the software version ?		
33. How well does the cover of the software manual identify the software company ?		
34. How clearly is the cover of the software manual dated ?		
35. How well is the software manual presented ?		
36. How well are the software manual's pages numbered and indexed ?		
37. How easy is it to find information in the software manual ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
38. How clearly is the software manual written ?		
39. How well does the software manual explain the health and safety management theory behind the software ?		
40. How well does the software manual provide definitions of key health and safety terms as they are used in the program ?		
41. How well does the software manual describe the software ?		
42. How well does the software manual provide examples and illustrations from the software ?		
43. How well does the software manual cater for the novice user ?		
44. How well does the software manual provide a glossary of technical terms ?		
45. To what extent is the software manual able to answer any questions you may have concerning the software ?		
Starting the Software		
46. How easy is it to start the software ?		
47. How promptly is the program accessed ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
48. How well designed is the software title screen ?		
49. How up-to-date does the software title screen appear ?		
50. How clearly does the software title screen display the software name ?		
51. How clearly does the software title screen display the software version ?		
52. How clearly does the software title screen display the software company name ?		
53. How clearly does the software title screen display the software date ?		
54. How easy is it to tell from the software title screen what the purpose of the software is ?		
55. How consistent is the software title screen with the software manual cover ?		
56. How easy is it to read the information on the software title screen ?		
57. Does the software avoid resorting to using the title screen to present the user with an alleged legal no claims agreement ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
Main Screen		
58. How good is the design of the main screen ?		
59. How well does the main screen design compare with the Microsoft Windows standard ? E.g. menu bar, scroll bars, tool bars, status bar ...		
60. How clearly is the program name displayed on the main screen ?		
61. How easy is it to access the software's main features from the main screen ?		
Menus		
62. How easy is it to use the menu system ?		
63. How logically are the options ordered within the menus ?		
64. How clearly are the menu options labelled ?		
65. How quick is it to access the menu options that you require ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
66. When menu options are not available how clearly is this indicated ? E.g. Are the menu options dulled out or removed ?		
67. How easy is it to set up short-cut keys for menu options ?		
68. How well do the menus compare to the Microsoft Windows standard ? E.g. File menu, edit menu, tools menu, window menu, help menu in familiar positions.		
Tool Bars		
69. How good are the toolbars in the software ?		
70. How logical is the ordering of the icons on the toolbars ?		
71. How easy is it to tell what the toolbar icons refer to ?		
72. How easy is it to distinguish the toolbar icons from each other ?		
73. How well do the toolbar icons comply with Microsoft Windows standards ? E.g. Are familiar icons used for cut, copy etc. and does the software avoid using familiar icons for unusual purposes ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
74. To what extent is there a corresponding menu option for each toolbar icon ? E.g. Can the toolbar options be selected without using the toolbar ?		
75. To what extent do the toolbar icons have the same description labels as the corresponding menu options ?		
76. To what extent do the toolbar icons act identically to the corresponding menu options ? E.g. Do they take the user to the same screens, perform tasks the same way ?		
77. To what extent does the software allow the user to customise the toolbars by adding extra icons or rearranging the icon ordering ?		
Information		
78. To what extent does the software allow you to record all of the data that you would like ?		
79. To what extent does the software allow you to record data in the style that you would like ?		
80. To what extent does the software cater for the level of detail with which you would like to record data ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
81. To what extent does the software allow you to record data in a way which is consistent with your existing health and safety management systems ?		
82. To what extent does the software allow the user to operate between multiple windows at one time ?		
Data Structures		
83. How clearly are the data screens titled ?		
84. To what extent is clear explanatory text provided on data screens to guide and inform the user as to how they should complete tasks or interpret terms ?		
85. How clear is the layout of the datafields on the data screens ?		
86. How easy is it to understand what the datafields refer to ?		
87. How easy is it to enter data in the datafields ?		
88. How easy is it to modify data in the datafields ?		
89. How easy is it to delete data from the datafields ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
90. How well are drop-down lists and radio buttons used to simplify data entry ?		
91. Are the datafields large enough to record the data that you require ?		
92. How easy is it to enter your own notes and comments on datascreens ?		
93. Are the datafields large enough to clearly display any data that is entered in them ?		
94. When there are data screens or datafields that contain too much data to display on screen at once how easy is it to scroll through the data ? E.g. Are scroll bars and page up/down buttons provided ?		
95. To what extent do the datafields avoid redundancy ? E.g. The user should not be required to enter duplicate information at several points in the system, they should be able to enter it once and have related datafields updated automatically.		
96. To what extent does the software have data consistency checks to prevent incorrect dates and conflicting data from being entered into datafields ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
97. If there are data consistency checks, when incorrect data is entered into a datafield how clearly does the software explain why the data is incorrect ?		
98. How easy is it to add your own user-defined datafields to the software ?		
Saving Data		
99. To what extent is a save option always available on data screens ?		
100. How easy is it to save data that has been entered into the data screens ?		
101. To what extent is there an autosave facility ?		
102. If there is an autosave facility, to what extent can the user set the save frequency in minutes ?		
103. Before the user exits the software, are they clearly prompted to save any unsaved data ?		
Backing-Up Data		
104. To what extent is there a facility for backing-up data from the software ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
105. To what extent does the back-up facility allow the user to back-up data on a variety of media such as floppy disks, CD-Rs, CD-RWs, network drives, tape streamers, Zip and Jaz disks ?		
106. How well does the back-up facility clearly guide the user through the back-up process ?		
107. How well does the back-up facility keep the user informed as it progresses through the back-up operation ?		
108. When the back-up process is complete, to what extent does the system check that the back-up copy is accurate ?		
109. To what extent does the back-up facility keep accessible records on the data that has been backed up, who it was backed up by, when it was backed up and where it was backed up to ?		
Feedback		
110. How good is the feedback that you receive when you move the mouse pointer around the screen ? E.g. Is there a status bar at the bottom of the screen to clearly describe the items that the mouse points to or bubble help ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
111. How good is the feedback that you receive when you select a command ? E.g. Do you receive a clear acknowledgement that the computer has received the command ?		
112. How good is the feedback that you receive if you select a command that is irreversible ? E.g. Are you presented with a confirmation screen that clearly asks whether you are sure you want to continue with the command and requires you to select between yes and no buttons ?		
113. How good is the feedback that you receive if you enter data incorrectly or enter the wrong command ? E.g. Are you clearly informed of why the data or command is incorrect ?		
114. How good is the feedback that you receive when the computer is undertaking a task ? E.g. Do you receive clear feedback on what the computer is doing and how long it will take ?		
Printing		
115. To what extent is it possible to access printing facilities from each screen within the software ?		
116. To what extent is it possible to print any single screen within the software ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
117. To what extent is it possible to select a set of screens from the software to print ?		
118. How flexible are the print options that are provided ?		
119. How good is the quality of printouts from each point in the program ?		
120. How clear and intuitive are the headings on printouts ?		
121. To what extent do the headings and text on printouts match that on-screen ?		
122. To what extent does the ordering of items on printouts match that on-screen ?		
123. If multiple pages are printed, how clearly are the pages numbered ?		
Help System		
124. On entering the software for the first time, how good is the guidance with which the user is presented ?		
125. On entering the software for the first time, to what extent are good learning tools provided for the user, such as information screens, slide presentations and tutorials ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
126. After initial use, to what extent are good learning tools provided for the user, such as information screens, slide presentations and tutorials ?		
127. How easy is it to access context-dependent help for a particular screen or command ?		
128. How consistent is the context-dependent help command ? E.g. To what extent is the option available for every data screen and datafield ?		
129. How reliable is the context-dependent help command ? E.g. Does it promptly take you to the relevant part of the help system ?		
130. How clearly is the help option made available on every screen in the program ?		
131. How quickly does the system access the help files once the help command has been selected ?		
132. To what extent is the help system designed to match Microsoft Windows standards ? E.g. contents option, search option, technical support option ...		
133. To what extent does the help system make use of hypertext ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
134. How clearly is the help text written ?		
135. How clearly is the help text presented ?		
136. How well does the help text describe the software ?		
137. How well does the help text cater for the novice user ?		
138. To what extent does the help text include examples and illustrations ?		
139. When the help system describes how to perform tasks, how well does it divide the information into convenient stages ?		
140. When the help system describes how to perform tasks, how easy is it to understand the guidance ?		
141. When the help system describes how to perform tasks, how easy is it to follow the guidance to complete a task ?		
142. To what extent does the help system explain the health and safety management basis of the program ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
143. To what extent does the help system make explicit the links between the software and health and safety legal requirements ? E.g. Does a risk assessment program's help system explain which parts of the program intend to aid compliance with which parts of the legal requirements of the Management of Health and Safety at Work Regulations 1992 ?		
144. To what extent does the help system provide copies of relevant health and safety legislation ?		
145. If the help system does contain health and safety legislation, to what extent does it provide copies of official guidance literature ?		
146. To what extent does the help system provide a glossary of technical terms ?		
147. To what extent does the help system provide a glossary of health and safety terms ?		
148. If the help system does provide definitions of health and safety terms, how clear are the explanations ?		
149. If the help system does provide definitions of health and safety terms, how well do the definitions match those that are used within health and safety literature ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
150. If the help system does provide definitions of health and safety terms, how well do the definitions match those that are used within your organisation ?		
151. To what extent is the information in the help system consistent with the information in the software manual ?		
Security System		
152. How good is the software's security system for preventing unauthorised access ?		
153. How flexible is the software's security system for setting different users different access rights ?		
154. When data is entered on a data screen, does the software automatically complete datafields at the bottom of the screen for user name and date ?		
155. When data is modified on a data screen, does the software automatically complete datafields at the bottom of the screen for user name and date ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
Software Compatibility		
156. How compatible is this version of the software with previous versions ?		
157. How compatible will this version of the software be with future versions ?		
158. How compatible is the software with the general office software that you use?		
159. How compatible is the software with other health and safety software ?		
160. How easy is it to import data from other software into the health and safety software ?		
161. How easy is it to export data from the health and safety software into a word-processing program ?		
162. How easy is it to export data from the health and safety software into a spreadsheet program ?		
163. How easy is it to export data from the health and safety software into a database ?		
164. How easy is it to export data from the health and safety software into a presentation program ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
165. How easy is it to export data from the health and safety software into a graphics program ?		
Software Stability		
166. How stable is the software from crashing and errors ?		
167. How stable is the software if you work with more than one application open at a time ? E.g. The health and safety software and a word-processing program ?		
168. To what extent does the software provide clear warnings if the system has lost stability ?		
169. To what extent does the system allow you to close down safely if there is a loss of stability ?		
Software Usability		
170. How easy is the software to learn ?		
171. How easy is the software to use ?		
172. How intuitive is the software ? E.g. How self-explanatory is the software ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
173. How intelligent does the software appear to be ? E.g. How sensibly does it approach health and safety management tasks and respond to user input ?		
174. How flexible is the software ? E.g. To what extent can the user adjust and modify the software to suit their own needs ?		
175. How much control does the software offer the user ? E.g. To what extent can the user choose how to perform tasks and what order to perform them in ?		
Software Integration		
176. How well does the software suit the level of computer competence of those who will use it ?		
177. How well does the software suit the level of health and safety knowledge of those who will use it ?		
178. How well does the software fit in with your existing health and safety management systems ?		
Support Service		
179. How well are the support service details provided in the software manual ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
180. How well are the support service details provided in the on-line help system for the software ?		
181. To what extent is the support service operated by the software company who created the software ?		
182. To what extent is the support service operated by people who have a good understanding of the software ?		
183. How quick is it to access the support service by telephone ?		
184. If the telephone support service is busy, to what extent is there a good procedure for acquiring assistance ? E.g. Answering machine with prompt call back, telephone waiting list, recorded information system for basic problems ...		
185. How helpful is the support service ?		
186. How well informed is the support service ?		
187. In evaluating the software, to what extent are the software and its manuals designed to reduce the need to contact the support service ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
Software Company		
188. How stable are the software company in terms of the years that they have been established ?		
189. How stable are the software company in terms of the size of their company ?		
190. How stable are the software company in terms of the range of health and safety products that they supply ?		
191. How experienced are the software company in terms of the number of health and safety programs that they have produced ?		
192. How experienced are the software company in terms of the number of people who are involved in the design of the health and safety software ?		
193. To what extent is the background of the people who designed the software suitable for providing health and safety software for your organisation ?		
194. What type of views have you heard concerning the software company ?		
195. What type of views have you heard concerning the software ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
196. What type of views have you heard concerning other health and safety software produced by the software company ?		
197. What type of views have you heard concerning other software produced by the software company ?		
198. What type of reviews has the software received in health and safety literature ?		
199. What type of reviews has the software received in industry literature ?		
200. What type of reviews has the software received in computer literature ?		
201. How has the software fared in terms of product awards ?		
202. How reliable are the software company in terms of how often they have produced new versions of their health and safety software ?		
203. How reliable are the software company in terms of producing developments and new products at the scheduled times ?		
204. To what extent are the software company committed to the continuous development of the software ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
205. To what extent do the software company communicate with their clients ?		
206. To what extent do the software company keep their clients up-to-date on their latest plans and developments ?		
207. To what extent are the software company willing to listen to ideas for improving their software ?		
208. To what extent are the software company responsive to their clients needs ?		
209. To what extent can the software be tailored to match an organisation's needs ?		
Costs		
210. How reasonable is the initial price of the software ?		
211. If the software is sold with an annual license, how reasonable is the price of the annual license ?		
212. To what extent is the future price of the annual license guaranteed in advance ?		

Software Evaluation Aspects	Aspect Rating	Software Evaluator's Comments
213. How reasonable is the price of a network license for the software ?		
214. How reasonable is the price of additional software manuals ?		
215. How reasonable is the price of training in the software's use ?		
216. How reasonable are the prices of upgrades for the software ?		
217. How reasonable is the price of the registering for the software support service ?		
218. How reasonable is the price of contacting the software support service via telephone ?		
219. How reasonable is the price of contacting the software support service via fax ?		

Health and Safety Software Evaluation Chart Totals

Software Evaluation Category	Total Marks Available	Total Marks Awarded	Percentage Rating
Acquiring the Software			
Software Installation			
Software Manual or Instructions			
Starting the Software			
Main Screen			
Menus			
Toolbars			
Information			
Data Structures			
Saving Data			
Backing-Up Data			
Feedback			
Printing			
Help System			
Security System			
Software Compatibility			
Software Stability			
Software Usability			
Software Integration			
Support Service			
Software Company			
Costs			
Overall Rating			

Chapter 6: Conclusions

I've seen the future and it will be ...

Prince (1989) *The Future*[75]

In this final chapter of the thesis, I will examine the implications of the research findings for the use of information technology in health and safety. I will focus upon three key issues: (i) the lessons that can be drawn for health and safety software; (ii) the directions that should be pursued in the use of information technology in the field of health and safety; and (iii) the future research that should be conducted in this area.

6.1 The Implications for Health and Safety Software

When I commenced the research I held a somewhat naive view that computer software which was designed to aid organisations with proactive health and safety management tasks would undoubtedly be beneficial. The research has examined in detail one particular area of health and safety software, namely the proprietary health and safety software market, and has found this view to be incorrect. Whilst there is no question that information technology can be of value for health and safety management, it has become apparent that specialist health and safety software is not necessarily a "good thing" just because it is state of the art technology.

Nevertheless, the increasing interest in and use of information technology in the work environment will not cease; indeed as time passes by organisations will look more and more for technological solutions to the problems that they face. Inevitably, as was outlined in Chapter 1, this search for technological solutions will include organisations seeking computer software solutions to proactive health and safety management tasks. The commercial market for health and safety software will, in all likelihood, continue to expand as more organisations become adept in information technology and health and safety management, and see the potential benefits of undertaking the latter through the former.

[75] Quotation from original source.

Given that this is likely to be the case, the question arises as to how health and safety software can be designed and marketed so as to reap the potential benefits without falling into the quagmire of problems that have been identified throughout Chapters 2 and 3. Drawing upon the knowledge and experience that has been gained during the course of the research, I have attempted to answer this question by proposing a number of lessons that can be learnt which would improve the quality and value of health and safety software. The lessons are aimed at proprietary health and safety software in particular, but are broad enough to be relevant to all health and safety software. They are outlined below.

The lessons are not profound but if they are employed with common sense they could greatly enhance the quality of many pieces of health and safety software. As was emphasised earlier in the thesis, one of the difficulties with health and safety software is that if a single aspect is incorrect, unsuitable, or poorly designed, the value of the software as a whole is likely to be significantly decreased, and in some instances the software may prove to be misleading and confusing. At many points in the software evaluations, which are described in Chapter 2, the thought arose that *"if only this had been done differently, the software would have had far more value"*.

6.1.1 Operating System

In Chapter 2, the software evaluations were shown to have identified many problems which were due to the proprietary health and safety software being based upon out-of-date operating systems. Furthermore, in Chapter 3, the distinctive nature of the proprietary health and safety software market was examined, which highlighted the difficulties that exist which hinder software companies in their attempts to keep this software up-to-date, and the problems that the user is likely to experience as a result. Given these points, it is essential that when health and safety software is designed it is based upon the one of the latest computer operating systems. If a new version of the operating system is due to be available in the near-future, it will be wise for health and safety software companies to wait until after its release before designing their products.

6.1.2 Interface Design

In Chapter 2, the software evaluations were shown to have identified a large number of weaknesses in the interface design of the proprietary health and safety software. This varied from being of major significance, where, for example, the interface design made it easy to erase accidentally data, to minor significance, where the design was likely to prove frustrating, confusing and time-consuming for the user. The range of problems included internally inconsistent interface design, externally inconsistent interface design, inadequate text presentation, inappropriate choice of controls, poor icon design, poor navigation methods, poor use of colour, poor title screens, inadequate toolbars, absence of status bars, absence of scroll bars, and inadequately sized free text boxes.

The field of human-computer interaction has frequently demonstrated the importance of interface design for producing a successful computer software product. Health and safety software should be designed so as to be consistent with the software standards set by the latest computer operating systems. Health and safety software companies need to devote the time to design programs which have clear and consistent title screens, program screens, toolbars, status bars, scroll bars, controls and icons. These items need to be consistent both internally (within a piece of health and safety software) and externally (between a piece of health and safety software and other commercial software which is designed for the same operating system). Pre-existing conventions should be used appropriately whenever possible in interface design, and where this is not possible, original, intuitive designs should be created which do not contradict pre-existing conventions and intuition.

6.1.3 Basic Functions

In Chapter 2, the software evaluations identified several difficulties with the proprietary health and safety software failing to adequately provide basic functions which are commonplace in the latest computer software. Examples included the absence of commands for "cut", "copy", "paste", "undo", "redo", "spellcheck", text formatting and interface customisation. The programs also often lacked basic functions to allow the user to work in multiple windows, adjust window sizes and adjust view sizes. For the quality and value of health and safety software to be enhanced, such basic functions

need to be available at all points. This will help to make the software more consistent with other commercial software, and thus more intuitive and usable. It will also improve software flexibility and user control.

6.1.4 Software Compatibility

In Chapter 2, one problem which was drawn out from the software evaluations was the lack of compatibility between the proprietary health and safety software and other proprietary office software. Health and safety software needs to be compatible with proprietary office software if it is to be used optimally. Users need to be able to transfer easily information from health and safety software into proprietary office programs for word-processing, spreadsheets, databases, drawing, statistics, e-mail, internet and presentations.

Further, as was discussed in Chapter 3, the problem of the health and safety data that is stored within proprietary health and safety software becoming unusable with time if the software is not regularly updated needs to be tackled. There is no easy solution to this, although with many proprietary health and safety software companies now basing their software heavily upon the Microsoft Office programs, and Microsoft Access in particular, the logical step forward is perhaps to design the software so that it includes an option which allows the client organisation to transfer easily all of the data which is recorded in the software into a usable, meaningful Microsoft Access database file. An alternative option would be if health and safety software companies could extract the data which an organisation has recorded in their software and provide them with a CD-ROM which features the data in a meaningful format in exchange. Until the problem can be resolved, it places a huge question mark over the use of computer software to record health and safety data over the long-term.

6.1.5 Accurate Health and Safety Knowledge Base

All too often the proprietary health and safety software that was evaluated failed to ensure that it was based upon accurate health and safety knowledge. This was highlighted time and again in Chapter 2, and was exemplified by instances such as Ergosystems Limited's Safety Auditor program being designed so as to conduct

auditing and risk assessments in an unsuitable and insufficient manner, by the poor definitions that the programs provided for key health and safety terms, and by the provision of poorly explained health and safety information. Health and safety software can only be as good as the health and safety knowledge upon which it is based. For this reason it is essential that health and safety software is properly researched and that appropriate health and safety expertise is drawn upon in the design of the software. Organisations who purchase health and safety software are relying upon that software to convey correctly important health and safety information. It is the responsibility of health and safety software companies to ensure that the informational contents of their software can be relied upon.

6.1.6 Realistic Scope

During the proprietary health and safety software evaluations, the programs were often considerably let down by the quality of some of the health and safety knowledge and tools which they attempted to provide. Sometimes this was because the software company had attempted to over-simplify the recording of a particular piece of health and safety information; sometimes it was because they had attempted to cover a large variety of health and safety management tasks but had failed to accomplish them with sufficient depth. As was emphasised in Chapter 2, if a piece of health and safety software features incorrect health and safety information or inadequate health and safety management tools, its value is likely to be significantly reduced, since it may prove to be misleading and may encourage organisations to undertake health and safety tasks in an inappropriate manner.

The key to avoiding such problems is for health and safety software to have a realistic scope. It is better for health and safety software to cater for one health and safety management task in depth than four tasks inadequately, and it is better for health and safety software to allow only basic information to be recorded with appropriate depth, than to attempt inadequately to allow a vast quantity of data to be recorded. The idea of a single piece of health and safety software allowing a wide variety of health and safety management tasks to be accomplished and a large quantity of health and safety data to

be recorded is fine in principle. But in practise it is not yet possible to create one program which can achieve so much at a consistently high standard.

6.1.7 Kept Up-to-Date

Because proprietary health and safety software is built upon numerous time-dependent factors, such as health and safety legislation, health and safety management theory, technology, work practises, and work materials, it needs to be kept up-to-date if it is to remain of value. This issue was examined in depth in Chapter 3. The annual software license is not a bad method for software companies to use to supply regular program up-dates to client organisations, if it is reasonably and consistently priced. However, client organisations should perhaps also be provided with discounts if they purchase two or three years worth of updates at a time, and should receive full refunds if the promised up-dates fail to materialise on time. Updates for health and safety software should be available through a variety of media, such as floppy disk, CD-ROM and the internet.

The binding nature of the annual software license would be considerably lessened if the problem of health and safety data which is recorded in a piece of health and safety software becoming unusable with time if the license is not renewed is resolved. As was stated earlier in this chapter, this could perhaps be accomplished if health and safety software was designed so as to allow health and safety data to be easily transferred to a proprietary office program such as Microsoft Access or to long-term storage media such as Iomega Zip and Jaz disks, CD-Rs and CD-RWs. The integral problem of regularly keeping health and safety software up-to-date perhaps favours larger rather than smaller companies as suppliers. For health and safety software to be of value, the supplying companies must be stable enough to supply regularly high quality program updates over a period of at least five years.

6.1.8 Properly Referenced Information

As was described in Chapter 2, when the proprietary health and safety software which was evaluated did provide health and safety information, it was often inadequately referenced. This significantly decreased the value of the proprietary health and safety software as a learning tool for the health and safety novice and as a reference tool for

the health and safety expert. Whenever health and safety knowledge is presented in health and safety software it should be properly referenced. This means that abbreviations and jargon should not be used without full explanation, that the titles of pieces of legislation should be provided fully, and that the source of information should always be indicated. Additionally, full reference details should be provided so that the user can easily pursue the original source of any information that is presented, and further reading lists should be supplied which provide the full reference details for relevant texts along with a description of the contents of those texts.

6.1.9 Explains Health and Safety Management Basis

Chapter 3 drew attention to the point that for proprietary health and safety software to be of value it needs to explain adequately its health and safety management basis. The software should seek to describe the theory of health and safety management upon which it is based. It should explain how the knowledge and tools that it provides can be utilised as part of the health and safety management system of client organisations. It should explain how it relates to health and safety legislation, and if it is legislation-based software, it should provide full original copies of relevant health and safety legislation. It should also provide suitable definitions for key health and safety terms. Information concerning the health and safety management basis of health and safety software should be located in the on-line help system and the program manual. It should be written in a clear, detailed manner, including high quality illustrations where they would help to communicate a point. If this was accomplished, health and safety software would offer far more as a learning tool for the health and safety novice. It would also offer the necessary information to allow the health and safety expert to determine how best to integrate the software with the existing aspects of their organisation's health and safety management system.

6.1.10 Emphasises Limitations

Whilst at some points the proprietary health and safety software that was evaluated did emphasise its limitations, as was demonstrated in Chapter 2 and 3 this was not accomplished to a great enough extent. Because many client organisations may be looking for a quick fix solution to proactive health and safety management, or a way of

shifting responsibility from themselves to a computer software company, and are likely to view health and safety software as being comprehensive and competent, the software should make the effort to explain the basics of health and safety management to the user and to explain in realistic terms what it can and cannot accomplish. Every piece of health and safety software has boundaries in terms of the depth of knowledge that it carries, and the way in which it can achieve health and safety management tasks. Those boundaries should be made explicit in the software manual and the on-line help system. When health and safety software generates risk assessment, reactive monitoring and auditing results, when it produces reports, and when it provides guidance, it should emphasise that the output is not comprehensive, should highlight any factors which are not taken into account in the output, should urge client organisations to examine carefully the output in relation to their unique environment, and should emphasise that the output is only a starting point for further thought on health and safety management.

6.1.11 Encourages Users to Transcend Software Boundaries

In a way this point is related to the previous two points, but it is so important that it needs individual attention. One of the frequent observations of the software evaluations was that the proprietary health and safety software failed to encourage the user to look beyond its boundaries. This point was discussed in Chapter 3. The failure was evident in the poor referencing and the reluctance to emphasise software limitations, but most of all in the general design of the software. The software often stated or implied that it offered a comprehensive coverage of a health and safety management task. It rarely provided a description of its health and safety management basis, rarely described its relevance with regards to compliance with health and safety legislation, rarely actively encouraged the client organisation to take a greater interest in health and safety management, and rarely actively encouraged the client organisation to consider how they could build upon the foundations that it offers.

6.1.12 Encourages Users to Think about Health and Safety

At many points during the software evaluations it was concerning that the software did not greatly encourage the user to *think* about health and safety. Because health and safety is such a unique field, which involves new problems constantly arising, a variety

of knowledge and skills having to be integrated to develop quickly solutions, and the application of creative, ingenious, flexible thinking, it is most important for health and safety texts and software to encourage people to think about health and safety. This theme was discussed in Chapter 3. Thus whilst it is essential that health and safety software should explain its health and safety management foundations in clear terms, it is equally essential that throughout the software, knowledge and skills are not spoon-fed to the user without explanatory comments and without encouragement to think.

Health and safety software should not perpetuate the myth that there are easy, shortcuts to effective health and safety management. The software should not entice the user to believe that they can undertake health and safety management tasks without thought, simply by following what the software says or does. This point is inextricably linked with the previous points, since by including properly referenced information, emphasising software limitations and encouraging the user to look beyond software boundaries, the user can be encouraged to think about health and safety management. Health and safety software should clearly emphasise that it only shows one way in which health and safety management tasks can be accomplished, and that users should use the software as a starting point for considering how they can best accomplish the tasks to suit the health and safety management needs of their organisation.

6.1.13 Greater Flexibility

One of the problems that was frequently encountered during the software evaluations was a lack of flexibility. This typically meant that the proprietary health and safety software dictated to its client organisations how health and safety management tasks should be undertaken, with no allowance for individual variation or adaptation to match evolving health and safety management needs. This issue was discussed in Chapter 3. For health and safety software to be of greater value it needs to be designed with greater flexibility. At the least, the software could offer the user basic customisation options so that they can select the main colours that are used on the program screens, the type and size of font which is used for text in the program, and the view size for the program screens. Even minor improvements in flexibility can enhance the feeling of user control.

At a more complex level, health and safety software needs to be designed in a way which provides alternative methods for accomplishing health and safety management tasks. Thus a health and safety legislation reference program such as Gee Publishing Limited's Health and Safety Lawbase should allow the user to access its information by a legislation-based approach as well as a topics-based approach. Similarly, when a program attempts to provide a health and safety policy creator, such as in ErgoSystems Limited's Safety Auditor, multiple health and safety policy templates should be provided for the user to choose amongst. Further, when health and safety software provides assessment forms, as in the two aforementioned programs, it should be possible for the user to modify their content and presentation format. The instances could be continued ad infinitum, but the principle of providing client organisations with more options, more choice, more flexibility and more control remains vital. The nature of health and safety management demands flexible and adaptable software. Ultimately health and safety management requires interactive software systems that the user can easily configure to perform whatever tasks they want however they like.

6.1.14 Improved Consistency

Frequently in the software evaluations which are summarised in Chapter 2 attention was drawn to the lack of consistency within the programs which were being evaluated. The programs often failed to be designed in a manner which is consistent with Microsoft Windows standards. They often failed to provide data consistency checks to ensure that only valid data is entered. There was often a lack of consistency between the way in which information is presented on the program screens and the way in which it appears when printed. There were contradictory health and safety definitions within some of the programs. The main point is that health and safety software needs to be designed so as to be internally consistent, and to also be externally consistent with the latest computer operating system software standards. When computer programs allow inconsistencies to exist, those inconsistencies are likely to confuse and deter the user - they reduce the overall quality of the software.

6.1.15 Enhanced Feedback

As was highlighted in Chapter 2, the proprietary health and safety software that was evaluated often failed to provide the user with adequate feedback. At the simplest level, only HASTAM Limited's Microsafe, MicroCOSHH and S-CHASE featured a status bar to provide feedback on the user's command selections. At a more complex level, several of the programs, such as Safecode Limited's IRIS, failed to include adequate warnings of potential data loss, irreversible commands or system instability. The lack of high quality feedback made the programs harder to learn and use than was necessary. It is recommended that all health and safety software should be designed so as to keep constantly the user fully informed via suitable feedback.

6.1.16 Enhanced System Stability

A constant feature of the software evaluation process was the instability of the pieces of software that were examined. This was drawn out in Chapter 2. It is vital that any computer software be designed to be as stable as possible, and that to incorporate checking mechanisms to ensure the continuity of system stability. When system stability is threatened, the user should be presented with clear, meaningful warning messages, so that they can ascertain the nature of the problem and judge how they should respond. With health and safety software there is perhaps an even greater need to ensure system stability, since it is vital that data can be reliably stored over the long-term if the software is to be of value. Further, as was discussed in Chapter 3, if data corruption occurs due to system instability, the effects may not be immediately transparent to the user, especially if they are a health and safety novice or a computer novice. If corrupted data is acted upon it could result in significant negative consequences.

6.2 The Implications for the Use of IT in H&S

> *We are reaching the stage where problems that we must solve are going to become unsolvable without computers. I do not fear computers; I fear the lack of them.*
>
> Isaac Asimov[76].

[76] Quoted in Beekman (1994) - date of quotation not given.

Although numerous broad lessons have been presented above for improving the design of health and safety software, the glaring problems of providing long-term data storage, keeping the software up-to-date, ensuring accurate health and safety knowledge and tools are provided, and providing client organisations with flexibility in terms of how they undertake health and safety management tasks, suggest that whilst proactive health and safety management software may be desirable at the present time we do not yet have the means to create and maintain it adequately in the format which has been examined in this research. Even if proprietary health and safety software could be designed with accurate health and safety knowledge, suitable health and safety management tools, a high level of software design competence, and a suitable degree of flexibility, it would still only offer a short-term solution to proactive health and safety management tasks at best.

As the quality of information technology and proprietary office software is constantly improving, one would question the extent to which health and safety management needs can be catered for by these rather than by proprietary health and safety software. Health and safety reports, forms, letters, policies and tables can be created by using word-processing software. Health and safety data can be stored in database and spreadsheet programs. Statistical tables and graphs can be developed in statistics software. Diagrams, maps, photographs and illustrations can be developed in graphics programs. Posters, booklets, and notices can be created in desk-top publishing software. Detailed maps and drawings can be created in computer aided design software. Health and safety legislation can be acquired on multimedia CD-ROM and DVD, and health and safety information can be acquired from the Health and Safety Executive (HSE)'s internet web site. Information can be presented and communicated by presentation software. Health and safety meetings, schedules and activities can be recorded in organiser software.

Nevertheless, one of the main reasons why organisations seek to purchase proprietary health and safety software is to buy pre-packaged, ready-made health and safety knowledge and tools. Often this is because they feel that they do not have the necessary knowledge and skills to develop their own proactive health and safety management

systems. Many organisations are looking for step-by-step practical guidance as to how they should undertake proactive health and safety management tasks. For organisations to be able to make use of existing proprietary office software for health and safety management they first need to have a good understanding of health and safety knowledge and tools, and a very clear idea of what they want from their health and safety management systems. It is this point which also means that although it is possible for organisations to purchase custom-made and tailored health and safety software which offers a more flexible alternative to proprietary health and safety software, and may not differ too greatly in price, many organisations may choose not to invest in this type of software.

Crucially it is the same difficulty in understanding health and safety knowledge and tools which drives organisations to seek ready-made solutions to health and safety management, and which is evidenced in the contradictions and confusions throughout health and safety software and literature. The starting point has to be an attempt to clarify and consolidate health and safety knowledge and tools to remove many of the confusions and contradictions, and to explain health and safety management in a practical and complete manner which makes explicit much of the detail which has hitherto been left implicit. When this is accomplished health and safety knowledge and tools must be made freely available and readily accessible to everybody. The medium for accomplishing this which has the most potential is the internet, and in particular the HSE's web site. There will be no need for organisations to purchase special computer software and CD-ROMs or DVDs to obtain copies of health and safety legislation, approved codes of practise, industry guidance, HSE guidance, research papers and British Standards. They will instead be able to access this information quickly and directly when needed from the internet, and need not fear that the information will be out-of-date or incorrect.

I do not envision the future resulting in the use of less information technology in health and safety, but rather in more. In particular, there are great possibilities for the use of information technology to make explicit and understandable the many visualisation processes that are involved in health and safety management. This should help to

present health and safety knowledge and tools in a clearer, more readily understandable manner. It should help to clarify how proactive health and safety management tasks can to be practically undertaken. As time passes by a larger and larger percentage of the workforce will possess computer skills, and hopefully will be more familiar with health and safety management. In addition to the internet serving as a vital communication and reference tool, there are a number of other areas where information technology may be able to make an important contribution to health and safety management. Several of these areas are discussed below, although the list is by no means comprehensive.

6.2.1 Interactive Multimedia Training

Training is an area in health and safety management where information technology could have a large-scale influence. Since it can be difficult to understand health and safety management from text alone, information technology offers the possibility of new interactive training methods which incorporate sound, pictures, animations and films. At one level, CD-ROMs and DVDs could be developed to contain training courses for particular areas of health and safety management. Organisations could purchase health and safety training CD-ROMs or DVDs and their employees could work through the material at their own pace. At a more advanced level, an internet support service could be provided for the health and safety training CD-ROMs and DVDs, so that users could ask questions related to the material and receive answers via e-mail. At an even more advanced level, the CD-ROMs and DVDs could form the basis of a taught course with an examination and qualification at the end. Organisations could build-up a library of health and safety CD-ROMs and DVDs, which could be available for use by any employee.

Ergosystems Limited's Safety Auditor demonstrated the potential for developing computer software which allows multimedia training programs to be created and viewed. Although the software evaluation identified flaws with the auditing and risk assessment aspects of the program, no fault was found with the training concept. In many ways Safety Auditor would have been more impressive had it concentrated upon providing a full service for the creation and viewing of training programs, rather than attempting to cover auditing, risk assessment, and training in one program. With a few

enhancements the training aspect of the program could provide a very useful facility. It would be a great step forward in health and safety training if organisations had the means to create easily multimedia training files. A complete health and safety training program may need facilities to allow client organisations to create their own animations, pictures, sounds and films, rather than just being able to import them from other software. The one query that does exist with this type of specialist health and safety training program, is that in many ways organisations could accomplish the same feats by utilising existing proprietary office presentation software such as Microsoft PowerPoint.

Training CD-ROMs and DVDs or computer programs could enable interactive training to be developed, whereby the user is not merely presented with information, but is also presented with learning activities to undertake. These could involve educational games, which are discussed separately below, or could involve the user working through the completion of a risk assessment or incident report form with the computer as in a tutorial. At an advanced level it should soon be possible to undertake interactive training from a distance by the use of video-conferencing methods. This would allow the feel of a live training course to be maintained and would allow feedback to pass quickly from students to trainer. At the moment video-conferencing is relatively expensive, so an alternative is the broadcast of training material via CD-ROM and DVD or the internet, followed by a live internet chat session about the issues raised. Although e-mail is already used to enhance distance learning methods, live chat sessions would have the benefit of bringing together many distance learners at a time to talk together and with the trainer about health and safety.

I would expect to see a wider use of Virtual Reality for health and safety training, particularly in the case of high risk scenarios, such as offshore work, firefighting, and electrical engineering. Whilst Virtual Reality programs are still relatively expensive to construct, they have the great benefit of being individually crafted to match the purchasing organisation. Rather than training individuals in knowledge, Virtual Reality programs can train individuals in practical, and often complex, skills. Any computer software which can help to train people in a realistic environment with the actual chance

of physical harm removed is invaluable. In addition to this, Virtual Reality could also be used for training people in hazard identification and risk assessment. Extensive workplaces could be generated in Virtual Reality which the user can walk through looking for hazards, checking that suitable control measures are in place, and assessing risks. The opportunity to learn to assess risks in a mock yet realistic environment would be greatly appreciated by many who feel daunted by the responsibility of risk assessment.

Information technology can perhaps also be used to provide tests and examinations in health and safety. At the simplest level, software could be devised which allows individuals on training courses to complete multiple-choice tests and written examinations on-site on computer rather than on paper. A suitable security system would need to be devised to lock up the original answers once the student had completed the test or examination. The completed scripts could be collected together on computer disks and distributed to examiners. The examiners would work through the scripts on computer being able to add comments and marks in a different colour text, but being unable to tamper with the original answers. The results would be fed into a spreadsheet or database program. Once this method is implemented it would mean that individuals could easily complete tests and examinations, with supervision, anywhere in the world, with the results immediately fed back to the trainers. Individuals would be able to use the same technology to practise for tests and examinations by completing former papers and then reading recommended answers.

The use of information technology for tests and examinations would mean that different types of test and examination could be more easily devised. They could incorporate text, pictures, sound and films, which would be of particular benefit for health and safety because of its strong practical basis. For example, colour photographs and video footage could be presented of different types of metal failure in machinery with a description of the machinery's task and surrounding environment. The user would be required to describe the failure, its possible causes and the possible consequences if it is not acted upon. For another example, a display screen equipment assessment form could be presented with a description and video footage of the location in which it is to be used,

and users would be required to discuss the strengths and weaknesses of the form, with recommendations for improvement. They could even be required to re-design the form in a word-processing program or desk-top publishing program. As a final example, users could be presented with a description of an incident, together with illustrative pictures and video footage, audio recordings of witness interviews, and a copy of a piece of health and safety legislation. They could then be asked to identify possible breaches in the legislation. These types of test, together with similarly devised training materials, would better enable trainers to educate people in the practical side of health and safety management. At the moment so much becomes lost by the attempt to confine health and safety to words alone, or to words with a few static black and white pictures. The visual richness of the subject is ironically often neglected, when it is this aspect which can offer the best communication method between the health and safety expert and the uninitiated.

6.2.2 Flexible Reference Sources

Several of the pieces of proprietary health and safety software that were examined for this research attempted to provide health and safety reference sources, most commonly for legislation or hazardous substances. Although the software evaluations identified some problems with these reference sources, see Chapter 2, the idea of utilising information technology to provide health and safety reference sources has great potential. There are already a number of CD-ROMs available on the commercial market which feature particular areas of health and safety information. In all probability, these will continue to be available, and will be of considerable use in health and safety management, to convey health and safety research articles, health and safety legislation and guidance, British Standards and industry guidance. Beyond this I imagine that more and more health and safety information will be readily available at internet databanks, which can be accessed by any organisation. Internet databanks for hazardous substances, work practises, machines, and risk control measures amongst others will be able to offer up-to-the-minute pooled multimedia health and safety knowledge. Organisations will no longer need to purchase specialist health and safety software to obtain such information.

Another way in which information technology can aid health and safety management is by the provision of portable reference sources. These could be in the format of multimedia reference files loaded upon a portable computer which can be taken out on site. The tool could be used by the health and safety professional to have expert information at their finger tips, or by the health and safety novice to enable them to have practical, step-by-step guidance to follow when undertaking health and safety management tasks. For example, an individual who is new to air monitoring would be able to go out on site with a portable computer loaded with an air monitoring multimedia reference source. They would then be able to refer to the portable air monitoring reference source for detailed step-by-step practical guidance with pictures and films of the task being undertaken by experts utilising the same equipment.

6.2.3 Educational Games

Information technology could contribute significantly to health and safety by being a medium for providing educational games. The basic tenet of educational health and safety games should be to transfer practical skills from health and safety experts to health and safety novices, and to teach the latter how to apply health and safety knowledge in the workplace. Educational games are essentially another type of training material but they can offer a greater level of participation and interaction than many other training methods. If a game is well-designed it can offer a method of learning which is appealing, and which does not necessarily require the presence of a health and safety expert. Whilst educational games can be used in the workplace and in training courses, they have the added benefit that they can also be used in schools and colleges.

Computer technology could be used to provide a large number of different types of health and safety educational games. One example is a basic question-and-answer game, where the user is presented with a set of questions concerning a particular health and safety topic, and for each question they are presented with several set answers. The user selects the answer that they believe to be correct and gains points for each correct answer. At the end of the set of questions, the user could be presented with a percentage to indicate how well they did, and could be automatically taken through the questions which they answered incorrectly to be presented with explanations of the appropriate

answers. With this game, not only can sets of questions be developed for different topics, but they can also be developed to cater for different difficulty levels. Thus it would be possible at one extreme to provide a broad set of questions regarding office safety for employers, and at the other extreme provide a detailed set of questions concerning types of machinery guards for individuals who are studying for a NEBOSH Diploma.

The basics of the question-and-answer game can be enhanced by the provision of pictures and sounds, by developing team competitions, and rewarding good performances with prizes. The game can be represented in a different format in computer software by the provision of a more interesting interface. Thus, for example, users could be required to answer questions as before, gaining a piece of a health and safety certificate each time they answer a question correctly, and losing a piece for each incorrect answer. The game could be played between one to eight individuals, with the winner being the first person to complete their certificate. A board game interface could also be used where one to eight individuals move their pieces around the board answering questions on different health and safety topics when they land on different coloured squares. The users could simply be awarded points for their answers with a certain points target determining the winner, or be required to complete a health and safety certificate as described before, or advance through a mock health and safety scale from health and safety novice to health and safety expert.

A different type of educational game which could be provided for health and safety by information technology is spot-the-hazard. A piece of computer software could offer a vast variety of drawings and photographs of rooms in workplaces, machines, vehicles, protective equipment, and people performing tasks. These could be divided into categories for easy access, and when one is selected the user would be required to identify the hazards by circling areas with the mouse. When the user had completed their hazard identification process, the program could provide a percentage for the number of hazards that the user identified, and could demonstrate where any hazards existed that the user had failed to identify. The user could then be presented with a piece of explanatory text describing the hazards in the picture. The same game could be

played by requiring the user to type into a notes datafield a description of any hazards that they identify. They could then compare this with the program's description of the hazards in the picture, or work through the description with a health and safety expert. The same game could be played at a more complex level for those with a greater depth of health and safety knowledge, by requiring the user to entering a notes datafield a description of all of the health and safety issues that need to be considered for the situation or item shown in a picture. They could then compare this with the program's description of the health and safety issues that need to be considered for the picture, or work through the description with a health and safety expert. Whichever way the game is played, the program would always need to emphasise that it is not comprehensive, and that the user may identify additional hazards or health and safety issues to those that are listed.

Another type of educational game could involve a computer program presenting multimedia versions of various health and safety scenarios and case studies with associated questions for consideration. A scenario could be selected and presented to a group of individuals. The scenario could include text descriptions, audio soundtracks, and photographs, drawings, charts and films. The type of scenario could vary considerably, from a description of a real or mock legal case with questions as to where breaches in health and safety legislation occurred, to a description of an emergency health and safety situation with questions as to what should be done next, to a description of a health and safety report with questions as to what parts of its contents or approach is incorrect, to a description of risk assessment results with questions regarding what actions should be taken to reduce risk. The group would be required to consider and discuss the questions posed. Then the recommended answers could be viewed for the scenario or case study from the computer software. The software would need to emphasise that the recommended answers are not absolute, and encourage the viewers to discuss them in light of their own answers. The game would probably need a health and safety expert to be present to provide guidance in order to be most effective.

6.2.4 Visual Tools

Another way in which information technology can be used in health and safety is for the provision of visual tools such as clipart, picture catalogues and health and safety signs. With regards to the first possibility, clipart can conveniently provide organisations with many health and safety symbols to use on labels, letters, documents and notices. The clipart can include chemical symbols, personal protective equipment symbols, and symbols illustrating hazards in the workplace. The picture database in Ergosystems Limited's Safety Auditor demonstrated how such a facility could provide a useful means of aiding visual communication for health and safety. Although specialist software is now available on the commercial market to provide health and safety clipart, I would strongly suggest that there is no need for organisations to purchase this, since general clipart programs such as Corel Gallery, which features thousands of clipart images for an extremely low price, include hundreds of health and safety symbols.

A different type of visual tool that computer software could provide to aid health and safety management is picture catalogues. These could be purchased on CD-ROM or DVD and would contain a variety of health and safety related photographs and drawings. The photographs could include images of different types of metal failure, health and safety warning signs, personal protective equipment, and machines amongst others. They could also include series of photographs from key health and safety incidents. Picture catalogue CD-ROMs and DVDs could be used for health and safety training purposes. They could be viewed directly from the CD-ROM or DVD, or could be transferred into word-processing programs to be used in training documents or into presentation software to be used in presentations. In other words, picture catalogue CD-ROMs and DVDs could be used in health and safety management to enhance the link between health and safety theory and practise.

Although pictures and diagrams are already used in health and safety management, they are not used often enough. Many health and safety texts and pieces of training literature make only minimal use of pictures and diagrams, and fail to use visual communication at the points where it would be most helpful. When pictures and diagrams are used in health and safety texts and pieces of training literature they are often of poor quality.

This is because the photographs which are presented are often black and white close-ups which are awkward to view and understand. The removal of colour from photographs results in the loss of a large quantity of information, and may in some way reduce the directness of the link between photographs and the workplace. Similarly, diagrams which are presented are often entirely black and white when the use of colour could have significantly enhanced and clarified the information that they are attempting to present. Finally, when pictures and diagrams are used in health and safety texts and pieces of training literature they often do not make explicit the link between health and safety theory and practise. For example, Stranks (1996c) provides sketches of machinery hazards, such as shearing traps and in-running nips, but does not make the hazards explicit by then showing clear photographs of machines in the workplace with the same hazards highlighted upon them. If high quality pictures and diagrams are regularly used in health and safety training and literature, the visualisation processes that are important for hazard identification and risk assessment can be constantly reinforced, and the means of applying health and safety knowledge and skills to the workplace can be made clearer.

As well as providing ready-made health and safety picture catalogues, information technology can also be used in health and safety to allow organisations to construct readily their own health and safety picture catalogues. Proprietary office computer software which is available on the commercial market for the collection, storage, viewing and manipulation of photographs can be utilised to great effect. With such software every organisation can create their own valuable health and safety catalogue of photographs of workplace locations, operations, risk control measures, hazards, emergency facilities, and health and safety assessment forms. These photographs can then be used to enhance training by strengthening the link between training material and its application in the workplace. For example, when induction training is being provided for canteen workers, they can be informed of the variety of hazards in the canteen through verbal information and the provision of photographs illustrating those hazards. So there could be a photograph of an unattended chip pan boiling over, or a worker carrying an overloaded tray, or loose electrical wiring. The new canteen workers could be asked to discuss these photographs with regards to the danger that may result, and

how the hazards could be eliminated. The fact that the photographs are of the actual workplace should make the training more salient and effective. The same photographs can also be used by organisations to communicate better health and safety information in reports and documents.

6.2.5 Internet Sites

I believe that internet web sites are going to play an increasingly important role in the communication of health and safety knowledge and tools. In the near future the majority of homes and workplaces will have access to the internet. This provides an excellent opportunity to take health and safety management into a new era. One where the strong connection between expert health and safety organisations, such as the HSE, the Royal Society for the Prevention of Accidents (ROSPA), the Institute of Occupational Safety and Health (IOSH) and university health and safety departments, and the employer and worker in the workplace is revitalised. Every major non-commercial expert health and safety organisation will have its own high quality, interactive internet site to meet the health and safety management needs of the general public.

The HSE's internet site is already moving along the right lines. It offers a friendly informative service with free information on many health and safety topics available for down-loading. The potential for the site far exceeds its current status however. At the moment only a fraction of the HSE's booklets and guidance sheets are available for free viewing via the internet. I envision a time in the near future when every single one will be available, along with every piece of health and safety legislation, and every British Standard related to health and safety. Organisations will then easily be able to check their legal responsibilities, or a technical detail or obtain basic information. I also envision the HSE's internet site providing basic health and safety assessment forms and notices which can be downloaded free and used by organisations. Many organisations, particularly small businesses, will continue to seek ready-made health and safety forms and notices. It is surely far better that such forms and notices are provided free by a reputable authority like the HSE than that organisations purchase specialist health and safety software from small software companies to provide them or purchase ready-made booklets of forms and notices from office suppliers. Further, the HSE internet site

should include interactive health and safety games such as those that were described earlier. This should encourage people to take an interest in health and safety, and would be useful for schools and other educational establishments.

In addition, the HSE's internet site should move beyond mere text to offer video clips, pictures, animations and tutorials to demonstrate practically how proactive health and safety management tasks can be undertaken. There should be a live chat room where anybody can discuss health and safety issues, so that health and safety information and advice can be freely exchanged, and new contacts can be made. There should be a regular series of interviews with health and safety experts, industry leaders and business people to encourage discussion of health and safety management. Computer users would be able to send questions in for each interview, and a moderator would select the best questions for the guest to answer. The interview transcripts would then be available for viewing at any time on the internet site. As well as interviews, there could be regular live question-and-answer sessions with members of the HSE and other health and safety experts. These would allow the general public to ask respectable sources about the basics of health and safety management, about how they can obtain advice on particular areas of health and safety, and to discuss particular problems that they have encountered. Again, the transcripts of these question-and-answer sessions could be made available at the internet site for free viewing at any time.

6.2.6 Advanced Possibilities

The possible uses of information technology in health and safety management which have been discussed so far are, I believe, realistic in the near future. However, a great number of possibilities can also be conceived for the use of information technology in health and safety management in the long-term future. One possibility is the development of portable health and safety management systems. These would need to be created to match specifically a particular organisation's unique health and safety management needs. Thus an incident recording system could be developed where an individual can enter incident details directly into an on-line incident record which is contained in a portable computer incident book. When data entry is complete, the incident record would be electronically transferred straight into the main incident

recording database where it can be analysed. The system would allow incident records to be accurately completed on the spot. Further, digital cameras and microphones could be linked directly to the computer incident book to allow photographs and interviews to be taken at the incident scene. The photographs and audio recordings could be automatically incorporated in the incident record in the multimedia incident database.

Similar portable systems could be developed for other health and safety management tasks, such as risk assessments and active monitoring. For these areas the systems would probably be part reference source, part practical tool. Hence, an organisation would be able to own a risk assessment system designed specifically for their health and safety management needs, which could be easily transported around the workplace to allow on-line risk assessments to be completed and analysed, with interactive step-by-step guidance, direct contact via the internet with reputable health and safety organisations for advice, and information search facilities to allow on-the-spot research to be conducted to aid practical problem solving. The health and safety manager and business manager of the future need never feel isolated and uninformed, they will be able to contact health and safety databanks, organisations and experts rapidly. Eventually it may be possible for the quality of long distance health and safety advice to be enhanced by the use of digital cameras and microphones to allow on-the-spot visual images and audio recordings to be easily communicated from the workplace to the experts. Thus if an organisation is unsure about the hazards that exist with a particular machine in their workplace, they could send live video footage and photographs through the internet to reputable health and safety experts for immediate advice.

6.3 The Implications for Future Research

This thesis has a variety of implications for future research. Firstly, it has demonstrated that this is an area in health and safety which has lacked proper attention. There has been little academic research conducted concerning the application of information technology to health and safety management, there are few journal and magazine articles upon this subject, even fewer texts, and very few health and safety courses which cover this topic in any detail. This situation needs to be addressed. There is room

for an immense variety of research projects in this area, including ones based upon the following topics.

There should be research conducted to examine the impact of the Information Technology Revolution upon health and safety management. At the time of writing, we are still in the midst of this revolution, so it would be an ideal time to attempt to examine how, if at all, IT has changed the nature of health and safety management, and to what extent any changes are for the better. I firmly believe that the Information Technology Revolution is as vast a force as the Industrial Revolution, and that we are crossing a crucial boundary which will forever change the nature of work and leisure. Imagine if researchers for health and safety had been able to conduct meaningful research projects during the Industrial Revolution concerning its implications for health and safety. Such research projects could have been of immense value. This is equivalent to the research opportunities which are available to us now during the Information Technology Revolution. Health and safety researchers must surely seek to take advantage of these opportunities.

Another area where research is required is to examine new ways of utilising IT in health and safety. This would involve attempting to develop practically the types of ideas which were discussed in the previous section, and to generate new ideas both in theory and practise. This is a vast research area where the expertise of IT researchers could be combined with that of health and safety researchers. Organisations may be particularly interested in collaborating with research projects in this area, especially those which produce new training methods.

The value of the internet to health and safety management is a further area for future research. It has already had a significant impact upon academic research in terms of the wealth of information and contacts from around the world which are readily available. It has important implications for the future of health and safety management, with the design and operation of health and safety websites and chat forums, the ability for organisations to market health and safety products via the internet, the ability for universities and organisations to offer training courses via the internet, and the

possibilities with regards to on-line health and safety databases concerning hazardous substances, legislation, machinery and work equipment, control measures, previous experiences and advice. As an example, a research project similar to this one could easily be conducted to examine the quality of health and safety websites and their implications for health and safety management.

This research project focused upon proprietary health and safety management software, but there are many other types of health and safety software which could be examined in future research projects. Examples include high-level software which is designed for: modelling the environmental effects of industrial accidents which involve fire, explosion and vapour cloud release; modelling the environmental effects of water, air and ground pollution; undertaking detailed epidemiological analyses; and operating industrial processes and health and safety controls. The application of artificial intelligence to health and safety management is another topic worthy of research. The possibilities for expert systems could be re-examined in the light of the recent improvements in information technology.

Further research could be undertaken concerning the evaluation, selection, implementation and maintenance of computer software for health and safety management. One idea following this research project would be to conduct experiments to test the practical value of the software evaluation chart. Another idea would be to undertake case studies with organisations to observe the practical and long-term issues which are involved with the whole evaluation, selection, implementation, and maintenance process for health and safety software. Finally, as was mentioned in Chapter 3, the issue of product liability for companies who create health and safety software needs to be examined in greater depth, with the analysis drawing upon appropriate legal expertise.

6.4 Final Thoughts

Twas brillig, and the slithy toves
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

Lewis Carroll (1872) *Through the Looking Glass*[77].

This research project has involved a journey being taken from the first naive assumption that there was a need for integrated health and safety software in proactive health and safety management, to the view that the current range of proprietary health and safety software has crucial weaknesses which seriously undermine its potential value to health and safety management. The journey has not been easy as the problem with proprietary health and safety software was found to have much deeper roots than was originally thought. The easy part would be to look at the software evaluations of the seven pieces of proprietary health and safety software and blame the software companies for the numerous problems which exist. I would not seek to do this though, since one of the points which this research has highlighted is how immensely complex it is to attempt to design and maintain proprietary health and safety software that is competent from both a software design angle and a health and safety management angle.

The research has also shown that in its current rigid and rudimentary form, proprietary health and safety software is probably not the area where information technology can be used to greatest effect in health and safety management. There are numerous other possibilities which need detailed consideration, including custom-made software, tailored software, and many of the options that were mentioned above. The important point is for the health and safety experts to take a keen interest in the possibilities for the use of computer software in health and safety management and actively guide its development rather than continue to observe from the sidelines. In the future rather than

[77] Quotation from original source. This quotation provides an interesting comment at the end of the thesis, because on initial reading it appears to make sense because of its correct surface structure (its grammatical form), even though it entirely lacks deep structure (meaning). In a similar way, it is easy to be deceived by the attractive packaging of health and safety knowledge and skils into computer software which claims to offer a ready-made solution to proactive health and safety management tasks. Just because the surface structure is appealing, however, does not automatically mean that there is suitable and sufficient deep structure.

small software companies attempting to supply the computer software for health and safety by themselves, I would envisage software being produced directly by or in collaboration with respectable health and safety organisations, such as the HSE, IOSH, ROSPA, and university health and safety departments. These organisations would of course need to become fully up-to-date with the intricacies of information technology if they are to be able to offer more than a superficial input in this area and if they are to avoid offering their support to software which is poorly designed. This is surely the best way to ensure that the necessary degree of health and safety competence is present in health and safety software, and to ensure that if such products are created there is a long-term commitment to them by the suppliers. Additionally, the direct involvement of reputable health and safety establishments with health and safety software could provide a guide for organisations as to how they should best utilise information technology for proactive health and safety management.

Above all, the links that the research has drawn between the weaknesses in health and safety management theory, the weaknesses in health and safety literature, and the weaknesses in health and safety software are of the utmost importance. When I commenced this research project I had previously studied many different academic fields, including psychology, artificial intelligence, management, economics, mathematics, English literature, physics, chemistry and history. Yet I would maintain that I have never encountered a field which is so inaccessible to the average person, nor one which has so much direct relevance for the average person. When health and safety texts are often too technical, rarely start with the basics, assume too much knowledge in the reader, are expensively priced, under-utilise visual communication methods, and contain conflicting knowledge and skills, the average person does not stand a great chance of learning how to undertake complex proactive health and safety management tasks. This is the point which must first be addressed. Health and safety should never lose sight of the fact that its purpose is ultimately to create a solid foundation of knowledge and skills which can be applied practically in the workplace to educate and protect the average person. With the emergence of proactive health and safety management there is a greater need than ever to evaluate and consolidate health and

safety knowledge and skills, and to attempt to communicate them in a clearer, more advanced manner[78].

[78] The HSC (1997) have recently acknowledged the extent of the problem with their unprecedented attempt to use television to communicate health and safety knowledge and skills to businesses. They have stated, five years after the release of the risk assessment based health and safety legislation, that "*we know that many small companies do not know how or where to begin with health and safety*".

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