THE AUDIT OF EXPERT SYSTEMS

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ABSTRACT

This study presents the results of an investigation into the methods of auditing Expert Systems. Such systems have already proved to be, and are increasingly becoming, a very powerful tool in many areas such as medicine, geology, finance and banking. They embody unique risks which are not treated by conventional audit methods of operating or developing software. The lack of awareness and information about Expert Systems in general and their auditability in particular are somewhat surprising.

The author, in tackling this new area, has developed and proposed two models of auditing Expert Systems; a) the Audit of an Operating Expert System(AOES). b)the Audit of an Expert System under Development(AESD). The first model incorporates the "control band" which aims at eliminating the exceptional risks and to allow the internal auditor to treat it as conventional software. The second proposed model is based on "NESDEM" ; a normative evaluation model for Expert Systems.

The test of the proposed AOES model was conducted in two different organisations: ARJO-WIGGINS APPLETON which developed and still uses an Expert System for it's paper mill and the CITY UNIVERSITY DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE which developed an Expert System for eye-tests.

Unfortunately the author was unable to test his proposed AESD model under a "live" development process due to lack of cooperation from organisations which the author contacted. Consequently he tested this model by mailing questionnaires to internal/external auditors within the U.K.

Given the research performed in this study and subject to the limitations detailed , the proposed models appear reliable, flexible, practical and suitable to the internal auditor in assessing the effectiveness of the internal controls within Expert Systems.

CHAPTER I

DESCRIPTION OF THE STUDY

1.1 INTRODUCTION

In the past few years, we have faced a tremendous expansion in the commercial use of software named "Expert Systems" (defined below). There was substantial progress in the area of Expert Systems (E/S's) in the U.K when a committee was set up in 1993 to inquire into the potential of Intelligent Knowledge Based Systems (IKBS). In response to the committee's recommendations, the British Government initiated a five-year $1 billion research and development programme for information technology (1).

Another research project was undertaken in Great Britain, the results of which, published in 1989, showed that the use of E/S's had become widespread in various aspects of the British economy. The study focused on twenty-four large organisations who have 200 E/S 's in use.(2). The reports published by these twenty-four firms (which include Barclays Bank , BT and TSB) indicate great success, an annual saving of millions of Pounds and sometimes a one-year return on investment. The advantages of E/S's mentioned by the users included: time-savings, quality improvements, increases in productivity and cost-savings. RADA and others (1991) stated that the UK is a major developer of E/S's and concluded that the knowledge bases for many activities is widely accepted in the UK(3).

Research into one hundred insurance companies in the USA in 1987 indicated that, twenty-two (of the largest) used E/S's, forty-one had such software in various stages of development and sixteen were planning similar development. Only twenty-one firms did not have any plans to use E/S's (4).

From a marketing point of view, the advantages of E/S's, as reported by the users, are very important accelerating factors in the software market. Funds are continuously being invested in research and development of new E/S's, so the expectation is that they will be impacting the market in the future.

HOLSAPPLE and WHINSTON estimated in 1986 that the E/S's market would grow from a nearly negligible level in 1984, to well over $1 billion by 1990(5) (no recent quantification is available). In 1991, the Department of Trade and Industry and the British Computer Society concluded that although the known number of operational knowledge-based systems within the UK is still relatively small, many more companies are considering their use(6).In 1985, Artificial Intelligence (AI-the science from which the Expert System was developed see below) was 0.1% of the computer market. Scientists predict that in the year 2000, it will be 26% of the total computer market (7); a remarkable progression in a short time.

HSU and KUSNAN, (1989) are adamant " The field of E/S's is expanding, and as more work is done in this area, you will find computerized experts in more fields and industries. This is one of the most promising areas of AI and the fifth generation, and one that will be of considerable benefit to persons of all careers and backgrounds "(8).

WHAT IS AN EXPERT SYSTEM?

An Expert System is a derivative of ARTIFICIAL INTELLIGENCE (AI)(9) about which it has been said :"AI is a revolution in the making...the goal of AI is to make computers do things which human minds can do..."(10). The other branches of AI are:

- Natural language understanding
- Pattern recognition
- Intelligent computer-assisted learning
- Speech recognition
- Models of human cognition (11)

Research into AI started before the Second World War (12). The first E/S, which appeared in the Sixties, were DENDRAL in chemistry, and MYCIN in medicine. This history will be discussed in detail in Chapter II (Review of Literature). However, for purpose of clarity a useful definition is: " E/S's are computer programmes that exhibit the behaviour characteristics of experts. They can be used to replace the expert's expertise to make it available to others "(13). That is to say that, contrary to other known software, these replace the human expert, " Dozens, perhaps hundreds, of E/S's have been developed for a number of different problem domains ranging from medicine, engineering, finance and science, and covering tasks such as diagnosis, design, problem solving, planning, repair, research, interpretation, training, monitoring and control, to name but a few. A common feature of these applications is that their structure includes:

- a natural language system
- an inference engine
- an internal store problem domain, and task knowledge, called here a knowledge base "(14).

Some authors use the definition knowledge based system for E/S's. Although there is extensive daily use of E/S's, some scientists still think that their real expansion is yet to come (15).

CHAMBERS and COURT, (1991) explained the necessity for the involvement of the internal auditor in the development and the use of computer software; "Computer applications are widely used to support commercial activities in both large and small-scale business environments, and functionality depends largely on software. This is why both internal and external auditors are almost certain to become involved in the design or evaluation of such systems, the use of such systems in the course of their work, and the implementation and checking of procedures adopted to ensure that the use of such systems is properly controlled "(16). In Chapter II, the E/S's will be compared to other conventional software, and the existing risks of using E/S's will be pointed out.. However, there is virtually a consensus that E/S is a powerful tool and so it is important to recognise it's power but without overlooking it's limitation (17).

Therefore, it is necessary for the internal auditor to be involved in the development of E/S's to ensure the establishment of proper controls, and to monitor E/S's in order to evaluate their reliability.

What are the skills required by the internal auditor considering E/S's? Do we need an E/S Auditor (18)? How can we assume that the Internal auditors possess the necessary skills to enable them to conduct an effective audit on E/S's (19)?.

1.2 THE E/S AND THE INTERNAL AUDITOR

The Internal Auditor might tackle E/S's in his/her organisation within one or more of the following scenarios:

1.2.1 Expert Systems for Auditing

The Auditing Department makes a decision to purchase an E/S for auditing purposes. Most of the current E/S's for auditing concentrate on the financial aspects of the operation. The author believes the reason for this is that the developers are the large accounting firms (20). It is expected that Expert Systems that assist the auditors are likely to be very useful and therefore to encompass a commercial advantage (21).For that reason, it is likely that in the future more E/S's geared specifically for auditors will emerge.

1.2.2 An Expert System Shell

Some organisations prefer to buy an E/S Shell which comprises the inference engine and skeleton user interface without the knowledge, and build on it to develop in-house E/S's. The reason for this is generally the desire of the organisation to develop software which does not exist in the market-place. The main advantages of the shell lies in cutting costs and tailoring it to the organisation's needs (22). ARJO WIGGINS, winners of the Department of Trade and Industry Award for 1991, were among those who developed their own E/S with a CRYSTAL SHELL.

1.2.3 An Expert System Developed and Supplied by an Inference Corporation Software/House

Some organisations will prefer this option, either because of the lack of IT people with knowledge in AI, or because of the complexity of the required E/S. In any case, they are the users who, at the end of the development process, should decide whether or not to accept the E/S from the supplier; e.g. American Express contracted with a system's developer, to build the prototype for an E/S that would assist them in controlling the authorization process (23).

The options which were presented in sections 1.2.2 and 1.2.3 enable the internal auditor of the organisation (the user) to be involved during the main stages of development. The auditor's recommendations at this stage have more chance of being accepted and implemented than at the end of the development (24).

1.2.4 Off-the-Shelf Expert System

In a some instances, it is cheaper and more effective to buy an off-the-shelf E/S, generally in an area of ordinary business activity. An insurance company can buy an E/S which is operated by other insurance companies, and a bank can buy the same E/S which is used by its competitors in the banking world. The business activity is the same and the laws are the same; the difference is within the unique demands of the bank, but not in the basic application. KPMG, one of the big six accountancy firms developed an E/S to help its banking clients evaluate their commercial loans(25). In this case, the clients purchase an E/S 'off- the- shelf'; in other words, a ready made E/S.

Contrary to the options described in1.2.2 and 1.2.3, here the internal auditor is not involved in the development stage; however, he/she may need to be involved in later stages, most probably after the purchase.

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There are a few papers which describe the desirable audit plan for developing E/S's. JAMIESON and CHING, (1990) discussed the model of evaluation of knowledge-based systems under development (26). SOCHA, (1988) raised the problems in auditing E/S's development (27). There is very little literature on the question of how to audit E/S's either under development or in operation. This raises the question of how internal auditors presently audit E/S's. It may be assumed that they use the conventional type of software audit.

The following aspects of the audit environment must be analysed and consolidated into the design of any methodologies for auditing E/S's:

- the desirable and appropriate type of internal auditor for auditing E/S's
- E/S comparing conventional and decision support system
- models of developing E/S's
- evaluating E/S's and
- the risks of using E/S's.

1.3 OBJECTIVES OF THE STUDY

The research has the following objectives:

1) to investigate the differences between the E/S and other systems such as DSS
2) to consider whether there is a methodology of auditing E/S or whether the existing computer system audit methodology is sufficient
3) to propose models for E/S audit in two environments; how to audit an operating E/S (AOES) and how to audit E/S under development (AESD) and
4) to test these models and to explain the test's outcome.

This thesis is organized into three sections. The first section (chapters 1 and 2) discusses the meaning of E/S's today and the need for developing methodologies for E/S. It elaborates different definitions of E/S's and their implications. This section refers to the type of internal auditor who is capable of conducting an E/S audit.

The second section (chapters 3 through 5) presents the AOES model for auditing an operating E/S and AESD model for auditing E/S under development. The definitions of the " control band " and the audit techniques are detailed. Chapter 5 analyses the difficulties faced in the research, and the methodology used to test both the AOES and AESD models.

The third and last section (chapters 6 through 8) deals with the results of the tests carried out on both the AOES and AESD models and makes some recommendations and research suggestions.

This thesis offers an audit plan which an internal auditor can use in his/her organisation; either to audit E/S's under development (AESD), or an E/S's already in operation (AOES).

1.4 WHY IS THIS STUDY NECESSARY

One consideration when applying an E/S as ordinary software, is whether it is too risky for the organisation concerned. E/S's are more powerful than ordinary software, and, as described in Chapter II, the risks of using E/S's are different. The internal auditor who ignores that, either deliberately or by mistake, will not properly fulfill his/her duty. The elimination wherever possible of inefficient or risky methods in the E/S would greatly assist internal auditors in helping other members of the organisation to operate efficiently and economically, and as a consequence would not only reduce errors, but also assist in cutting down on fraud (28). For instance, does unauthorised access to an E/S, which is a powerful tool, reflect the same risk as in the case of ordinary software? The answer is inherent in the name of the software "Expert" . The public will have to learn to trust AI systems as much as the human experts they will replace, whatever the sphere in which they operate (29).

MURRAY and RICHARDSON, (1989) highlighted the potential risk of E/S's. "...People writing Expert Systems for commercial and institutional use, should make every effort to enable future critics to investigate what was going on when the programme reached its conclusion..."(30). A subsequent problem of the above is a lack in proper documentation. Generally there are agreed rules for the documentation of traditional systems, but no such rules exist for E/S's. These systems are developed on a continuous learning process based upon iterative input from the users. Consequently the documentation process is almost impossible to achieve (31). O'LEARY raises the issue of E/S validation. He suggests that an E/S that has not been validated sufficiently may make poor decisions which will cause a loss of confidence ,resulting in discontinued use at financial loss. It may well affect the confidence of the user in other E/S's (32).

A work team including experts from different universities in the UK has done a comprehensive research study on E/S's. One of the team's conclusions was that widespread use of E/S's may have negative effects in the long-term: an increase in unemployment, a loss in human skills, etc. (33). Although these risks seem socio-economic, to some extent they affect the organisation in question (34). These risks present a greater challenge to the internal auditor than ordinary software. In the next decade, technological developments will focus the auditing and control principles on the aspects of process and information systems. Auditing will be required to move expertise and technological means in order to tackle the regional missions (35). Thus, the internal auditor must invest more resources to keep himself/ herself up-to-date.

This study will provide the auditor with practical models of how to audit E/S's to be used when he/she is faced with an E/S's either under development or as an operating system. To my knowledge, no research has yet been conducted in the UK with this objective. The research will be carried out in the U.K and the tests of the proposed models for auditing E/S will also be conducted within BRITISH organisations. During the research , some organisations which are using E/S expressed their fear of E/S secrets leaking, and refused to cooperate with the author. It effected the size of the sample (see chapter 5 and 6 and subsection 8.5)

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CHAPTER II

EXPERT SYSTEMS: REVIEW OF THE LITERATURE

2.1 INTRODUCTION

Four basic topics within the literature were reviewed in order to provide and formulate the necessary background information for this study. These topics are:

- the boundaries of the E/S's,
- the problems of the E/S's,
- evaluations of E/S's and
- the need for auditing the E/S's and current audit approaches

This chapter reviews the literature on the subject of E/S's from a chronological aspect as well as from different point of view of the E/S. It refers to the issue of who is an expert as well as to that of whether computer data can replace an expert. It discusses the structure of the E/S and it's components. The differences between E/S and DSS and conventional system are discussed in detail. The chapter refers to the current debate on the different types of internal auditor and it's impact on the question of what are the skills of the E/S internal auditor. In it's last part this chapter reviews the existing literature on the audit of E/S.

2.2 HISTORY OF EXPERT SYSTEMS

Although the first E/S's were presented in the early Sixties, the history is much older, especially because of the strong connection with the parent science, AI, which includes computer science, linguistics, psychology and philosophy (1).

NEBENDAHL identifies the first roots of the research before World War II with the "FORMAL LOGIC" and "COGNITIVE PSYCHOLOGY" (2).Until 1955, scientists researched several aspects,such as administrative behaviour, cybernetics, and developed computers. This was the year in which there were indications of the imitation of AI. The years 1971 - 1980 are defined by the author as years of success in which the discovery of Knowledge-Based Systems occurred (3).To some extent, this explains how some of the aspects were incorporated into E/S's. Today, more than 45 years after the initial steps of the E/S, the real fruits of the research have become commercial, and have spread all over the world.

WANG and others (1991), stated that although the Basic research in E/S's is not progressing as fast as development and implementation, the annual expected growth for E/S's is 13% (4). They forecast that in the year 1995, the sales of E/S's will reach $1,500 million, almost double those in 1990, and concluded that E/S's technology pervades the computing environment (5).Yet, as in other scientific ventures, the full impact has yet to be assessed and no more recent quantification has been found. MURRAY and RICHARDSON, (1989), explained that implications such as economical, legal, sociological and others had still not been researched (6).

Following the success of E/S's, there remain a few unanswered questions. One of these relates to the risks to which the organisation is exposed. To some extent, the success of current E/S's blurs the difficulties and problems inherent in their development and use . The following case demonstrates this. In a British survey, respondents claimed thousands of successful applications of E/S's, but personal interviews, proved a rather different story. Less than 300 systems were claimed to have been produced, and only one quarter of those were operational (7).The risks in developing and using E/S's lead to another inevitable question of how to audit E/S's.

2.3 EXPERT SYSTEMS: CONCEPT AND REALITY

2.3.1 Expert Systems: Definitions

To some extent, the following quote identifies one of the difficulties that underlies some definitions of E/S's. " The most important issue for technology users is that, at present, the technology is leading the development of information systems, rather than user requirements dictating the system specification and the pace of development. Too often the technology is presented as providing a solution without first understanding the problem "(8).

VERKRUIJSSE, (1991), points out another difficulty. The fact that E/S's is a very young discipline means, that a substantial definition of the IT has not yet been formulated (9). The definition of an E/S does not have a purely semantic meaning. The definition expresses the aims of the system, (anticipated and current), the limitations, the advantages. Mostly it reflects the position of the definer - salesman, programmer, scientist, etc. A further dimension that is evident from the definitions is the chronological development of the E/S's. In this chapter, definitions are quoted in chronological order. Those cited here are believed to be a representative sample and demonstrate the concept of E/S's for each period.

FEIGENBAUM, who is recognised internationally as "the father of Expert Systems", defined E/S in 1983, as "...a computer programme that has built into it the knowledge and capability that will allow it to operate at the expert's level. The Expert System is a high-level intellectual support for the human expert, which explains its other name, intelligence assistant..." (10). In this definition one notes two main points: a) the author emphasizes the level of expert performance, b) the main aim of E/S's is to assist the expert (in contrast to the increasingly widespread use of E/S's to assist lower levels).

In the same year, HAYES-ROTH et al defined E/S as a "...computer system that achieves high levels of performance in task areas that for human beings require years of special education and training..." (11). In this definition E/S's powerful performance compared with other conventional computer software is emphasised.

One of the most common definitions of E/S's, quoted in many books, is that by GOODALL, (1985): " An Expert System is a computer system that uses a representation of human expertise in a specialist domain " (12). This definition is "clean" of pretensions of being able to solve problems that may give the user the feeling that he/she is using "super"-software. The linkage between expertise and problem-solving has since become a basic factor in the definition of Expert Systems. The layman may have the impression of an infallible system. HOLSAPPLE and WYINSTON, (1986), described it thus: " An Expert System makes use of expertise that has been gathered from a human expert about how to solve a specific type of problem or class of related problems " (13).

COLLIGAN and ALLERMAN, (1986), also stressed the use of expertise: " An E/S is a limited application of AI..., designed to multiply the value of real human experts by capturing their expertise and putting it at the fingertips of non-experts. ...The objective is to distribute the human expertise across a wide number of non-experts, thereby reducing the real expert's direct involvement in the decision-making process "(14).

WOLFF and VIATOR, (1986), suggested in the same year that E/S's "...are a subject of AI, designed to solve problems of a limited scope by applying and manipulating the knowledge of experts, represented as data..." (15). But the authors did not forget to highlight certain important limitations such as errors in the system and the fact that decision- makers in the final analysis are irreplaceable (16).

SPRAGUE and WATSON,(1986), clarified the differences between E/S's and Decision Support Systems. The decision-maker is the system, while in Decision Support Systems, the human being is the decision-maker (17). FAYE BARTHICK and WEST, (1987), emphasised the element of problem-solving: " Expert Systems are computer programmes exhibiting behaviour characteristics of experts, e.g. a medical expert diagnosing infectious diseases. An Expert System solves a problem requiring an expert's interpretation, reaching a solution comparable to one an expert would reach. The purpose of Experts Systems is to augment or amplify the expert's abilities. Expert Systems can be used to replicate the expert's expertise to make it available to others " (18).

The emphasis on problem-solving aspects has overtaken that of advising and this trend continues. NEBENDAHL, (1987), explained: " By Expert System we mean a new kind of software that simulates the problem-solving behaviour of a human expert. This software can store knowledge of a narrowly defined subject area and solve problems by problems by making logical deductions " (19). In 1988, FEIGENBAUM added word-solving to his definition of an E/S (20).

The British Computer Society provided this definition: "An Expert System is the embodiment within a computer of a knowledge-based component derived from an expert skill, in such a form that the system can take intelligent decisions about a processing function. An additional characteristic, which many would consider fundamental, is the capacity of the system to, on demand, justify its own line of reasoning in a manner directly intelligible to the inquirer...". SALENIEKS disagrees with this definition because of the use of the words "intelligent decisions", and would have preferred "decisions"(21). MURRAY and RICHARDSON, (1989), defined an E/S as a :"Programme giving advice on specialist topics, including medical diagnosis and prescription, financial investment, tax law, genetic engineering, chemical analysis " (22). The user can accept or reject advice. The ability to do so gives the human being control over the system, and the whole system (the computerised and the human) should by no means be likened to a factory in the Charlie Chaplin film, "Modern Times".

Further development of the E/S encouraged more researchers to tackle the different aspects of such a sophisticated system. The definitions of the E/S in the last few years found in the literature, contained the element of advising. That is to say, the human being is still the ultimate decider and he/she has the ability to control the system (contrary to the SPRAGUE and WATSON definition).

VERKRUIJSSE finds the current definitions of E/S's in recent literature to abstract and not suitable for forming a clear definition (23). He suggests a wider definition: " Expert Systems are systems with knowledge in them. Then they are a part of the family of knowledge-based systems...An Expert System has to meet the following requirements: Firstly, the three components of an Expert Systems, that is to say, knowledge-base, inference-engine, and inference, have to be present, whether integrated or not. Secondly, the system should be able to explain its own reasoning. Thirdly, at least one of the following characteristics has to be present:

- no need to answer a question
- be able to work with certainty factors (uncertainty) and
- be able to work with contradictions.

Using this working definition, it's easier to distinguish between dealing with an E/S or with a very complex conventional information system" (24) .

This working definition appears most acceptable and will be used in this thesis research, with the following additions which relate to the uses of E/S's:

- as an assistant, with routine data process
- as a colleague, to get a second opinion and
- as an expert, where advice is followed without doubts or further questions or investigations (25).

This definition includes several important elements: the technical components, the uniqueness of the E/S's in relation to other systems, and the ways in which it can be used. In other words, this definition comprises a wide range of views of the E/S's and will avoid confusion.

2.3.2 Who is an Expert?

In the last section, the author discussed the difference between four definitions of an E/S. The next step is to understand and agree who is the Expert.

In a few E/S's, the acquisition of expertise was elicited from non-human experts: books, tapes etc. This study will include only E/S's that have captured the behaviour of human experts. "Experts" which are books or tapes have a capacity of information that the human being cannot capture or analyse. Yet this type of E/S is still very powerful, and, in the author's opinion, reflects expertise.

MURRAY and RICHARDSON, (1989), defined an expert as someone who can justify his misjudgment (26). VERKRUIJSSE, (1991), defined an expert as persons who makes mistakes less often than a specialist (27). EDWARDS, (1986), characterises the behaviour of experts as including:

- the ability to reason through the manipulation of concepts and rules-of-thumb acquired over many years of experience

- the ability to explain the need for more information
- the ability to justify conclusions
- the ability to negotiate through knowledge of the inquirer, and
- the ability to satisfy enquiries at different times during the course of the dialogue (28).

In addition to these characteristics, in order to eliminate non-human experts as explained earlier, we must distinguish between human and computer expertise. MURRAY and RICHARDSON, (1989), presented five differences between human and computer expertise:

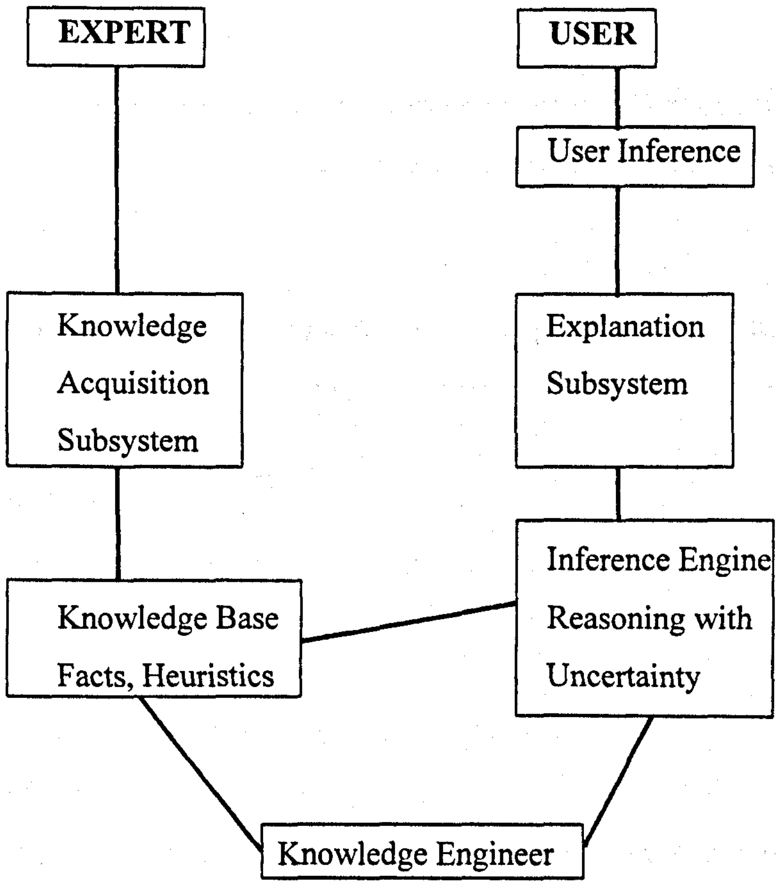
- the human can treat errors, among other things, as the occasion for revision of his/her knowledge or theory
- the human can do much more with his/her knowledge than can the system
- the human expert has a large amount of tacit knowledge that he/she cannot readily articulate in words
- the human expert has knowledge about things, and
- the human expert makes inferences using rather different mechanisms (29).

The characteristics of a human Expert as expressed in this subsection give an indication of the complexity and difficulty of acquiring the expertise and translating it into a computer language. This part of the development process of any E/S is considered to be crucial to its success.

2.3.3 Expert Systems: Structure and Components

In contrast to the dispute over what constitutes an E/S, there is general agreement on the structure of the E/S's and their components. To abstract the structure of the E/S's, the author submits the following diagram

FIG.1: THE STRUCTURE OF AN EXPERT SYSTEM



Source: FEIGENBAUM, E. McCORDUCK, P. and NII, H. Penny (1988) The Rise of the Expert Company. How Visionary Companies are Using Artificial Intelligence to Achieve Higher Productivity and Profits, p.33.

The knowledge acquisition subsystem is: "...The computer programme that provides dialogue between the Expert System and the human expert...The two most commonly used programming languages in E/S's are LISP (List Processing) and PROLOG..." (30).

The knowledge base of E/S's contains both factual and heuristic knowledge. Factual knowledge is that knowledge of the task domain commonly agreed upon by those knowledgeable in this particular field.

Heuristic knowledge is the less rigorous, more experimental, and judgmental knowledge of performance - the knowledge that constitutes the "rules of good judgment" and the "art of good guesswork" in a field (31). The reader will often encounter the definition that a Knowledge-Base System is synonymous with an E/S.

EDWARDS, (1991), reviews the differences between E/S's and Knowledge-Based Systems (KBS), and concludes: " All E/S are knowledge-based systems; there are some Knowledge-Based Systems which are not E/S, but relatively few of them at present are " (32). " First, most management or administrative applications of KBS at present are likely to take the form of E/S's. Second, the distinctions between the various types of systems, as usual, are not clean cut; for example, the knowledge- base of an intelligent front-end may rely on the expertise of a human who is used to "interpreting" for the package concerned. In such a case, it does not matter whether one calls it an E/S or an intelligent front-end; it is whether or not the system is useful that matters " (33).

The knowledge engineer (or other knowledge- based engineer), is the person who is responsible for the creation and development of the knowledge base (34), and his/her main object is to elicit the knowledge from the expert and encapsulate that knowledge into a working system (35). The knowledge is stored in the computer by means of different methods: " There are primarily two types of E/S: rule-based and example-based systems. A rule-based system applies to a series of: 'if...then' rules that the human expert utilizes in reaching decisions. An example-based system is one in which the user enters actual cases and the system tries to find matches between them on prior cases that have been entered into the knowledge- based of the system...Rule-based systems are probably the most commonly used type of E/S today " (36). The heart of the E/S's processing is the inference engine: it is a computer programme that examines the facts, the rules, and the input in its attempt to reach conclusions (37).

The explanation component is a feature of the E/S's built mainly for the user. It supplies him/her with information about the questions and the prices of making decisions by the system. Yet, it is very difficult to meet all the requirements of a good explanation component (38),as unsatisfactory explanation components could cause difficulties for the user (39).

The user interface is the component that determines how the E/S interacts with the user.

- how should questions be answered by the user?
- how will system responses to questions be formulated? and
- what information is to be represented graphically?

The following requirements must be met by the user interface:

- operation must be easy to learn
- erroneous input must be prevented as far as possible
- results must be supplied in a form appropriate to user, and
- the questions and explanations must be understandable (40).

To exemplify the structure of E/S's , the following is a rule from a simple medical E/S: " Patient should take an aspirin if he has a headache and he does not have a sensitive stomach ". The rule links the "if" and "and". This pattern is important when the computer is asked a question such as: Should Fred take something? The computer matches the question to the rule before providing the answer. It can be formulated as : " If Fred has a headache and Fred does not have a sensitive stomach, then Fred should take an aspirin..." (41).

2.3.4 Expert Systems vs Decision Support Systems

The comparison between E/S's and Decision Support Systems (DSS) is important for the following reasons:

a) The concept of the DSS developer is similar to that of the E/S developer. SPRAGUE and WATSON, (1986), defined DSS's as: "...computer-based systems that help decision-makers to confront ill-structured problems through direct interaction with data and analysis models..." (42). In E/S's, as is shown in Table 2.1, the system also assists the user in decision-taking, but in a more definitive way. One can therefore assume that if the developers of DSS had not lacked the technology of the artificial intelligence, their product would have been identified with E/S's.

b) The history of the DSS echoes in a few instances that of E/S's. The first DSS's began to appear in the late 1960's and early 1970's. " They were the result of a number of factors: emerging computer hardware and software technology; research efforts at leading universities; a growing awareness of how to support decision-making; a desire for better information; an increasingly turbulent economic environment; and stronger competition pressures, especially from abroad " (43).

Despite this similarity between E/S's and DSS the reader and the internal auditor should not be misled into concluding that their performances and risks are identical. The following table points out the important differences:

Table 2.1:The Differences Between Decision Support Systems (DSS) and Expert Systems (E/S's)

		DSS	E/S
*	**Objective**	Assist human	Replicate (mimic) human and replace him/her
*	**Who makes the decision?**	The human	The system
	Major-orientation	Decision-making	Transfer of expertise (human machine-human)
*	**Query direction**	Human queries the machine	Machine queries the human
*	**Clients**	Individual and/or group uses	Individual user
*	**Manipulation**	Numerical	Symbolic
*	**Problem area**	Complex, integrated, wide	Narrow domain
*	**Data base**	Factual knowledge	Procedure and factual knowledge

Source: SPRAGUE, R.H. and WATSON, H.F. (1986) Decision Support Systems, Prentice-Hall, p.141.

It is important to emphasise that this comparison was undertaken in 1986, at a time when it was firmly believed that E/S's were created primarily to solve problems. Subsequently, the definition of an E/S slowly changed to that of a system that advises in the process of solving problems . Nevertheless, the above table is important in understanding the differences between the E/S's and DSS.

2.3.5 Expert Systems vs Conventional Programmes:

As explained earlier, E/S's were developed as a product of AI of recent years, and thus are completely different in concept and structure from conventional software, which will now be described.

The main difference between E/S's and Conventional Programme is that E/S's operate expert knowledge, and Conventional Programmes operate data. Another difference results from the system's processing; Conventional programme produce the correct answer every time, while E/S's are designed to provide the best answers (44). The means for correction of software mistakes is an additional difference. " When , they both make errors, it is very difficult to convert conventional programme because their algorithms and basic assumptions are not explicitly stated in the programme code. However, for E/S's, with the help of skillful users, they can be made to improve their problem- solving abilities " (45). It is important to emphasise that this difference relates to the practical way of correction, and not to the effect and future implications of errors made by E/S's or conventional software.

VERKRUIJSSE points out the next difference between E/S's and other conventional software regarding the Audit: " One of the most important differences is that an Expert System need not be right. The system is allowed to make mistakes. As such, doubts concerning the certainty of the knowledge in the system arise to some extent. Uncertain knowledge can occur on two levels, namely the intentional and extentional level. Uncertainty on the intentional level is a consequence of the unspecified definition of terms " (46).

Second, " The characteristic of an Expert System (is) to be able to work with gaps in the knowledge...It's logical that such a gap in knowledge will effect the output of the Expert System . Contrary to conventional information systems, the Expert System can continue processing even if not all data is available. Another difference, an Expert System is able to work with not only a numerical representation of knowledge, but with a symbolic one too " (47).

In section 2.3.3, the unique structure of an E/S, including its components were described. VERKRUIJSSE, (1991), adds: " An E/S has a heterarchical structure, whereas a conventional system has a hierarchical one. With a hierarchical structure (also called a tree), it's already known which variable is decisive for the choice of a following statement. Not all statements have the same chance of selection. With a heterarchical structure, each statement has a priori one and the same chance to be selected " (48). He points out another difference: " And finally, for the future a very important difference: E/S's will be able to learn from their own experience. This implies that the reasoning problem extends " (49). Table 2.2 portrays the differences between Conventional Systems and E/S's:

Table 2.2:The Differences Between Conventional Systems and Expert Systems

	Conventional Systems	Expert Systems
*	Simple processing	Complex processing
*	Large volume of data	Small volume of data
*	Logic embedded in programme	Logic in knowledge base
*	Revision difficult	Easy: changes in rules
*	No explanation of processing	Explanation of reasoning
*	Outcome predictable	Outcome not predictable
*	Systematic analysis	Iterative design

Source:PRUIJM, R.A.M. "Mission Impossible" Lecture at International Conference in Using E/S, Amsterdam, 26-28 September ,1988.

2.3.6 Expert Systems: Uses and Advantages

E/S is usually used for:

- increasing creativity of experts and non-experts
- decreasing the "mistake price" in the decision-taking process
- improving consistency in decision-taking
- availability of knowledge for non-experts, and
- training and educating non-experts in problem-solving in domain to the level of decision-taking by experts (50).

BARR & FEIGENBAUM, (1982), mentioned the main domain of E/S's (51) as being:

- interpretation
- prediction of events and results
- diagnosis, clarification
- debugging
- systems planning/process
- monitoring
- training and decision-taking , and
- simulating and model-building

In other words, we can translate these as the unique activities of an expert.

The following advantages, as described by the users, are impressive:

- "...saves money (DIGITAL EQUIPMENT CORP estimates that XCON (E/S) has saved them some $25 million)
- differentiates products (BARIOD'S MUDMAN and AMEX'S AUTHORIZERS' assistant makes this claim)
- increases productivity (AMEX estimates its E/S has increased productivity by 20%; BLUE CROSS, 80% reduction in Labour costs)
- decreases administrative problems (IBM's CONSULTANT has this effect)
- allows knowledge to be protected and shared , and

- improves quality of service (HONEYWELL'S MENTOR diagnoses problems with commercial air-conditioning)..." (52).

An internal document in one of the British banks which has developed its own E/S in 1991 explains successful completion of the project by the following advantages technology can provide: reduce the clerical workload in the reporting application by up to 60% and productivity benefits that could be expected of around 30% across the development life-cycle (53).

2.4 AUDITING EXPERT SYSTEMS

2.4.1 Introduction

Despite the consensus of scientists about the importance of E/S's, the author is still surprised at the small number of books and articles on the subject of auditing E/S's. In 1991, VERKRUIJSSE stated: " It will not surprise anyone that Expert Systems are set to play a very important role within the business community. In future, information received from Expert Systems will, in most cases, be the basis on which company policy decisions at a strategic and tactical level will be taken " (54).

Three years earlier, SOCHA, 1988, warned the internal auditors of the challenge of auditing an E/S which would be a frustrating task (55). Three years later, JAMIESON stated: " If auditors neglect this challenge (KBS audit investigation), then there may be many KBS's in production that have inadequate documentation, are difficult or impossible to maintain, and provide the potential for abuse either intentionally or unintentionally, as they operate on a daily basis " (56). After careful examination, it seems to be fair to say that the E/S has yet to find its proper place in the written and researched auditing profession. It is essential to understand the reasons why this is so.

The lack of a common definition could cause misinterpretations and make it very difficult to understand and so audit an E/S. It leaves the E/S's interpretation to the user's perception (57). There is also a risk that in such cases the experts would refer to incorrect information given by the E/S (58) . which may well be because of lack of experience in auditing E/S's (59).This means that there is an existing risk that the organisation uses E/S's and, because of a lack of a proper and agreed definition, the internal auditor still audits this system as an ordinary one.

The "booster" to new audits as a result of published information about losses, frauds, abuses within E/S's still does not exist. We still do not know enough about the costs of using the E/S's incorrectly. One of the risks of misuse of the E/S's is that either the user will never realise that the E/S's gave the wrong solution, or he/she will realise it too late. How can a patient, having received medicine from a physician who uses an E/S, claim that there has been a mistake? How can a bank customer, whose application for a loan was checked by an E/S and denied, claim that there has been a mistake and an error of judgment made?

The following illustrates the pitfalls faced by developers and auditors: "Scientists AT LOS ALAMOS wanted an accurate global weather forecasting program. An Expert System was required. An elegant solution was developed and implemented using four Cray MP-P Super computers, four DEC VAXES, and four IBM 43XX processors. This system produced accurate, detailed global forecasts. Unfortunately, it took 26 hours to produce a 24-hour forecast. By the time the solution was developed, it was history " (60).

2.4.2 The Type of Auditor : Question of Definition

(i) Introduction:

The history of internal auditing as a separate and independent profession is brief, if we compare it with other 'white-collar' professions - around 50 years. The Institute of Internal Auditors was established in the USA in 1941 (61). Others will date the inception of a new profession called Auditing to the beginning of the 20th Century when the Companies Act ,1900, firstly made it legally compulsory for every company to appoint independent auditors (62). It bore resemblance to the auditing profession as we recognise it today, but was in fact another facet of the accountancy coin, as DE PAULA and ATTWOOD agreed (63).

Yet we do find organisations that have both a controller and internal auditor. In some articles, we still read about a controller when the issue is internal auditing. " Responsibility for internal control is an ever-increasing concern of the controller...Historically, manual systems were under complete control of the controller. Then, in quick succession, came unit-record systems, batched electronic systems...During this revolution, direct control by the controller has diminished...Internal auditors can gain an additional perspective by looking at the problems of control for database systems from the controller's traditional viewpoint " (64).

During the late 60's and the beginning of the 70's, in line with the technological developments, some branches of the profession were developed. The nature of the latest branches lie in the information systems which are conducted through with computers. Their names are: EDP (Electronic Data Process) Auditor, Computer Auditor, Information Systems Auditor and Computer Information Systems (CIS) Auditor. There are three main reasons why the reader will be faced with different names for Auditors, and, from the author's point of view, it is essential to explain these:

a) There are authors and lecturers from related domains, like management, accountancy, marketing etc, who do not make a distinction, and so use the incorrect terms.

b) The auditors who perform auditing often realise that in certain cases the boundaries between computer auditing and other kinds of auditing (i.e. organisational or financial) are very narrow, and sometimes do not exist. In other words, we find an internal auditor who for a time "penetrates" the computer auditing area, and vice- versa.

c) The dispute is over the question: Is EDP Auditing a separate profession? Or maybe it is the real and only genuine internal audit? " EDP Auditing today is only the auditing of tomorrow. What an organisation first sees as an EDP specialist is what all its audit staff will look like in a few years. Accordingly, exclusion of the existing auditing staff from the EDP audit training and experience will inevitably lead to complete obsolescence of these individuals and eventually make them useless as auditors " (65).

Does the EDP Auditor (or in other words, Computer Auditor, Information Systems Auditor) affect any aspects pertaining to the internal auditors profession? The following aspects should be noted:

a) " The Institute of Internal Auditors must decide if it intends to meet this challenge itself (specialist EDP Auditors), or accept that for specialist EDP Auditors engaged in internal audit, a second professional institute is required. Within the UK, we have taken the decision to represent all internal auditors and have developed a computer audit qualification " (66). Yet, in 60 countries (including the UK), there are chapters of the EDP Auditors' Association, which was established initially in the USA.(67).

b) One of the main justifications for establishing a professional institute is to define professional parameters, code of ethics, etc. If that is the case, is it possible that the institutions of EDP Auditors would be different from those of the internal auditors?

c) The effect of separate institutions results in separate training for auditors. The bottom line of this issue is: "...are we trying to develop a separate specialised EDP audit/controls capability, or do we wish to train all personnel to be self-sufficient in EDP audit and control?..." (68).

In the next subsection, the main points of the debate will be indicated and a view of the type of auditor who can confront the E/S successfully will be put forward.

(ii) <u>The Debate:</u>

Today, the professional literature includes two approaches to EDP auditing. "One states that in the near future, all the auditors will be involved in EDP auditing as a unified part of their job, and the definition "EDP audit" will vanish as an independent term. The second approach states that EDP audit is an independent profession. The environment of EDP auditing demands some basic conditions which can be considered as an analysis of whether or not the subject (EDP auditing) is defined as a profession; there being some ethical rules, such as certificate examinations etc. So why is it that EDP auditing as a profession is undetermined? arguments which have been raised included:

- " The professionals (EDP auditors) have not contributed to the development of controls: those were developed mainly by other computer professionals.

- The EDP Auditors have not got proven prediction skills for future needs and future developments. The attitude to the profession is passive and the reaction to changes is very slow " (69).

Regarding the controls issue, ATTWOOD and STEIN, (1986), concluded that in fact the basic principles of internal control and auditing are the same in a computer and non-computer environment (70). Supporters of the approach of "EDP Audit" as a unique and separate profession stress the following points:

- The computer environment is unique, and is not similar to the fields covered by other organisations, such as finance, marketing, etc.
- The data is a basic resource of any organisation, which requires resource investment and an increasing budget.

The developments being achieved in the computer environment, hardware and software, force the auditor to invest a lot of time in learning and in improving his ability to accept the innovations and their implications. This builds upto a "breaking point" from the basic internal auditor (71).

Some support the expansion of the EDP Audit to "...internal audit of information systems and data process units...The role is to audit the complete systems which are operating in the organisation and, using computer services, to audit the activity of computer units, to examine the firmness of the data flows in the information systems, to audit the efficiency of the collection, registration and management processes, to give his opinion on the authenticity of the data, and to advise the organisation's management on the ways to improve the processes and the internal controls " (72).

In 1982, CLIVE DE PAULA & ATTWOOD stressed: "...in recent years there has been a rapid development in the use of computers as a means of producing financial information. This development has created certain problems for the auditor in that, although general audit principles have not been affected, he has nevertheless had to revise his approach and use specialised audit procedures and techniques..." (73). CHAMBERS AND COURT, (1991), present a different analysis of the current situation. " Some auditors therefore need to specialise in systems support techniques.

Others need at least an ability to talk to system support specialists in their own technical jargon - based on a sound level of technical knowledge. Although micros are so widely available, and so many systems are developed or acquired, and operated by their users rather than by computer specialists, the need for specialist "computer auditors" is in some ways even greater than before " (74). To some extent, the debate highlights the question of whether to train an internal auditor on computers, or whether to train computer staff in auditing. Generally, the different approaches may affect the concepts of internal auditor training (75).

(iii) <u>Influential Evolution:</u>

It is essential to recognise the evolution over recent years and it's affects on the characteristics of the profession. " In the light of current and future advances within IT is apparent that we have become an information-based economy... It is possible for businesses to succeed or fail as a result of how effectively they use, process and convert data into useful information to be used as a resource " (76). The immediate effect is: " Since most of the big organisations are being managed by means of EDP systems, so practically speaking the internal auditors are the EDP auditors of the organisation" (77). " The unique knowledge which was the EDP Auditor's "legacy" in the 70's is today of general use, and most of the professionals in management and auditing terms possess the same knowledge " (78).

The expansion in the use of PC's forced the internal auditor to confront the question of computer auditing. A few years ago, the problem would have been in the computer centre with mainframe computers, which were unseen by the internal auditor. " It is now possible to purchase PC's with the performance levels of mini computers at a very low price. The move among corporate users away from mainframes towards high-powered personal computers is an important trend for the industry. The chief reason for the migration is to allow users to take advantage of the power and sophistication of the latent software " (79).

In the current situation, when the use of PC's has become part of the daily routine in the departments of most organisations, "...auditors who cannot use audit inquiry software find themselves in the position of a blind auditor in earlier times, who depended upon someone to read out the accounting records..." (80). The competition between internal and external auditors has never weakened. " The conflict is exacerbated because the objectives of internal and external audit, while different, overlap. Both have a legitimate concern about the competence and effectiveness of the other, both are interested in the results of the other's work. Since both are auditors, they are perhaps both ultrasensitive to the notion of review by the other party " (81).

Since financial systems have become computerised, the external auditors, mainly accountants, have had no other alternative than to learn how to use the "new machine". The professional bodies of accountants faced the new challenge by organising computer courses and producing some books explaining basic terms for the accountant. The computer audit became a regular part of their work. Their involvement in data process auditing became substantial. " One of the areas of cooperation between internal and external auditors is computer auditing.... The external auditor provides an opinion on the statutory accounts. The internal auditor is concerned with compliance and efficiency, both financial and operational. Both internal and external auditors are interested in the internal control of the financial accounting system " (82). This imposed on the internal auditors the necessity of learning, of being up-dated and of challenging the new area, as well as not leaving it to others. Among other things, it led to the conclusion that: "...all internal auditors should be computer auditors in the sense that they should be capable of auditing systems which are computerised...The general internal auditor must be trained to cope with computerised systems " (83).

(iv) The General Internal Auditor

The outcome of the debate on this issue in the near future is not likely, but in the meantime there are some current important conclusions. " In the US, it is popular to say that all internal auditors must be computer auditors. As most systems will be computerized, there will be little room for the auditor who is not able to audit computer-based systems, but there will also continue to be a developing need for the computer audit specialist who is competent to conduct the internal audit of the computer operation, as well as advise on the more technical audit problems encountered by his or her colleagues during their audit of computer-based systems " (84).

A similar but more vigorous view was voiced in Israel, in a special panel on the issue of: "Training Internal Auditors to work in an EDP Environment". " EDP auditing is not a separate profession, but a part of the internal auditor's work. The computer is an aid instrument, and computer penetration in an organisation does not change the basic approach of auditing. An internal auditor should not learn to use computers. He/she should learn about information systems and how they operate, so that he/she will be able to use the computer efficiently in his/her work. The conclusion is that there is an immediate necessity to train all internal auditors in EDP auditing. There is no place for internal auditors with unique training, especially when their cost is so high " (85).

BENTLEY, (1990), describes two levels of internal auditors, and explained the background: " The complex nature of these technical developments, the increased risks from inter-linked networks, and the demands for internal auditors to keep up-to-date with rapidly developing technology, have in my view strengthened the case for specialist EDP auditors. It needs a specialist to understand the technology and become technically competent to the depth required to deal with audits of advanced systems. We must look at the audit of computer systems at two levels: firstly, every auditor auditing in a computerised environment must be sufficiently computer-literate to carry out general audits of application systems. Secondly, there will need to be specialists who can undertake the more advanced areas of the work and provide technical guidance and support to general auditors, including the development of automated audit tools " (86).

MARSH, (1991), expresses his opinion about the future of the EDP Auditor, while emphasising the broader internal auditor profession: " Integration of the EDP Auditor into the new broader auditor will happen, but only in a limited way. For years, internal audit departments will need specialists to help them carry out the audits of systems technology " (87).

The view held by the author of this thesis is that all internal auditors should have basic training on information systems. Inevitably they will be confronted with the computer in any given audit area. As a consequence of technical development, the basic training of the internal auditor will be expanded in the years to come, so that in a few years, the internal auditor's knowledge of information systems will be deeper, wider and more sophisticated than it is today. Yet, a large internal audit department will still need some internal auditors with more experience and training in information systems than others. This will enable them to tackle special information system's auditing missions, such as artificial intelligence applications, even though they are still internal auditors. This is like other auditors who have specific training and expertise in areas such as financial auditing.

It is the general internal auditor who is referred to in this thesis.

2.4.3 Auditing Expert Systems under Development

(i) Auditing Theories

It is a common concept that in a few instances the role of the auditor is easier when he/she is auditing systems under development. CHAMBERS et al state that: " It is easier for the auditor to win the argument if control and audit recommendations are made at the design stage before DP personnel are committed to particular design solutions, and while analysts and programmers are still assigned to the project. Amendments to the system after implementation are costly and unpopular, as well as risking the creation of logical errors within the programs " (88).

In 1988, SOCHA provided a list of the twelve major problems that must be faced in the auditing of expert systems under development:

Problem 1	Understanding the technology
2	Experience
3	Lack of standards
4	The real world
5	Do cost/benefit ratios work?
6	Testing and validation

7	Common sense
8	Documenting an evolving system
9	Patented technology
10	Security
11	Lack of environmental controls
12	Is the system based on "expert knowledge" ? (89).

MITCHELL (1990) lists the threats posed by E/S's:

- uncoordinated responses to E/S's opportunities
- life expectancy of E/S's generators and the complexity of use of both E/S's generators and E/S's themselves
- machine-determined software
- maintaining internal E/S's rule and probability integrity
- giving undue weight to E/S's generated solutions
- inadequately controlled access
- incorrect data being fed into the E/S's
- incorrect data input to other systems from the E/S's
- system crash
- expensive solution to an area of concern
- inefficient solutions generated
- lack of readily available audit trail
- familiarity breeding contempt
- change control procedures no longer applicable, and
- over-reliance on E/S (90).

He concludes that: " It is likely that E/S's will not replace our existing applications, but supplement them. They will become the front-and back-ends to the systems which capture, process and hold commercial data. If this is the case, then control over the E/S's will be at least as important as control over the main application" (91). Regarding the involvement of the internal audit, he suggests that: "the extent of audit involvement is dependent upon the importance of the system and the application concerned, and is determined by considering the risks involved " (92).

VERKRUIJSSE, (1991), analyses the differences between the E/S's and conventional software, how they are expressed in risks and how they impact on the work of the auditor. In his view, the risks of E/S's are basically drawn from the knowledge which was elicited from the expert and transferred to the computer. The uncertainty of the E/S answers, either because they are not predictable or because it is impossible to argue with the expert, contributes to the necessity of the controls built into the E/S's.(93).

JAMIESON, (1991), divides the risks in the knowledge-based systems into four sections: planning, accidental or intentional, fraud and computer abuse and other exposures. He warns that: "...in the future there is a danger that auditors may abrogate their own responsibilities, as KBS's audit captures human expertise and makes audit decisions. The potential risk is that the KBS's results and reports will be accepted without adequate review, that is, overt reliance on the KBS. There must be human judgment to provide an audit opinion..." (94).

SIBLEY, (1994), defined seven audit concerns regarding E/S's:

- the effectiveness of the shell for the particular applications
- the skills and perceptiveness of knowledge engineer
- the monitoring of use and outputs
- the Upgrading
- the maintaining knowledge of expert
- the possibility of fraud, and
- the depending on application ,different control systems required (95).

There is a wide consensus that internal audit of E/S's is at least as essential as in conventional software. The obstacle to the design of an adequate audit model for E/S's lies in the difficulties of evaluating their risks.

JAMIESON and CHING, (1989), offered an evaluation model of E/S's under development. The evaluation of E/S's is an issue which stems from the development process. " Domain experts aid in the assessment of the embedded knowledge, advice on conclusions which are provided by the system, whilst users reflect the usefulness of the functions covered by the system, the design of the user interface and other issues, including system reliability and efficiency " (96). Later on, they described evaluation as a necessary step in the E/S's development process " (97). It is important to emphasise this point, because, the process of evaluation , is seen from the point of view of a developer, not an auditor. This does not necessarily mean that the model cannot be adopted by an internal auditor, but that in some aspects the emphasis will be different.

The model includes 41 methodological steps, from the first one: "Introduction and developer training if required" to "integrate E/S's with other applications". These 41 steps are divided into 9 phases:

1) orientation
2) feasibility
3) selection
4) knowledge analysis
5) knowledge base design
6) build and test prototype
7) build and test operational version
8) system release, and
9) maintenance and enhancements (98).

The people involved in the evaluation are, according to JAMIESON and CHING:

- system developers: the knowledge engineers
- experts: Inter-experts,
- management of the project
- potential users of the system
- system auditors, and
- quality assurance group (99).

According to the model, the auditors should be involved in the crucial phases of the development process. In Chapter IV, this model of evaluation will be discussed in detail.

(ii) Other Theories

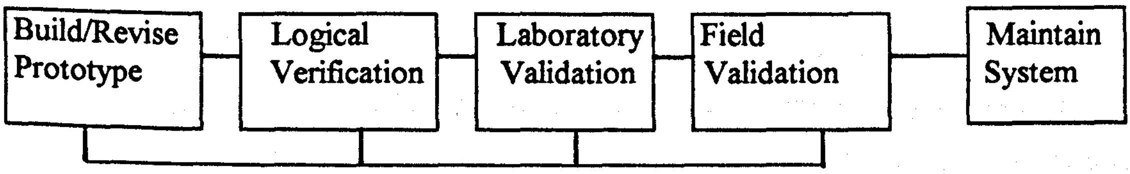
As mentioned before, there is little material dealing with the issues of auditing E/S's. There is more published material aimed at the E/S's designer, such as knowledge-based engineers. These articles describe guidelines to the engineers to ensure that, in each stage of the design, the process is continued correctly. It is worthwhile pointing out that most of these models do not apply to Auditors; they require mathematical and programme knowledge; from the very beginning, these models were designed for engineers. Nevertheless, some of the basic principles are important, and will be demonstrated in Chapters III and IV.

BUNDY, (1988), discusses the technique of how to improve the reliability of E/S's, considering it's significance for knowledge engineers (100). The definition of the term "reliability" is explained by the definition of the reverse: "unreliability". What do we mean by the term" unreliable", as applied to an E/S? It is a catch-all term, and can include any of the following overlapping phenomena:

- Fragility (non-robustness): The system may fail in unexpected ways.
- Unpredictability: The user either cannot specify the circumstance under which the system will produce an answer, or cannot specify the type of answer that will be produced.
- Brittleness (non-flexibility): The system cannot deal with problems on which it has not been previously tested.
- Discontinuity: The system gives very different output in response to similar input (101).

PREECE, (1989), developed a checking tool, as shown in Fig.2, for E/S developers who "...must test their systems as extensively as possible throughout the development process, using methods of validation and verification. Validation applies to testing that E/S outcomes resemble the outcomes of the human expertise modeled by the knowledge base. Such testing should be performed both in laboratory trials and in field trials. Verification applies to testing that the knowledge base is logically sound and complete " (102)." Validation and verification are complementary, and should be incorporated in development methodology for E/S's, as shown in Figure 2 (103).

Fig.2: A Development Methodology for an Expert Systems



Compared with the JAMIESON methodology for evaluation of E/S's, PREECE suggests a methodology for the developers. It is a purely mathematical model, which aims to help the knowledge engineers.

O'KEEFE, BALCI and SMITH, (1987), presented qualitative and quantitative methods of formal validation for the use of the knowledge engineers. Their definitions are: "..validation means building the right system, verification means building the system right (104). They provided some guidelines to the following major problems:

- What to validate?
- What to validate against?
- What to validate with?
- When to validate?
- How to control the cost of the validation ?
- How to control bias? and
- How to cope with multiple results (105)?.

O'LEARY et al, (1990),present a proposal for validating E/S's (106) .They define "validation" as being distinct from "evaluation". Validation is the process of determining that an E/S accurately represents an expert's knowledge in a particular problem domain. This definition of validation focuses on the E/S and the expert. In contrast, we define evaluation as the process of examining an E/S's ability to solve real-world problems in a particular problem domain. Evaluation focuses on the E/S and the real world. Validation has two dimensions - verification and substantiation. Verification is the "...authentication that the formulated problem contains the actual problem in the entirety and is sufficiently well-structured to permit the derivation of a sufficiently credible solution". Substantiation is defined as the "...demonstration that a computer model within its domain of applicability possesses a satisfactory range of accuracy, consistent with the intended application of the model " (107).

The validation process includes three stages: face validity, sub-system validity and input-output comparison (108). The process is again designed just for the E/S developer. SHAIM, (1989), has done research into the question of validation of E/S's, and has developed a model including special software (109). The definition of the term "validation", according to the author, is a: "...system check to determine if it is working correctly..." (110).

The aim of the model developed by SHAIM, (1989) is to help the E/S's developer in the process of designing the system . The issue of validation is also important because the traditional process of designing E/S's in which it (the design), is changing dynamically, and therefore demands checking according to each change. It is important to emphasize that in contrast to a database, in which a change in data does not affect other details, each change in the knowledge base changes its meaning, and therefore it is very important that there is a tool which can validate it (111). SHAIM presents a validation process for knowledge bases which comprises five stages: syntax check, grammar check, logical check, expertise transparency check, and level of expertise check. Like other models of validations, this one is designed for the knowledge engineer.

2.4.4 Auditing an Operating/Live Expert Systems

As mentioned in the introduction (2.4.1), there is little existing material dealing with auditing E/S's. In the last section, the author pointed out a few of them.

VERKRUIJSSE discusses the subject of auditing E/S's from the point of view of the auditor (112). " Expert systems are information systems and therefore they have to pass the reliability test in regard to the information supplied...The auditor wants assurance on the reliability of the information." (113). He defines an information audit as: "...an investigation into the reliability of the information supplied, the effectiveness of the information system, and the efficiency of the system " (114). This author describes as an impossible task the thought that "...the auditor evaluating an Expert System will have to review all possible thought paths and verify to what extent there is uncertainty in the knowledge. The auditor lacks the time and specific knowledge, as well as the concept of certainty. Moreover, the question arises as to whether the auditor may be expected to distinguish between the actual rules of knowledge and the wishful thinking rules of the human experts, or the knowledge engineer and whether he is able to form an opinion of the level of certainty " (115).

Yet, the auditor still has an important role, and will do it by "...directing his questions to the control or meta- information of the Expert System. This implies a change in the audit approach...the emphasis will be put on the analysis of the output when evaluating an Expert System " (116). It is important to point out that VERKRUIJSSE focused on the necessity to certify the financial statements in the financial sector of the business community; so, some of the aspects discussed by the author are not quite applicable in other sectors which use E/S's, i.e. medicine. Nevertheless, it is significant that an auditor is faced with the problem of auditing E/S's and pointing weaknesses out, even though there is a paucity of guiding material.

2.5 SUMMARY AND CONCLUSIONS

This selected review of the literature was designed to:

1) Reach a clear and accepted concept of an E/S .
2) Express the exclusiveness of an E/S in comparison with conventional and other advanced software.
3) Establish whether current models of auditing E/S's exist.

The conclusion of this review is that there are a few models which will guide auditors on how to audit E/S's, both systems under development and operating systems. It is not quite clear which of them has been tested; in other words, whether they have advanced beyond the theoretical stage? In the next chapter, the author will present his model of how to audit an operating E/S's (AOES).

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CHAPTER III

PROTOTYPE: AUDITING AN OPERATING EXPERT SYSTEM - LOCKING THE" BLACK BOX"

3.1 INTRODUCTION

The expansion in the use of E/S's, as described in the first two chapters, has been remarkable and currently they are being used successfully in a range of professions and industries (1) such as legal and financial services, advisory and tax services(2), as well as external and internal auditing (3). The forecasted sales of E/S's for the year 1995 was $1500 million (4).

It is more than reasonable to assume that most users have not taken part in the design and development of the E/S's. This means that an E/S basis for acquisition was quality comparison, price comparison, etc. The internal auditors are faced with the problem of auditing an E/S which is in daily use within their organisation, without having been involved in its development .

As the author has explained in Chapter II, to the best of his knowledge, as yet there is no tried and tested method for auditing those E/S's currently in use. What does exist, consists only of lists of objectives, guidelines, and description of risks and controls (5).

In this chapter the author describes seven essential assumptions for the understanding of the proposed model of auditing an operating E/S(AOES). After discussing the audit approach and it's stages this chapter details the " control band " system which is a vital component in the proposed AOES model.

3.2 ESSENTIAL BACKGROUND

In Chapter II, the author portrayed the differences between E/S's and other software. These differences may affect adversely the internal auditor's position in the whole complex of users, developers, advisors etc., and may blur his/her role. The following parameters are the basis for the model of auditing an operating Expert System (AOES) which will be presented in this chapter:

a) The internal auditor is not an expert in the audited field and never will be.

EDWARDS defined an expert as one who includes among other characteristics, the ability to reason through knowledge which was acquired over many years of experience (6). The internal auditor, although very experienced in auditing, does not have many years of experience in the audited field; so it is obvious that he cannot compare his knowledge in this particular area with that of the expert. This very important parameter, is clarified by the following example:

A hospital is using E/S to analyse heart diseases. This expertise was acquired from two famous experts in the field of cardiology. The internal auditor cannot compete with the expert who has the knowledge, experience and skills . In some other fields, such as finance, insurance etc, it is reasonable to assume that the internal auditor should have a good knowledge of the subject. Yet, there is a gap between the expert and his/her knowledge.

b) The internal auditor or the internal audit department has limited resources.

" Even small internal auditing departments are significant users of corporate resources and must be controlled. Effective control presumes a system of accountability " (7). These limited resources affect, among other things, the long-term career of the internal auditor. " But the prospect of a satisfactory career in internal auditing by means of "job hopping" is inevitably limited, as internal audit jobs at senior levels in management hierarchies are universally severely limited. Management's attitude is also ambivalent; on the one hand they attribute a professional role to internal auditing, in that they concede it should be advisory; on the other hand, by co-opting employees for short-stay assignments in internal auditing, they deny the need for a thorough professional grounding in its theory" (8). Another area in which resources within the organisation are severely limited is training. While the internal auditor is faced with substantial technical development, he/she needs the knowledge and the skills to up-date himself/herself in order to conduct a proper audit. The whole process is very expensive (9).

c) The documentation of the E/S is still not standardised and so not complete.

" Then again, for the most part, these people (systems developers), comply with standards, not only out of a true appreciation and understanding of the long-term benefits of uniformity, but also because at some point, the auditors or quality assurance personnel arrive to review a project. The Expert Systems development environment, on the other hand, has enjoyed a somewhat distant relationship with the professional reviewers since the early days of specialised LISP machines and stand-alone Expert System applications ".(10) Developing and operating E/S standards allows the management to monitor and to coordinate the development process properly (11), and also ensure that the developers write and keep appropriate documentation. DR PRUJIM, the Chief Auditor of the NMB Bank in Amsterdam,(1988), found that one of the problems in auditing E/S's is the lack of adequate documentation and agreed rules for the documentation of ES's (12).

d) The System Development Life Cycle of E/S's is still not standardised.

In contrast to current computer systems in which there are some known SDLC (System Development Life Cycle), E/S's development is still too new to be consolidated, and there is little standardization of development tools (13). BUNDY, (1988), explains one of the reasons leading to unreliability of the E/S as a lack in the system's development techniques (14).

e) The auditor has not taken part in the E/S development process.

The E/S was not reviewed during its development by the internal auditor who now needs to audit it. He/she does not have the advantage of experiencing "first-hand" the problems and weaknesses of the E/S, which can be achieved only by being involved in the process of development. At present, the internal auditor is auditing the Expert System for the first time.

f) The evaluation of the E/S is not completely reliable.

The evaluation of the E/S is still not formalised enough, so it is more than possible that in different E/S's, the developers have applied different methods of evaluation. GROGONO et al describe some of the evaluation methods of E/S's and the various difficulties encountered (15). From the point of view of the internal auditor, the following conclusion is critical: " Although formal techniques for E/S evaluation are seen as necessary, the nature of E/S makes formalization difficult. Even the criteria for successful operation may be difficult to define " (16).

g) The internal auditor "needs" an available applicable and practical method for auditing the E/S'.

This applies equally to all the other methods of auditing. This assumption should be emphasised here particularly with regard to the E/S, in order to avoid the possible misconception that a practical model is not sophisticated enough.

MASCARAS and TURLEY, (1990), defined evidence as being "... the basis on which the auditor can discharge his or her responsibility to report an opinion. Without evidence, the audit report cannot be seen as the result of a rational process of investigation. Evidence can take many forms - oral, documentary or physical; it can come from a variety of sources - from the organisation and its management, from third parties, and from the auditor's own work " (17). Later on, they state that one of the problems in using audit evidence is availability: "...one of the most obvious problems is simply the availability of evidence. This includes the difficulties which arise if the records of a business are incomplete, but also refers to the constraints of time and cost within which the auditor works. The need to obtain evidence within a reasonable time and at reasonable cost may mean that certain possible approaches to collecting evidence may have to be omitted or that the comprehensiveness of the evidence that is collected is limited " (18).

The developers of E/S's are viewed in the literature as professional with expertise in computing at a far high level then average. It is unrealistic to expect the internal auditor to have the same level of expertise as the knowledge engineer. This is why it is crucial to offer him/her a model for auditing E/S's which is suitable for use by a professional in auditing. An appropriate model would have to be applicable to all E/S's and usable by an internal auditor. These characteristics are dealt with in detail in the introduction to the AESD model which follows and in the explanation in the questionnaire (see subsection 5.5.4).

BARNET, (1989), warns the internal auditor in "the small" EDP audit environment, not to attempt to cover too much . Instead of treating some of the aspects, he might try to cover all aspects, while achieving nothing (19). KOREN, EDP Auditor at El-Al Israel Airlines, experienced the same contradiction while preparing an annual audit plan (20).

Of the above parameters, that of limited resources is the most prevalent and should be born in mind by the internal auditor.

3.3 THE GENERAL AUDIT APPROACH

The general audit approach, which complies with different types of audit: computerised systems as well as financial audit, includes several common stages. The following schematic description of the audit approach is based on the professional standards of the internal auditor;

Fig.3: Audit Work - Main Stages

Based on Standards for the Professional Practice of Internal Auditing (1978)

Main Stage	The Content
a) Planning the audit	- establish audit objectives and scope - obtaining background information - determining the resources - communicating - performing survey - writing the audit programme - determining the receipt of audit results - obtaining approval of audit plan
b) Examining and evaluating information-	- collecting - analysing - interpreting - documenting
c) Communicating results	- written draft report - discussion on findings - final audit report
d) Following up	- determining the action

CHAMBERS and COURT, (1991), define ten stages of an audit of a computerised system (21).

Fig.4: Stages in the Audit of a Computerised System

Stage	Process
1	Determine the scope
2	Learn about the system
3	Record the system
4	Confirm the system
5	Evaluate the control
6	Conduct compliance tests
7	Conduct substantive tests
8	Overall review
9	Report with recommendations
10	Subsequent follow-up

Basically, these two schemes overlap, especially in the main stages, and they are applied to the proposed AOES model . In the following subsection, will follow a presentation of the AESD model, while referring to the above stages. In those stages where there is a difference or change in emphasis, detailed description will follow. Where only minor differences arise the process will not be described .

3.4 AUDITING OPERATING EXPERT SYSTEMS (AOES MODEL)

3.4.1 The Scope of Auditing the Expert System

The scope of an internal audit encompass the assessment of the effectiveness of the organisations's system of internal control . It includes the reviewing of the reliability and integrity of the audited system, it's compliance with the organisation's procedures .It also includes the appraising of the efficiency and the economy of the employed resources (22).

The scope of the internal audit of an operating E/S based on the AOES model is to evaluate the effectiveness of the internal control system of the E/S in safeguarding the organisation and protecting it against the high level risks of the E/S.

As explained in sub-section 2.4.3 the validation of the E/S is the process of determining that an E/S accurately represents an expert's knowledge in a particular domain. In other words validating the E/S means testing the value of the controls of the system which were designed to prevent it from misrepresenting the expert's knowledge(a major risk of the E/S). One of the methods of validation is the verification approach which basically test the logic and the completeness of the knowledge base . The second component of the evaluation , apart from the validation , is the process of assessment which is the analysis of the information on the E/S and the quality of the programming and the user inference,(see sub-sections 2.4.3. and 2.4.4). E/S's as described in the previous chapters are a very powerful tool compared with conventional software. As the author described in sub-section 2.4.3, the risks to which the organisation is exposed are a combination of those derived from ordinary software and those which are unique to E/S. Any auditor of an E/S needs to be aware of the difference, assess the possible impact of the risks on the organisation, and finally review the controls accordingly whereas the results of an E/S are accepted as final decisions and there is no "second opinion", the risks are much higher than in those where the results are just treated as advice.

The AOES model as described in this chapter complies with this standard for the professional practice of internal audit (1978) which oblige the internal auditors to plan each audit (23).

The objectives of an audit ,according to the AOES model are:

- to identify the risks of the E/S, those risks which are unique and are not appearing in a conventional system
- to identify the built-in controls of the E/S which are designed to protect the organisation from these risks, and
- to evaluate these controls by test data or exceptions test ; or by both, depending on the facilities and resources of the internal auditor (see sub-sectio 3.4.4 and 3.4.5).

The following definitions describe the terms which are used in this chapter and later on.

- "Control band"- the controls which are built-in the E/S and are primarily aimed to "cover" the E/S unique risks, in other words to prevent them from materializing. The "control band" is focused on the input and the output of the E/S (see figure 5).
- "Box"- the final stage after the test data and the exceptions test which expresses the fact that the E/S's risks are covered by proper controls, and therefore it's risks are at the level of a conventional system.

3.4.2 Background Information

The next stage of planning the audit is "obtaining background information about the activities to be audited" (24) (see figure 3) , in other words learning about the system (see fig 4).

In some respects, the E/S's environment is not far removed from the general data processing in the organisation; i.e. a cross-section of auditing, such as security, file documentation and data, training procedures etc, will include findings which are correct for the E/S. Other kinds of auditing within the organisation may also include findings related to, among other things, the E/S.

To complete and up-date the information which the internal auditor already holds regarding the E/S, mainly by analysing the circular documentation within the organisation, he/she needs to use a questionnaire. The questionnaire described in Appendix A includes the points which need to be covered before moving to the next stage. The internal auditor can fill in the questionnaire himself/herself, or circulate it to a key person, for example the IT manager.

3.4.3 "Control Band" Determination

A basic step for the success of the stage of " planning the audit " is the ability of the internal auditor to assess his/her resources for the E/S auditor .Given the premise that the internal auditor department has limited resources (see assumption b in sub-section 3.2) this is an essential step.

Fundamentally audit planning should include:

- Communicating with all who are involved in the audit.
- Performing, a survey to explore the activities and controls to be audited (25).

This is the stage in which the internal auditor needs to identify and assess the risks of the E/S in his/her organisation. In each organisation, given its various departments, unique risks arise. Therefore the stages of planning the audit should be conducted afresh in every audit (26).

CHAMBERS et al suggested development of audit risk analysis in which the first step is to involve management (27). " Even without an initiative from top management, the head of internal auditing is advised to obtain top management support for, and assistance in, designing and implementing an audit risk analysis method. It will probably be discovered that management themselves take a lively interest in the interpretation of business risk which emerges and many will wish to extend its application beyond that of being a tool for audit planning " (28).

The auditor should discuss the issue of risks inside/outside the E/S with all those involved in using the E/S. The aims of this are:

1) To define the risks to which the organisation is exposed from the point of view of each participant.

2) To understand and (later on) to improve the "control band" of the E/S. These discussions will contribute to better understanding of the E/S by the internal auditor and, as a by-product, by the other participants in the organisation. The results of this stage will be used as a basis for the control band test later on.

3) The E/S can be an extremely risky system, as explained in Chapter 2. It is crucial and essential to obtain the cooperation of the persons involved in purchasing/developing/ maintaining the E/S.

CHAMBERS and COURT, (1991), analyse the effect of using E/S's on the auditor. " This (the use of Expert Systems) will eliminate the requirements for some current control procedures. It will, however, require auditors and financial controllers to be more technologically literate in order to perceive the circumstances under which the system might be absurd. This responsibility will be shared with software and hardware suppliers, DP managers and systems support staff " (29).

One of the best ways to reach suitable cooperation is of course to maintain a good system of communication " Communication is a two-way process...the information transfer has to be in both directions. Unless the conveyors of information are attuned to the responses of the receivers, they will fail to convey the information satisfactorily, and will therefore fail to communicate; auditees will be more favorably inclined towards what auditors wish to communicate " (30). The necessity of this cooperation applies two fold in E/S's, when there is chronic lack of documentation (as explained above).

Who are the potential partners of the internal auditor in the implementation of this stage? The emphasis on the word "partners" is designed to point out that in auditing E/S's, the following persons must be considered as partners. Their involvement and full co-operation are cornerstones in this model of auditing.

a) **The Manager** - " The value of the managers is also in determining how E/S's are designed and introduced in their organisations. Managers set new objectives and I/T strategies for new systems objectives to which the systems are bound. Managers are influenced by their traditional organisational culture, structure and managerial philosophy " (31).

Who is the Manager? - One or more of the following:

- The most senior manager in the department which uses the E/S and is able to give details on policy is-a-is the expert system, i.e. if a bank uses an E/S to examine applications for loans, the internal auditor should meet the manager of the loan department.
- The manager of the group (department, team, section etc.).
- The manager of the data processing department.

The issues which should be discussed with the manager(s) are:

1) What type of information should not be put into the computer during the "conversation with the E/S" ?

2) Which results/output of the E/S are restricted use?

3) Where/when does the output of the E/S clash with the policy of the management?

4) What are the controls which were designed to prevent mistakes as described above?

5) What are the controls which were designed to prevent manipulation of the knowledge-base ?

b) **The Expert** - This is relevant only in the case where the expert(s) is/are available. It is strongly recommended that the internal auditor makes every effort either to meet the expert(s), or to ask him/her/them to fill in the questionnaire. If the expert(s) is/are not available, the internal auditor needs to try to involve other expert(s) from the same domain. If so, he/she should be aware of the implications of the differences between different human experts.

The following issues should be discussed with the expert(s):

1) What information should not be put into the computer at all (i.e. updating tables)?

2) What information, if incorrectly entered into the computer ,will cause errors in the final results?

3) What is "sensitive" information?

4) Which results are obviously mistakes and should not be used?

c) **The Knowledge-Engineer** - BRYANT, (1988), defined the knowledge engineer as the person with skills , experience and responsibility for building the knowledge base (32). Undoubtedly, this is one of the keys to success in building, and later in maintaining, the Expert System. " The onus on the designer knowledge engineer lies in his or her ability to identify the required expertise, acquire (if they do not have it) and programme it into the system in a manner that mimics that of a real expert faced with real world problems!. Acquiring the knowledge from the experts is undoubtedly the most difficult part of the expert system development process " (33). In particular, one of the E/S's "...limitations is disagreement among the experts. Experts may not agree amongst themselves on the best decisions for particular problems, and thus on the appropriate behaviour for the E/S " (34).

It is by no means certain that the knowledge engineer who was involved in the development will continue working in the same organisation. In any event, as in the case of the expert, the internal auditor should make every possible attempt to meet the knowledge engineer, or at least obtain his/her written answers to a questionnaire (see Appendix B).

The issues which should be discussed with the knowledge engineers are:
1) What is the type of information which the E/S should not accept? Will not accept at all?
2) Which results of the E/S are not reasonable/permissible in terms of the design of the inference engine?
3) What information did the E/S previously not accept and was not designed to accept?
4) What are the controls regarding the input to the E/S, the processing and output of the E/S?
5) How are disagreements among experts resolved?

d) **The User** - Generally he or she is the person who sits near a terminal/personal computer, and has a dialogue with the E/S. The end of this dialogue is the advice/decision given by the E/S, and the user is the one who will or will not use the expertise. "...users may not want to use an E/S for several reasons. They may not want an E/S that gives unacceptable results (35). They may not want an E/S if they do not believe in the results that it produces, even if the results are actually correct. They may even reject an E/S for reasons that have little to do with its expertise; for example, because it takes too long to respond, is "unfriendly", or is too expensive. The converse problem is that users may accept an E/S , "...users may not want to use an ES for several reasons, containing errors of which users may or, in the worst case, may not be aware " (36).

The issues that should be discussed with the user(s) are:

l) What are the issues that he or she is not allowed to put into the E/S ?

2) What is the information that he or she as a user will never put into the system, mainly because "it does not make sense"?

3) What are the instructions with regards to the results of the experts: are there decisions that he or she should fulfill or advice to be considered?

4) What are the controls to prevent the use of the results as decisions instead of advice, and vice versa?

5) The tests he or she has done before accepting the expert system. BURNHAM,(1991), considers the user testing as a key resource of information about the usability of the E/S system (37).

6) "Exceptions" and mistakes in the past.

The information can be collected either after discussing these issues with the "partners", or using questionnaires. It is recommended to use an interview/discussion to collect the above information; but in those cases where this is not possible, he/she can use the questionnaires (see Appendix B). The information which will be collected by the internal auditor, plus the primary general information in the questionnaire, will be used later to construct the test. Another important use for this information is to assess the quality of controls for the E/S. The assessment will be integrated into the final evaluation of the controls of E/S.

3.4.4 " Control Band" Definitions

The information the auditor has collected, as explained in subsections 3.4.2 and 3.4.3, is the basis he/she needs to assess the unique risks of the E/S and the parallel controls and to define the " control band " of the E/S . These definitions will include:

a) Which information should not be put into the systems

b) Which controls are required to prevent such exposure

c) Which information should not be produced from the system

d) Which controls are required to prevent such output in case of error

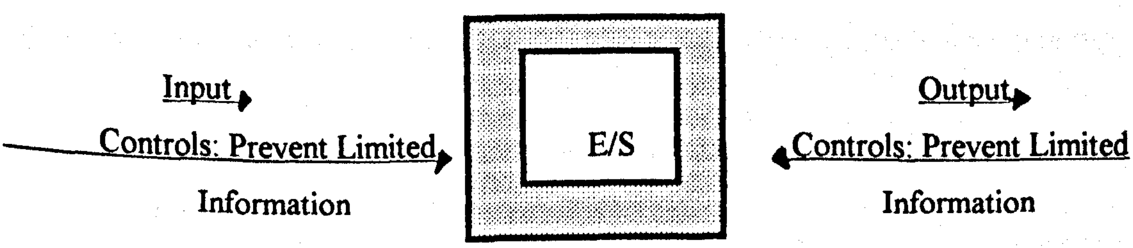
It should be noted that the aim of the following test is not to examine the process of concluding what is done by the system but the process of the expertise concluding within the E/S . Part of this process can be explained logically, but the rest is made intuitively by the expert. In subsection 3.2.1, it is assumed that the internal auditor is not an expert in the audited field, therefore, he/she cannot audit the process of concluding. Even in those organisations in which the internal auditor has a good knowledge of the audited subject, i.e. banks and other finance organisations, the process of concluding remains inauditable; yet, this process includes unique expertise, and for the most part cannot be traced logically. PRÜJIM,(1988), stated that the auditor cannot trace the processing in the same way that he traces the steps of the processing of an conventional system. (38).

The purpose is to test the controls of the input/output stages to ensure that false information will not be used, in contrast to testing conventional systems, where one of the aims is the test of the process itself. In an E/S, the auditor concentrates on input and output only. The stage of processing the data cannot be audited.

The above definitions of the E/S boundaries will be used for the following two tests: "Exceptions" Test and Test Data (39), which are equivalent to the second stage in the audit work “Examining and Evaluating Information” (see figure 3), or to stages 3-8 of the Audit of Computerised System (see figure 4).

Figure 5 demonstrates graphically the” control band “concept with regard to E/S. The E/S is framed with the “gray area “ which represents the risks which differentiate it from other conventional systems. Successful controls of the E/S mean that although the E/S is a more risky system comparing to a conventional one , still it is operating within the risk level of the conventional system (in other words it is “locked in the box “). The focus of these controls is on preventing incorrect information from being inputted to the E/S and protecting the users from employing incorrect output.

Fig. 5: Expert System - “Control Band”



3.4.5 "Exceptions" Test

The "Exceptions" Test can be applied by one of the following two methods:

A) From now on, the maintenance team of the E/S will produce a separate report for the internal auditor's use; this report will include all the "exceptions" defined by the internal auditor (sub-section 3.4.4)and processed. The report will be produced periodically. and should indicate zero findings, because they were intentionally defined as "exceptions", which the system should not produce. In the case of any findings in the report, the internal auditor should trace the history of the "exceptions" in order to formulate conclusions about the control.

Generally, the production of an "exceptions" report requires a simple programme. The advantage of this method is the fact that periodic report production is part of the daily process of the computer centre. The internal auditor uses computer resources in the same way as the users. However, the disadvantage is that the internal auditor relies on outside factors in order to programme the report based on the "exceptions" definition.

B) It is possible to use an audit enquiry package, which enables the auditor to extract details from files for further auditing (40). This is a preferable option, because it strengthens the independence of the auditor. In practice, limited resources may prevent the internal auditor from acquiring or developing such an audit enquiry package.

By themselves, the definitions of "exceptions" and the controls of input/output of the E/S, and the results of the "exceptions" test should show zero findings. In the case of positive findings, the internal auditor will investigate the only two possibilities:

1) the definitions were not accurate and left a "grey" zone or

2) there were not enough controls (41).

THE AUDIT OF EXPERT SYSTEMS

BY

HERTZEL COHEN

3.4.6 Test Data

The definitions used by the internal auditor as a basis fore the "exceptions test" are principally the same as for the test data. " The principal audit technique for the review of system controls is the test data method, formerly termed the auditor's test check, when punched cards were the main computer input medium. With this method, the auditor is able to stimulate in dummy data as many input conditions as are relevant to the audit objectives, and then to confirm that they are handled correctly by the system " (42). Basically, there are two methods of test data;

1. test data of "live" data during the real production, and
2. test data of "dead" data which is a copy of "live" data and does not interfere in the "live" production (43).

The internal auditor faces two main stages when using test data for auditing an operating E/S:

a) He or she will try to put into the system false/incorrect data and then follow up the process until results are produced.

b) Extract data from the files, dummy or live. This can be done either by using an audit enquiry package, or by using the "user inference".

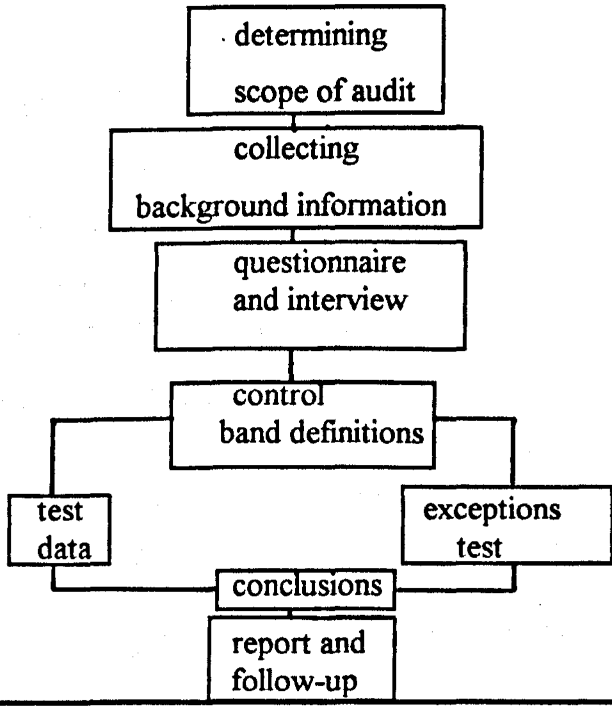
Zero findings in the test data means that the system has not accepted invalid or incompatible data, and that no exceptions or errors were present. Zero findings in the two tests: "exceptions" test and test data, indicate the reliability of the controls.

The following stages in the AEOS model which relate to the audit work are similar to the two approaches which were presented in subsection 3.3, in figure 3 and 4.

3.5 AUDITING AN OPERATING/LIVE EXPERT SYSTEM - DIAGRAM

The AOES model can be described in the following diagram:

Fig.6: Approach to Auditing Operating Expert System



While some of the stages in this model are integral parts of standard approaches of auditing other software, this model includes the "control band", which aims to respond to the unique risks of the E/S's. A "control band" which functions properly ultimately reduces the level of risk to that of conventional software.

3.6 SUMMARY AND CONCLUSIONS

In this chapter, the environment, in which the internal auditor needs to work while facing the task of auditing E/S, has been described. . Some of this environment had not been previously familiar . The difficulties of auditing the processing in an E/S have been explained and so a practical model of how to audit an operating/live E/S has been suggested. It is based on assessing the risks, and defining the "control band". Later on, this "control band" is examined by the internal auditor. A successful result of the test means that the audited E/S is no more risky than other conventional software.

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CHAPTER IV
AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT (AESD)

4.1 INTRODUCTION

In the previous chapter, the author described the prototype for auditing an Expert System already in operation. In this chapter, the prototype for auditing an E/S under development will be presented. A survey undertaken in 1988 by CULLEN & BRYMAN showed that as a result of problems with reliability, user acceptance, accuracy and cost-benefit 57% of the expert systems developed were abandoned, suspended, used for limited purposes, or still under development, and only 42% were successful (1).

These facts stress the importance of the internal auditor's involvement in the process of E/S's development within his organisation. CHAMBERS et al explain the significance of auditing computer systems. " Today, there can be little argument - information is the key corporate resource: availability, manipulation and use of high quality information is what marks out one corporation from another. The computer is at the heart of this information explosion and computer auditing a sine qua non of the modern enterprise. The reasons for this are that the information resource must be safeguarded. Information must be reliable and accord with local regulations; information underpins efficient operations and high-quality customer service, and information assists management in determining and adhering to policies. In other words, in audit jargon, there must be controls over data processing " (2).

The SDLC (Systems Development Life Cycle) methodology in which software is developed enables the internal auditor to be involved schematically and consistently in each stage of the process. The common advanced approach of SDLC ties computerised systems development to a cooperation between three factors: Users (including managers), Electronic Data Process Personnel, and Internal Auditors (3).

The benefits of known and common methodology in developing systems are shared by the various people involved in the process: " Standard methodologies have many benefits. They allow more flexibility when assigning people to projects, since the method of working is known to everyone. Standardized documentation formats make it easier for reviewers to provide quality control. In many cases, linking standard techniques to powerful automated tools has increased productivity significantly " (4). These benefits also reflect the function of the internal auditor. Generally, the ability of the internal auditor to fulfill his role is much easier in any environment in which a system is developed according to known and accepted methodology by the personnel involved in the process. In this case, there are known and defined stages, duties, responsibilities and procedures. One of the main problems of auditing an E/S under development is the lack of such methodology (SDLC). In 1989 a survey of the accounting and finance Expert Systems in the UK and the USA, found that only 25% of all E/S's developed employed any systematic methodology (5).

In this chapter, the author will focus on a few expert system SDLC methodologies, and the role of the auditor in the current literature. The " NESDEM" methodology for E/S development will be discussed and then will be inlaid into the proposed AESD model .

4.2 EXPERT SYSTEMS SDLC METHODOLOGY

ERNST & YOUNG, one of the Big Six accountancy firms in the UK, has developed a few E/S's in recent years, among them VATIA in 1988, THUMPER in 1990, and PANIC in 1991. Their approach to the E/S's life cycle includes five main phases:

a) Identify the opportunity. The opportunity to build an E/S's must arise because a real business exists.

b) Test the ability. Having identified an opportunity, it is necessary to test whether the project is feasible. From a business perspective, any project must provide benefits that justify the costs. From a technical viewpoint, it is necessary to see if the problem can be solved using E/S's techniques.

c) Organise project team. It is important to have a good project team structure. At ERNST & YOUNG, E/S's projects are set up as follows: steering committee, project management, users, experts, development group (knowledge engineers and programmers).

d) Building the full system. The four stages involved in building the system are: specify the system; elicit the knowledge and validation; programme the knowledge; test.

e) Implement and market (6).

This model does not indicate the internal auditor's role in the whole process. Nevertheless, it points out the importance of validation which aimed to ensure that human expertise is translated to a computer language correctly. The two methods used to validate expertise are:

- peer Review, where each expert revises the documented expertise and checks it for technical correctness, and
- walk-through, where the expert tests different cases (7).

ISKANNDAR and McMANN, (1989), describe a four-step process for building E/S's:

a) the knowledge engineer determines an understanding of particular judgment problems

b) solicitation of the expert's thought process in solving the problem

c) programming a computer model to reproduce the expert's decision process ,and

d) validation and test (8).

The authors do not specify the part of the internal auditor in this methodology, but mention the importance of the knowledge engineer in that process (9).

HAYES and DE POEL, (1990), mark five distinct stages in the development of an E/S model:

a) Domain Selection - this stage involved determining whether a domain is appropriate for E/S's modeling, identifying the expert(s) and determining in what form the domain-specific data will be collected.

b) Knowledge Elicitation - this is the process of extracting or drawing out knowledge from a source, usually human experts. The common knowledge elicitation techniques are: literature, search, observation, interviews, questionnaires, rapid prototyping.

c) Knowledge Representation - The third stage is defined as the systematic way of structuring knowledge about a domain so that it can be interpreted by the computer software. Knowledge may be represented as rules, semantic nets, structured objects, tree structures and frames.

d) Modeling Media Choice - In this phase, the developers have the choice as to which hardware and software to use: rule-based shells, induction-based shells, frame-based shells, an AI work-station, or a programming language.

e) Testing of the Prototype - There are two testing methods:

(1) testing by human experts and end users

(2) testing systems components: the system against other models, and the system against itself (10). This five-stage process is, according to the authors the most dominant methodology used in developing expert models by accountancy firms (11).

Like ERNST & YOUNG, KPMG PEAT MARWICK (USA), one of the Big Six accountancy firms, in 1989, developed an E/S to assist in the evaluation of loan collectability. The developers adopted a different development approach in the process which took two to three man years (12).

What is unique in their methodology, is that of the conceptual model, which consists of six stages:

1) a problem definition

2) proof of concept

3) knowledge acquisition

4) knowledge formalisation

5) prototype validation ,and

6) problem redefinition.

The conceptual model underlies the development of the system, while each stage is compared with the parallel one in the conceptual model. If there are differences, one of the two, i.e. the conceptual model or the system, has to be changed accordingly (13).

ALADIN, an Israeli company which has developed an E/S applications generator and which assists other Israeli companies to develop their own E/S, recommends four stages in E/S development to it's clients;

1) problem definition
2) building prototype
3) extension of the knowledge base, and
4) building the E/S for the user (14). The last stage includes testing of the E/S before delivery to the user.

J S EDWARDS was part of a team that worked on a collaborative project for Aston University and British Steel developing E/S's. This team used the following SDLC for the E/S development;

1) feasibility and requirements definition
2) analysis
3) design
4) implementation
5) testing , and
6) maintenance (15).

This approach is mentioned because it is an example of collaboration between academic and business developers.

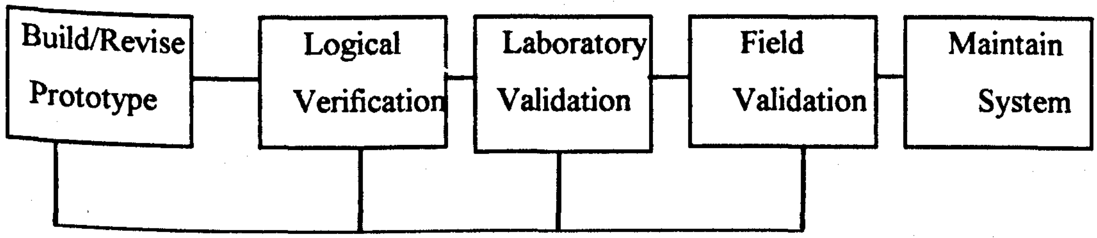
PREECE, (1989), described the E/S development cycle which includes five connected circulating stages as follows:

1) build/revise prototype
2) logical verification
3) laboratory validation
4) field validation, and
5) maintain the system (16).

Two stages relate to the process of validation, which in the author's opinion applies to testing the outcomes of the E/S (17), and one stage is the logical verification which enables the developers to test whether the knowledge base is logically constructed

(18). There is a continuous interaction between these five phases as the following figure shows:

Fig.7: The Expert System Development Cycle



The focus of this model is on the significance of the verification and validation, two steps which are basically testing stages.

JAMIESON & CHING ,(1989), proposed a normative model for knowledge-based systems development which is based on the work of researchers and practitioners in the field, on a review of the literature, and on several knowledge-based/E/S development methodologies (19). This model, "NESDEM" (Normative Expert Systems Development Methodology), includes 41 steps, which are divided into nine phases:

1) orientation
2) feasibility
3) selection
4) knowledge analysis
5) knowledge base design
6) build and test prototype
7) build and test operational version
8) system release, and
9) maintenance and enhancements (20).

The model has three main advantages from the point of view of the internal auditor, who is confronted with the task of auditing the development of E/S with this methodology:

a) The phases and the steps are clearly detailed, and instruct the developers as to how, when and where to keep in step with the methodology (more than in other known methodologies of E/S).

b) JAMIESON & CHING identified the persons who should be involved in a E/S development project;

- a domain expert
- knowledge engineers
- knowledge workers
- KBS management
- systems auditors (internal or external), and
- quality assurance personnel (21).

c) "NESDEM" draws on and integrates a number of E/S development methodologies, together with experiences of E/S practitioners. JAMIESON & CHING consider it to be complete and exact methodology (22).

Nevertheless, in Chapter III, the author mentioned that the SDLC of E/S's is still not standardised (see 3.2). Taking into consideration the above, the following aspects should be mentioned:

a) "NESDEM", as an SDLC of an E/S, is a normative model with which in reality some developers (and maybe most of them) do not conform. The current models are short, and the borders between the development stages are blurred, if indeed they exist at all.

b) The opportunity of developing a prototype on which the tests can be conducted is uncommon, because of limited resources. Pressure on developers to achieve a result that produces an operational system is common. The way to avoid such situations is to abolish the prototype phase and to jump straight to the operational version.

c) The involvement of the auditor in the evaluation processes is combined with the other evaluators. This co-operation holds some advantages for the auditor, side-by-side with the danger of destabilisation of his independence. This also applies when sophisticated software is developed, and the auditor may subvert himself to the group.

4.3 "NESDEM" - THE ROLE OF THE INTERNAL AUDITOR

"NESDEM" underlies the role of the internal auditor in evaluating an E/S under development, together with other functionaries in the process; i.e. experts, users etc. There is no specification for the role of the internal auditor, rather for a group presentation in which the auditor is but one member. The author has elicited from the "NESDEM" the following aspects regarding the role of the internal auditor in the SDLC of an E/S.

4.3.1 Stages of Involvement

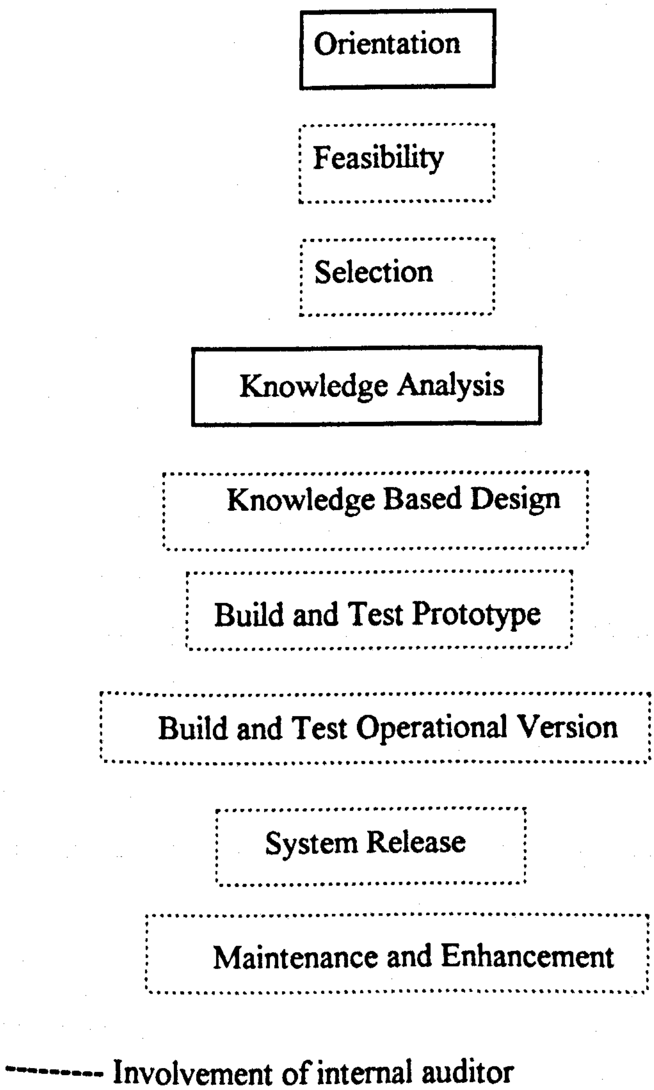
After analysing the forty one steps of the model and the check-points of each member of the personnel, Figure 8 shows the methodological steps in which the internal auditor should be involved, and Figure 9 demonstrates it in diagram form.

Fig.8: "NESDEM" - Internal Auditor Involvement

Phases	Methodological Step
Orientation	-------
Feasibility	Show commercial feasibility
Selection	Develop project plan
Knowledge analysis	----------
Knowledge base design	Conceptualisation
Build and test prototype	Test performance of prototype. Test user acceptance of prototype. Review full test results. Audit prototype
Build and test operational version	Test user acceptance of operational version Review field test results and perform follow-up studies Audit operational system
System release	Final evaluation of system by project team. Post implementation review
enhancements	Maintenance and necessary changes Integrate E/S with other applications

Source: Development of normative model for KBS. Development R Jamieson, M Ching: School of Information Systems, University of New South Wales, Working Paper, November ,1989.

Fig.9: "NESDEM" - Internal Auditor Involvement - Diagram



The only two phases in this model in which the internal auditor has no role are Orientation and Knowledge Analysis. The orientation phase includes the following methodological steps:

1) introduction and developer training, if required
2) form steering committee
3) select application
4) form initial development team, and
5) initial selection of expert.

According to the authors of this model, only the knowledge engineers and the management should be involved in these steps. The Knowledge Analysis phase includes that of Knowledge Acquisition, in which the knowledge engineer and the expert are the only ones involved.

4.3.2 Evaluating the Expert System

JAMIESON and CHING, (1989), followed through the" NESDEM" model and developed a model which details evaluation steps which are integrated into a normative E/S development model (23).

The meaning of evaluation according to the authors includes both validation and assessment, with which they use the definitions provided by O'LEARY:

" - Validation evaluates and compares the system's decisions against the expert's decisions, thereby determining the system's decision-making expertise. This also involves evaluating the boundaries of the system's knowledge and whether that knowledge is correct. O'LEARY mentions two other aspects of validation, namely the reliability of the system's decisions given similar inputs over time, and whether the system is theory-based. Basing a KBS on an established theory is acknowledged to be an efficient way of designing a system, and lack of a theory base has resulted in failure of at least one KBS.

- Assessment covers validation of KBS and in addition includes analysis of the documentation, the quality of the user interface, the particular development environment or language used, and the quality of KBS programming "(24).

JAMIESON and CHING, (1989), recognise two facets of the evaluation: "Formal evaluation processes are undertaken at certain specific stages in the E/S development life-cycle, and these stages are often toward the latter half of the development process where the developer is confident that at least part of the E/S will perform to expectations. Informal evaluation should be performed throughout the whole life-cycle " (25).

The basic difference between validation of a conventional system and an E/ S lies in the expected results from each of them. In a conventional system, the evaluator expects certain and known results of the system; therefore he/she is able to compare the actual results with those expected. But in an E/S, it is difficult to predict the exact results. Cases in which the input was similar could end with different output from the Expert System. This affects the techniques which the evaluator uses in validating E/S (see 4.3.5) (26).

SHAIM ,(1989), noted another difference; the validation process itself. While in a conventional system it is possible to come to a conclusion on the validity of the system by using test-data, in E/S validation, because of the complexity of the inference engine, it is necessary for the expert to come to a conclusion as to the validity of the result (27).

4.3.3 Testing Methodology

The authors of' NESDEM" recommend using a system testing methodology, developed by PERRY ,(1983),which involves 8 steps;

1) Establish test policy (state evaluation criteria and goals)
2) Develop test plan procedure (establish evaluation schedule - decide when evaluation should take place)
3) Select and prepare test methods (establish evaluation techniques)
4) Conduct tests
5) Evaluate results
6) Document test
7) Report test findings
8) Monitor and improve test process (28).

4.3.4 The "Evaluators"

The importance and complexity of an E/S evaluation are reflected in the people who are candidates for the process:

* System developers - the knowledge engineers
* Experts:- intra-experts (those involved in the implementation of the system - internal experts)
  - inter-experts (those not involved in the implementation of the system)
  - external experts
* Management for the projects
* Potential users of the system

  - the major functions performed by system auditors include - the development and review of control techniques
  - the testing of system's compliance with standards
  - the review of the system's documentation and project management.
* Quality assurance group (29).

PAYNE and McARTHUR, (1990), suggest that: "...three groups take part in this validation effort; the experts in the domain, the end- users, and management..." (30). In contrast to JAMIESON and CHING, the auditor is not mentioned at all. Schematically, the phases of the internal auditor's (and other evaluators') involvement in the evaluation process are:

- determine in which methodological steps the internal auditor should be involved
- define the evaluation areas (and sub-areas)
- define the evaluating goals
- define the goals, and
- define and use evaluation techniques.

4.3.5 Evaluating Techniques

The techniques of evaluating E/S performance are:

* validation with test cases
* direct examination by the expert(s) involved in the project
* modified Turing Test (31) - basically comparing conclusions of at least two experts
* validation by users - one of the important techniques
* sensitivity analysis - by small changes in the knowledge presented (32).

The technique recommended for each step by the authors of the "NESDEM" model is mentioned in Appendix C. Some of these techniques are not based on technical performance, yet they are still important, and an integrated part of the evaluation process. They include meetings/conferences .

4.3.6 "Around" The Evaluation

There are a few aspects which cut across parts of the development process; therefore an internal auditor should consider them:

* Availability of funds, and the analysis of the benefits versus costs in implementing the E/S. It is important to assess the benefit of acquiring the system and weigh these against the costs required to implement it.

* The administration/management of the development process. The assumption is, if the E/S development process is well-managed, there should be more control over the available resources and less costs should be incurred; for instance, there would be fewer hurried decisions, which might lead to greater expense if they were the wrong ones.

* The administration/management of the evaluation process. If the evaluation process is properly handled and administered, the acceptance of the system by the users may be increased.

* Personnel issues. The fear that personnel issues will affect the evaluation process performed on the E/S (33).

These four points are not unfamiliar to the internal auditor, mainly because they spring up intermittently in other systems development processes. The complexity of the E/S development cycle gives them double validity.

4.3.7 The Evaluation - Definitions, Goals, Techniques

JAMIESON and CHING ,(1989), distinguish formal evaluation areas which represent major areas of concern during the evaluation process and formal evaluation sub-areas which represent those which are either directly related or inter-related to the informal evaluation areas. These areas are:

- evaluation of problem definition
- evaluation of the prototype's/system's performance
- evaluation of the user acceptance of the prototype/system
- evaluation of the documentation for the system, including system's documentation and the user manual, and
- evaluation of the prototype's/system's user interface

For each of the evaluation areas/sub-areas, there are the evaluation goals, evaluation techniques, and the people involved (34). The author points out those areas in which, according to the proposed model, the internal auditor has a role (see Appendix C). It should be noted that the process of evaluation is performed during the whole development process by the other functionaries. The author refers only to the stages in which the auditor is involved. Yet, the evaluation process by others, like the developers/users is carried on throughout all stages. A point that should be mentioned is that some evaluation areas continue through a number of phases of the development, and the author mentions the most important of these.

4.4 THE ROLE OF THE INTERNAL AUDITOR IN AUDITING E/S UNDER DEVELOPMENT - NECESSARY ASSUMPTIONS

The audit objectives in auditing any system development are: " To ascertain whether there are adequate procedures to ensure that the development and maintenance of systems within the organisation results in well-documented computer systems, incorporating adequate controls and meeting properly defined user requirements in an efficient manner " (35). In other words, the aim of this system development auditing is to provide:"...audit reassurance that the stages of systems development have been complied with in accordance with laid down policy and are adequate to ensure well-controlled systems..." (36).

In order to develop the proposed model of E/S under development, a few assumptions will be pointed out; the reader will find full details about these assumptions in Chapter III. The internal auditor is not an expert in the audited field, and therefore unable to audit the process of concluding on the quality of the result. At the same time, he/she has limited resources, and is for the most part required to report on audited subjects in a short time. In other words, he/she does not have the time to invest in studying the E/S and to become an "expert". The current state of the E/S is that documentation is still not standardised and not complete. The methodology of the System Development Life Cycle of the E/S is also not standardised. This, in a way, makes the auditing more and more difficult. In addition, the evaluation of the E/S is not completely reliable. The auditor assumes that the internal auditor needs an available, applicable and practical method for auditing the Expert System. " The process of auditing E/S's is different from a process of auditing other software due to the unique characters of the E/S's..." (37). The differences were explained in the earlier chapters, and led to the conclusion that the auditing of E/S's requires a unique process.

In addition to the details mentioned above, the model for auditing an E/S under development must be flexible and adjustable; an internal auditor can deal with developing an E/S through different methodologies, from the shortest to the most detailed, so he/she needs a model which will respond to such differing conditions.

4.5 A MODULAR MODEL - AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

4.5.1 Prototype Principles

The "NESDEM" model is the basis of the model for auditing E/S's under development and its principles are integrated into the model, combining the approach of the "control band", like the one in Chapter III.

Its principles are integrated into the model, taking into consideration the assumptions which were described in subsection 4.4. The proposed model is based on the following ingredients:

a) In general, the steps are taken consecutively, with one step in the auditing process leading to the next. This is similar and parallel to the phases in the system development life cycle of the expert system. In some cases, the internal auditor will be required to sign-off at the end of each stage to allow the developers to continue to the next step.

b) In the stage: "Build and Test Prototype/Operational Version", the exception to the principle of modulation is the "Control Band Check". This check is basic and essential; therefore negative results in this check do not require further tests, because the required level of control installed in the E/S has not been satisfied. On the other hand, if the results are satisfactory, then other tests can proceed, the internal auditor can content himself/herself with this check for this stage, and continue to the next step.

As the author mentioned previously, the two main reasons underlying this principle are:

1) There exist processes of E/S development that contain barely defined stages. Sometimes the building of the prototype for the E/S is considered as redundant. Yet, the internal auditor needs to perform an audit within the approach and principles of the so-called SDLC of the E/S. The "Control Band Check" is the one that can assume a satisfactory level of control during this process.

2) To be able to proceed with the other tests in of "Build and Test Prototype/Operational Version" stage, the internal auditor stills needs to rely on the

other persons involved in the development. The availability of the expert/s himself/themselves is questionable. In a development environment of limited resources, they are unavailable.

c) In subsection 4.3.7, the recommended evaluation techniques of E/S performance were described. As mentioned above, there will be occasions in which the only action that the auditor will be able to take will be the "Control Band Check". Yet, if the internal auditor can go further, he/she might choose one or other techniques according to the circumstances.

4.5.2. Auditing Techniques Definitions

In order to specify the type of involvement of the internal auditor in auditing the process of developing E/S's, the following types of auditing technique are defined:

1) Administrative techniques: all the methods which do not include direct involvement in the programming steps: reading documents, taking part in meetings, investigating, questionnaires, interviews, etc.

2) Self-operational: all the methods which lead to direct examination of the programming by computerised means, and are performed and controlled by the auditors: test data, test case, "control band" check.

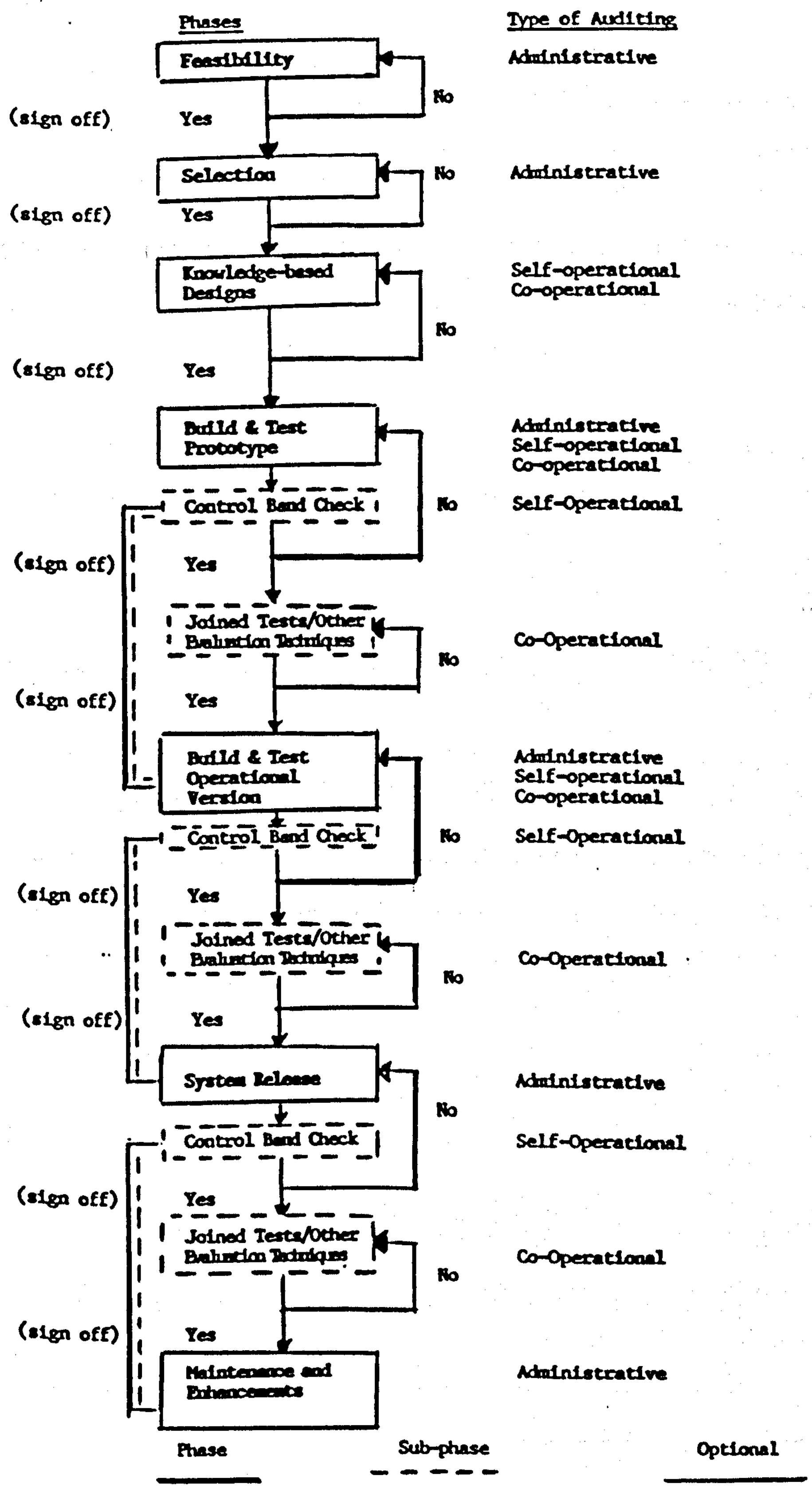
3) Cooperational: the same methods as in "Self-operational", but performed and controlled by others, and the internal auditor is part of the process.

These definitions are emphasised in order to differentiate between the various evaluation techniques which were described in the "NESDEM" model (see subsection 4.3). In the "NESDEM" model, the internal auditor is a part of a multi-evaluation process; the responsibility is not clear enough. The proposed AESD model obliges the internal auditor to conduct a personal and independent test in the "Build and Test Prototype"/ "Operational Version" stage. This is a basic test in the auditing process, and failure of this test enables the auditor to stop his auditing and assume that the developed expert system is over-exposed. The "Control Band Check" process is described in Chapter III and is the same remains unchanged.

4.5.3 The Diagram

The diagram in Fig:10 presents the stages in the modular model with the auditing techniques for each step. In the phases of "Building Test Prototype/Operational Version" and "System Release", the "Control Band Check" is essential; without it there is no further progress. The next step, "Joined Tests/Other Evaluation Techniques" is optional and will be held in those SDLC in which the circumstances allow (see more details in subsection 4.2 and 4.4).

Fig:10: Modular Model – Auditng an Expert System Under Development



4.6 LIMITATIONS

The AESD model can be used in any environment and within any framework of the development of the E/S. In cases in which the steps of the development system life cycle are detailed, the internal auditor would not have any difficulty in adapting the steps of this model to the one used in the organisation. In cases where there is no clear methodology, and the stages of the development process are blurred, the "control band" tests are extremely important as an objective and independent factor.

JAMIESON and CHING ,(1989), indicate other limitations of the general model, which apply to the internal auditor's model:

" The sample size of test problems are generally small and these problems may be inconclusive of the whole problem environment. The expert and/or users responsible for evaluating the system may represent different schools of thought and may rate the system by placing emphasis on different criteria. If different results are obtained, how should the system be rated overall?. O'LEARY ,(1986), suggests that it is possible to develop an E/S which derives better solutions than those of the expert(s). In this case, can we still employ the expert's solutions as a standard for comparison?. Changes are occurring all the time. Experts who agree on solutions today may not feel the same in the future. How then should the E/S mature over time if differences in opinion exist? " (38).

4.7 SUMMARY AND CONCLUSIONS

In this chapter some of the SDLC methodologies of developing E/S are described. The "NESDEM" model is elaborated on and its advantages compared with other methodologies. The "NESDEM" is the basic model from which the stages , in which the internal auditor should be involved, are extracted. Then the "Control Band Check" is integrated into this methodology, on the same principles as described in the previous chapter.

The modular AESD model enables the internal auditor to concentrate not only on the crucial steps of the development process but at the same time carry on the "Control Band Check". The author believes that this is a model which combines a flexible process of "step-by-step" with practical aspects, like the "Control Band Check".

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CHAPTER V
THE METHODOLOGY

5.1 INTRODUCTION

In Chapter III, the proposed model for auditing an operating E/S (AESD), which in his view is indicated, and aims to provide the internal auditor with a practical method. In the previous chapter, the complexity and sophistication of the E/S was emphasised on a number of occasions. The contradiction of a practical method and a complicated and sophisticated E/S raises the inevitable question: is it possible? The answer lies in the results of the test which has been conducted . The methodology of the test will be explained in this chapter.

In Chapter IV, the author presented his proposed AESD model . Whilst normally auditing an operating E/S is conducted by the internal auditor according to his/her schedule, priorities, risks, speed and progress. Here, the internal auditor is part of the development team. The meaning of such a partnership is that the audit will accompany the development process. It is reasonable to assume that such a process could well last several months, sometimes even more than a year. Yet, the AESD model for auditing E/S under development needs to be tested. The testing methodology used by the author will be described in this chapter.

This chapter discusses the research methodology used considering the difficulties faced, such as lack of cooperation and restrictions of information. The test case and the survey by sending questionnaires are the techniques used for testing the AOES and the AESD models

5.2 ABOUT THE RESEARCH

DIXON, BOUMA and ATKINSON ,(1987), define research as a method of learning about ourselves or our world. It is a process of answering some of the questions in order to understand more (1). The question raised by the author in this research is: Does the internal auditor need a specific model for auditing E/S's; if so, why, and which model would fulfill the purpose? Seeing as two models have been proposed on how to audit an operating E/S and an E/S under development, the research aims at establishing the suitability of the models. ADAMS and SCHAVANEVELDT ,(1991), define research methodology as a scientific tool which helps us to acquire answers to a wide variety of research questions..."; in other words, "the tools for obtaining useful information" (2).

BLUMER ,(1978), discusses the differences between researches in various disciplines and clarifies several different types of research in "social science":

1) **Basic social science**, concerned with advancing knowledge, whether through theory-building and testing, or whether through the satisfaction of curiosity.

2) **Strategic social science**, grounded in an academic discipline or subject, but orientated towards a problem which has arisen in society, without the aim of prescribing a solution to it.

3) **Specific problem-orientated research**, carried out for a customer who provides a specification to the researcher.

4) **Action research**, involving research as part of social programmes for planned social change.

5) **Intelligence and monitoring**, the collection of demographic, economic, and solid statistics in the repositories of data that may be drawn upon, with expert guidance, by politicians and administrators to help in the formation of policy (3).

Although BLUMER agrees that these types of research are not absolutely clear, the significance of this classification is derived from the fact that social research is broader than social science (4). The author considers his research as specific problem-orientated research, because according to the definitions of BLUMER, the results of such research are designed to help the researcher to deal with a practical, operational problem (5).

SOMMER and SOMMER, (1980), recognise the following types of research studies:

- **Basic research**: Seeks answers to long-range questions, motivated primarily by curiosity.
- **Applied research**: Seeks practical answers to immediate questions with the goal of obtaining usable information.
- **Instrumental research**: Undertaken as an academic, vocational, or professional requirement (6). MILLER, (1991), differentiates these research types according to the following defining characteristics: nature of the problem, goal of the research, guiding theory and appropriate techniques, even though the differences are still not so sharp (7).

KIDDER and JUDD, (1986), recognised two types of research: applied research and evaluation research. Applied research is designed to answer practical questions (8). It should be pointed out that the proposed models of auditing an operating E/S and auditing E/S under development, are highly practical, and could be used by the internal auditor. Therefor, the research conducted for this thesis complies with the definition of applied research.

DIXON, BOUMA and ATKINSON ,(1987), define three basic phases in a research process: essential first steps; data collection and analysis and interpretation (9). GILL and JOHNSON ,(1991), describe the research as a seven-stage process:

- identify broad area;
- select topic;
- decide approach;
- formulate plan;
- collect information;
- analyse data, and
- present findings (10).

ADAM and SCHAVANEVELDT (1991) outline seven steps in the research process which basically are similar to the above (11). MANN ,(1985), distinguished eight stages in the research process (12). Comparing the various processes indicates a basic similarity in the process. DIXON et al recognise five types of research design:

a) **The case study** - in which a single case is studied for a period of time and the results recorded.

b) **The longitudinal study** - which involves two or more case studies of the same group, with a period of time between each study.

c) **The comparison** - which involves comparing one measure of two or more groups.

d) **The longitudinal comparison** - in which two case studies, each one of two groups at the same time, are combined.

e) **The experiment** - which provides the most vigorous test of a hypothesis (13).

Each of the above research designs has advantages and disadvantages which the researcher should consider before deciding which one is the most suitable. The researcher should also take into consideration the environment in which the research takes place; in other words, the subject of the research, the availability of information, the access of the researcher to information sources, etc. The development of an E/S and its maintenance require substantial investments in capital and human skills. Some E/S's have been developed uniquely for the organisations in order to improve their competitiveness. All these factors have contributed to create an uncooperative environment for the researcher. The next subsection demonstrates the difficulties which were faced in finding E/S's for research purposes.

5.3 RESTRICTIONS ON THE RESEARCH

In the previous chapter, it was reiterated that one of the most outstanding characters of the E/S is it's level of sophistication and the currency of the knowledge encompassed in it. Companies are employing E/S's to improve their ability to compete in the market:

a) using a very powerful tool which the competition may not have gives a clear advantage - Zeneca Pharmaceuticals supports this claim ,and

b) cutting costs improves the ability to keep the prices of the products low.

To some extent, in the author's view, paradoxically, these facts were real obstacles in the efforts to test the AOES model. For a long the guidance given was to try locate organisations which use E/S's and which would agree to allow the testing of this model. Efforts were concentrated in two sectors: British companies located in the UK, and companies which operate abroad: in the USA, the Netherlands, Germany and Israel. Users of E/S in these countries were located, and applied for permission to test his models for auditing an operating E/S and auditing an E/S under development. In the UK, there was an official application to the DTI, the Department which supports developing knowledge-based systems in manufacturing.

Arjo Wiggins Appleton agreed to allow the conduction of the research on their E/S, with certain limitations, mainly because of time constraints . As a result of the efforts of the supervisor, the Department of Optometry and Visual Sciences at the City University agreed. Negotiations with other companies, as well as with the University of Sheffield, failed.

What are the main reasons for not having more E/S's which can be used for the research?

a) The main obstacle faced in the efforts to persuade organisations to co-operate was a genuine anxiety about the leaking of secrets. It became very clear that they are unwilling to risk allowing an outside researcher to investigate the use of the E/S, even at the price of advancing research. This applied basically to those companies which had developed their own E/S's.

b) Banks and other financial institutions expressed concern about infringing the privacy of their customers. The fact that the author is a researcher still does not permit him to look at data regarding customers, as would an internal employee.

c) A few of the organisations approached indicated time constraints imposed on their staff, and were therefore unable to cooperate . With regard to the AESD model , the option of the author joining a development team during the development process was not possible . With regard to the AOES model , this same argument was put forward by the banking sector.

It should therefore be pointed out that an internal auditor within an organisation using an E/S will not face these difficulties; he/she will not be under pressure of time, limited information and restricted cooperation.

The effect of the above on the test stage of the research is:

a) A small number of organisations exists on which the model can be tested; a larger number would have allowed a broader conclusion about the model.

b) As explained in Chapter III the internal auditor could use the test data and the "exceptions tests" at the same time. Due to the above circumstances, it was not possible to use the "exceptions tests" , mainly because of cost constraints and so only the test data was used

c) An internal auditor is able to achieve consistent information about the E/S. Due to his/her organisational status, which allows him/her unrestricted access to the inter-organisation information, he/she could initiate a meeting with colleagues within the organisation to enquire about the E/S which it intends to purchase or develop. He/she can also issue a questionnaire. This research it was significantly not possible to use the first resource.

5.4 THE CASE STUDY AS A RESEARCH DESIGN

In subsection 5.2, the author mentioned the case study as one of five research types. YIN ,(1988), defines a case study as an empirical enquiry which investigates a contemporary phenomenon within its real-life context; whilst the boundaries between phenomenon and context are not clearly evident. In that type of enquiry the researcher uses multiple sources of evidence (14). In his opinion , case studies are the preferred strategy when the questions 'how' or 'why' are raised, and when the researcher has little control over events. As a research strategy, the case study is used in many settings, such as; policy, political science, public administration research, community psychology and sociology and city and regional planning research, sciences (15).

What differentiates the case study from other research strategies relating to the research of auditing E/S ?. " The case study is preferred in examining contemporary events, but when the relevant behaviors cannot be manipulated. Thus, the case study relies on many of the same techniques as a history, but it adds two sources of evidence not usually included in the historian's repertoire; direct observation and systematic interviewing. Again, although case studies and histories can overlap, the case study's unique strength is its ability to deal with a full variety of evidence - documents, artifacts, interviews, and observations " (16). In other words, the case study enables the researcher to observe a "real life" case in which there is not the slightest possibility of manipulative behaviour by the audited subject.

In Chapters I and II the author described the expansion of the use of the E/S's within the non-academic world: banks, the insurance sector, industrial companies, etc. The few E/S's on which the author will test the AOES model comply with the characteristics of the case study:

a) They were selected from the E/S currently existing in the UK.

b) They are operating E/S in organisations, which means that their behaviour is not manipulative.

c) As they are in frequent use in the commercial sphere and a product of organisational necessity, they should be accompanied by other evidence, such as: documents, personnel involved in the development process, users, etc. The model for auditing operating E/S presented by the author in Chapter III is based on interviews, questionnaires, computer reports, etc.

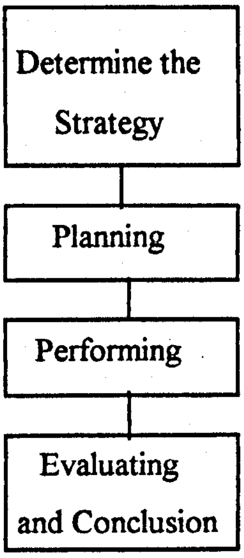
The actual check of the "control band" as it is described in Chapter III, subsections 3.4.5 and 3.4.6 is either by "exceptions test" or test data, or both. The "exceptions test" could be conducted either by the internal auditor using his/her own software to extract exceptions from the E/S, or by a programme built into the E/S, which will report on the exceptions on a routine basis. The difficulties faced in finding organisations which use E/S and were prepared to allow the testing of the models were described in subsection 5.3. Those who agreed, refused to allow the use of "outside software". Basically, the "exceptions test" can be used by the internal auditor within an organisation who has unlimited access to the E/S. The test data technique which is used here to test the AOES model does not include testing the use of the "exceptions test". This alternative technique is described in the next subsection.

5.4.1 Test Data - A Technique for Review of Systems Controls

Generally, the internal auditor uses one or more of the computerised audit techniques which enable him/her to review and evaluate the systems controls. CHAMBERS et al ,(1990), agreed that " The principle audit technique for the review of systems controls is the test data method...With this method, the auditor is able to simulate in dummy data as many input conditions as are relevant to the audit objectives, and then to confirm that they are handled correctly by the system. Ideally, the auditor would not prepare dummy data, but would identify examples from among the genuine input data which the system is processing " (17). Results of a survey that took place in the UK in 1985 shows that 40% of the organisations used test data, the commonest technique at this time in the UK. A world survey which was conducted in 1983 shows that 63% are using this technique (18).

CHAMBERS and COURT, (1990), define 13 steps of the test data technique, starting with a definition of the objectives, the means and the framework, through the test data itself, up to the conclusions (19). These steps could be well combined into four stages in using the test data technique, as shown in the following diagram:

Fig.11: Stages of Test Data



- Determination of the Strategy - In this stage the internal auditor determines the objectives of the audit, the technique which will be used, the principles of the test and its extent.
- Planning - The next step is to designate the logic of the test, the type of transactions and their scope. He/she also decides which testing file to use; either a live or a dummy one. He/she will probably produce a testing master file in order not to risk the live production. The planning also includes the expected results of the test, according to the known information about the controls.
- Performing - The internal auditor inputs the data to the system and collects the results.
- Evaluating and Conclusions - The results are compared with those which were expected. The differences are analysed and conclusions regarding the controls are drawn.

5.4.2 The Objectives of Test Data - Auditing an Operating Expert System

In Chapter III, described in depth was the methodology of auditing an operating E/S (AOES), including the limitations, the objectives and the various steps of the process. The test data is one of two auditing techniques; the other is the "exceptions" test, which the internal auditor uses in order to conduct auditing of the E/S. As mentioned previously, the additional objectives of such auditing, apart from the basic objectives stated in the "Standards for the Profession of Internal Auditing", are to identify the limits of the E/S and to restrict the risks. The test data is bound to serve the internal auditor in fulfilling the second additional objective. The test itself is carried out to test the internal controls of the system, if they exist at all; controls which have been established to reduce the exposure of the user to the possible risks.

It should be emphasised that the test data in auditing an operating E/S is not designed to replace any other test; i.e. "acceptance tests" or" user tests". Similarly, the internal auditor cannot and should not consider substituting for such tests any tests of the E/S's which have been conducted by the developer at any stage of the development process.

5.4.3 The Planning - AOES Model

The Internal auditor is, in theory, a key function in the flow chart of the information within the organisation. Ex- officio, he/she has unrestricted access to information. With reference to the methodology for AOES and AESD , one can assume that he/she will be kept informed during the whole process of purchase/development of the E/S . Such an event in the life of the organisation is not negligible, and therefore it can be assumed that the internal auditor, as well as those involved in other functions, will be informed.

It is extremely important and crucial that, when the internal auditor is planning the test data in the E/S , the test data should reflect the combination of the risks of using an E/S in daily use. In the research undertaken here, cooperation with the author was restricted in such a way so as to maintain the confidentiality of the system. It is obvious that the scope of test data in auditing an operating Expert System should be wider and reflect the risks more comprehensively.

The planning of the test data includes the following steps:

a) definition of the test environment; basically it will be tested on a similar system,(not live)

b) definition of the process of discussion on the results of the test, and design of the appropriate documents

c) running the test data and comparing it with the expected results

d) testing the "behaviour" of the E/S in a "borderline situation" with regard to its possible effect on the processing of the data, and hence to the risks of the system, and

e) testing the reaction of the Expert System in response to incorrect data with regard to its possible effect on the processing of the data, hence risking the system

5.4.4 Performing - AOES Model

Previously explained were the difficulties of using the technique of test data for a non-employee of the organisation, the researcher in this case. The processing of the test data will be performed with a "representative" of the organisation. Moreover, the details of the test data will be discussed with the "representative", as will the "framework" of the test, including the limitations of the computer resources.

5.4.5 Evaluating and Conclusions - The "Control Band" of the E/S

This final stage of the test data is a combination of two sub-stages:

a) The researcher will analyse all the results of the test data, and evaluate the reliability of the controls and the actual exposure to risks of using the E/S. Zero findings in the test data indicate that the risks of using the system are minimal, or non-existent. Positive findings indicate the weakness of the system, and the internal auditor should point out where and to what extent the risks exist.

b) The findings should be discussed with the representative. Obviously, positive findings will be followed by recommendations from the internal auditor.

5.5 THE QUESTIONNAIRE AS A RESEARCH DESIGN

In order to test the AOES model , the case study strategy was used: two live E/S's were chosen on which this model was tested, and throughout the various stages, meetings, data collection, questionnaires and test data took place. The AESD model requires the involvement of the internal auditor during the whole process, and therefore cannot be conducted after the completion of the development. Explained in subsection 5.3, are the difficulties of testing the model under a live process of development of an E/S.

YIN, (1988), distinguishes five different research strategies:
a) experiment; b) survey; c) archival analysis (e.g. economic study); d) history; e) case study (20). KIDDER & JUDD, (1986), explain that in a survey the researcher collects data from a population to assess the relative incidence, distribution, and interrelations of naturally occurring phenomena. (21). It should be stressed that the main advantage of the survey is its wide coverage (22). KIDDER & JUDD ,(1986), indicate other

advantages of the survey. It enables the researcher to asses the distribution of the population characteristics (23).

HAKIM (1987) points out an ad-hoc sample survey which offers a multi-purpose research design with many advantages. Its main advantage lies in sampling a representative population. Another significant advantage of the survey is the ability of the researcher to repeat it in similar or different circumstances, according to his/her judgment.(24). In his/her opinion, the "...main attraction of the sample survey design is its transparency of accountability - the fact that the methods and procedures used can be made visible and accessible to the parties, so that implementation, as well as the overall research design, can be assessed..." (25).

Having considered the difficulties of testing the AESD in other types of research strategy, such as a case study or an experiment, it was decided to use the survey strategy as the test. The population included in the survey consists of internal and external auditors. The common factor of this population is its connection with auditing. Previously, confidentiality was described as one of the major obstacles in the efforts to find organisations which use E/S and are willing to cooperate in the tests of his models. The survey will help to by-pass this obstacle; each person interviewed in this survey is able to take part in the survey, to contribute to a research project for the benefit of the internal audit as a profession without exposing the secrets of his/her organisation. It is believed that the population in the survey has a strong motive to fully participate in the survey with a view to contributing to the profession.

5.5.1 The Questionnaire as a Data-Collection Method

Subsection 5.2 mentioned some of the research framework. One of the most important stages is the data-collection. KIDDER and JUDD, (1986), recognise three main ways of gathering the data for the survey ,a written questionnaire, a personal interview, a telephone interview.."(26). CAPLOVITZ ,(1983), recognises that: the questionnaire is the basic instrument in a social research (27).

What advantages presented by the written questionnaire did the author consider when proceeding with the survey?

a) Low cost is the primary advantage of written questionnaires, whether they are mailed - the most common means of distribution - or handed out in other ways. Low cost means also less expensive time of those interviewed (28).

b) " Avoidance of potential interview bias which could be created by the appearance and the voice of the researcher (29).

c) Reducing the pressure on the interviewee to respond immediately. This means eliminating the excuse of "lack of time" which other methods, such as interviews, may provoke (30).

d) The anonymity which encourage open responses to sensitive questions. and gives the interviewee the feeling of protection against leaks of inter-organisational secrets (31).

The questionnaire will be used to collect data for the survey in order to test the AESD model .

5.5.2 The Questionnaire's Process

The process of using the questionnaire as a data-collection method comprises five principal stages:

A) Preparing the questionnaire - The questionnaire package includes documents: (1) a letter from the author, personally addressed to the interviewee, explaining the purpose of the survey, and the importance of his/her participation; (2) a questionnaire of six questions asking the opinion of the interviewee on the proposed AESD model . The questions include a scale of five ranks from 1 - 5; this scale enables the interviewee to rank his answers; (3) a short description of the proposed model comprising a short written explanation , a diagram, and a list of evaluation goals and techniques (see Appendix E).

B) The pre-test of the questionnaire - "...The pre-test is a try-out of the questionnaire to see how it works and whether changes are necessary before the start of the full-scale study. The pre-test provides a means of catching and solving unforeseen problems in the administration of the questionnaire, such as the phrasing and sequence of questions or its length. It may also indicate the need for additional questions or the elimination of others..." (32). DILLON ,(1990), suggests that one of the first stages of the pre-test should be: testing on friends and relatives, of the researcher (33). The questionnaire on the AESD model will be tested on five internal and external auditors, who will be selected at random from colleagues either in the City University, or in other sectors, such as finance etc.

The author approached five internal/external auditors who agreed to take part in the pre-test of the questionnaire. A package including a questionnaire, a short description of the proposed AESD model , and a letter explaining the purposes of the test was sent to them. After they had received the questionnaires, the author interviewed the participants by telephone on the design and structure of the questionnaire. Four of the five responded positively to the design, the structure and the clarity of the questions. The replies to the questions within the questionnaire will be analysed in the next chapter, together with the responses from other interviewees. The fifth participant, after reading the questionnaire, refused to complete it, but made comments. The main comment relates to the phrase "internal audit" which was used in the questionnaire. In the opinion of this respondent, the proposed model could also be useful for external audit. The author chose not to change the questionnaire, mainly because his background is in internal audit.

C) Sampling - ADAMS and SCHAVENEVELDT ,(1991), define sampling as: "...a process whereby one makes estimates or generalizations about a population based on information contained in a portion (a sample) of the entire population. It is the goal of quality research to have a sample that is truly representative of the total population from which the sample has been selected..." (34).

The distinction between a probability sample and a non-probability sample is that within the non-probability sample, there are few recognised sampling methods. The method employed by the author for the questionnaire is PURPOSEFUL

SAMPLING, which is a process of creating a sample based on cases, individuals, or communities who are very informative for the research (35) . The population used for this questionnaire is forty internal/external auditors from the following sectors: Banking, Accountancy and Management Consultants, Insurance, Services and Tourism, and Other.

What is the basis for this selection?

1) The six sectors mentioned above reflect the expansion of the use of E/S's in the UK and abroad. ANDREWS ,(1989), reported on a study within twenty four organisations that between them have over two hundred E/S's in action. These six sectors are based on that study (36).

2) Each sector will be represented by at least five "representatives".

3) The reason for choosing the organisations listed in Appendix E is a preliminary knowledge about their involvement in E/S, i.e., either they use or have used in the past an E/S, or have investigated the possibility of using an E/S. Some of them were surveyed by B. ANDREWS(37) in his research. In some sectors, such as finance and insurance, the exposure of the organisations to an E/S is relatively bigger than other sectors. The reason is basically the fact that a substantial part of the E/S market is targeted in these sectors.

4) The population which will be approached comprises internal and external auditors with a knowledge of computer auditing.

5) Some of the internal auditors were previously involved with the author in a discussion on the subject of how to audit an Expert System, and expressed their willingness to take part in any survey on this issue. The organisations which were chosen to take part in the questionnaire are divided into six groups: Banking; Accountancy and Management Consultants; Insurance, Industry, Services and Tourism, and Other.

To some extent the selection of the sample for the mail questionnaire was a purposeful sampling as explained before (see subsection c).This means that this sample is reflecting those organisations who are using E/S but are known to the author, and therefore it is not random sampling. The full implication of this fact is unknown due to the lack of solid and full list of organisations in the U.K who have or are using E/S.

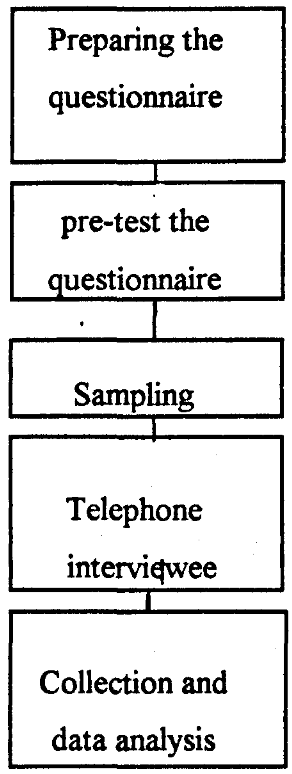
D) Telephone presentation and agreement to participate in the survey - The author will personally telephone the professionals ,present the aims of the survey, explain the method, and ask their agreement to take part. In the case of a positive response, he will send them the questionnaire. This presentation and the acceptance of the interviewee will increase the rate of the response. Given the population of this research, it is crucial to receive a high rate of response.

In addition to the five internal/external auditors who agreed to answer the questionnaire for the pre-test, the author telephoned thirty five internal/external auditors within various organisations . In total, forty agreed to cooperate and to reply to the questionnaire. A package including a questionnaire, a short description of the proposed model, and a letter signed by the author was sent to each of them. The author also answered various questions raised by the interviewees. The results of the questionnaire will be analysed in Chapter VII.

E) Questionnaire collection and data analysis - ADAMS and SCHAVENEVELDT, (1991), recognise the challenge of receiving a high rate of response to a questionnaire (38). They proposed using follow-up cards, telephone calls to urge the interviewee to respond to the questionnaires, etc. It is extremely important to receive a high level of response, particularly as the population was chosen in order to represent a wide range of those potentially involved The results of the questionnaires will be analysed as well as the comments, and consideration given on whether a change or amendment in the proposed AESD model. should be implemented.

The following figure describes the 5 stages:

Fig.12: Questionnaire's Stages



5.5.3 The Motivation to Cooperate

One of the key questions the researcher faces when using the interview or questionnaire is what motive the interviewee has to dedicate some of his/her time to taking in the survey. A strong motivation for cooperation leads to a high rate of response and to a considered response. The following factors are suggested as contributors to the motivation of the interviewees to respond:

A) To the best of the author's knowledge, no other similar research is taking place in the UK. E/S's are new and there is still no consolidated audit approach in this area. Internal and external auditors who the author has met over the past three years have shown a deep interest in the results of the research. It may be assumed that the development of an AESD model is also of interest to them.

B) In participating in this survey, there is no threat to the interviewee as there might be if, for example, the author had taken part in the process of E/S development within the interviewee's organisation. There is no risk of a breach of secrecy. Thus it gives the interviewee an open atmosphere to respond (39).

C) In some of the organisations which were chosen, an E/S had been developed without the involvement of the internal auditor in the process of development. One of the main reasons for this, as mentioned in the previous chapters, is the lack of a model for auditing an E/S under development. It is assumed that, in these organisations, the internal auditors will be interested to examine a AESD model, at least to enable them to evaluate their position and the risks. Some of them expressed this view in meetings with the author.

5.5.4 The Questionnaire

As already mentioned in subsection 5.5.2, questionnaires with six questions, together with a short description of the proposed AESD model, will be sent to the interviewees who agreed to take part in the survey. The questionnaire includes two parts: a) general details: name, title and the name of the employer; b) six questions with a scale of five possible answers, rated from 1 to 5 (option 1 is 'very poor', to option 5 being 'very good'). This scale measures the 'subjects' of the questions and allows the interviewee consistent and graduated scores.(40). The interviewee is asked to tick his/her answer to the questions. He/she is given an opportunity to receive the results of the survey.

How have the questions been chosen? In subsection 4.4, the assumptions which lead to proposal of the AESD model were explained. . The basic one is that the internal auditor needs an available, applicable and practical model, and yet a model which will enable him/her to evaluate the risks of the developed E/S and the suggested controls. He/she also needs a flexible and adjustable model which will enable him/her to perform auditing even if the system development life cycle of the E/S is either unknown or uncommon. The questions reflect these assumptions: 1. Does the proposed model enable the internal auditor to assess the effectiveness of the internal controls within the developed E/S? 2. Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an E/S? These two questions indicate the ability of the proposed model to evaluate the risks and the effectiveness of the controls. 3. Does the proposed model enable the internal auditor the flexibility to adjust his/her work in the development process according to the "System Development Life Cycle" which the E/S's may use? This question indicates the expected advantage of the proposed model on how to audit an E/S under development, the flexibility permitting its use in different environments of E/S development. 4. Is the proposed model practical for use by the internal auditor? This question emphasises the important element of the proposed model, the practicality of the model, i.e. the ability to use it on a day-to-day basis .5. Is the proposed model feasible for auditing an E/S? This question indicates the expected advantage of the proposed model, its feasibility in every organisation which develops an E/S. 6. Is the proposed model reliable?

The future benefit of the proposed model depends on its reliability in the eyes of the internal auditor. These questions point out this aspect of the model and encompass, it is suggested , a broad view of the model.

5.5.5 The Rating of the Questionnaire Results

Mentioned in different sections are the expectations of the proposed model, which in a way are expressed in the questions included in the questionnaire. The way in which these expectations could be supported would be by testing the model during the actual development process of an Expert System.

Considering the fact that, this appears to be the first AESD model , publications covering this area are not extensive enough. It is expected therefore that initially this model will be accepted. There is no doubt that during an actual test, improvements could be suggested on a more substantial and proven basis. The rating of 'average' and above (equivalent to options 3 to 5) in each question will mean that the AESD model was basically accepted and the advantages of the proposed model were achieved, i.e. that the model, from the perspective of internal auditors in the UK, is indeed practical, reliable and feasible. An accumulative score below 'average'(options 1 and 2) will mean that the author would need to consider making a necessary change in the model.

It is important to emphasise that the author will mention in the telephone conversation with interviewees his availability to answer any questions, if necessary.

5.5.6 Summary and Conclusions

In this chapter, the restrictions of the research with regard to the opportunities to test the proposed AESD and AOES models were described .After much effort, two organisations agreed to cooperate in the test of the AOES model . In this context, the case study research design was explained. In order to test the AESD model the questionnaire was sent to external/internal auditors with a knowledge of computer auditing. The process of sampling, pre-testing of the questionnaire, wording the questionnaire and the data collection were described in this chapter. The results of both tests, for both models will be detailed in Chapters VI and VII accordingly.

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CHAPTER VI
OPERATING EXPERT SYSTEM - TESTING THE "CONTROL BAND"

6.1 INTRODUCTION

In Chapter V, the methodology, the research design, and the difficulties of testing the proposed AESD and AOES models were described. The use of the Case Study technique for testing the AOES model, and the use of the Questionnaire for testing the AESD model were elaborated on.

This chapter includes details on the two case studies which were chosen for testing the AOES model ; the "Level Expert", an E/S which was developed by a commercial company, Arjo Wiggins Appleton, and "Vision Screener for VDU Users", which was developed within the City University by the Department of Optometry and Visual Science. The details of the test, beginning with the sending of the questionnaires and finishing with the test data and the results, will be elaborated here. The Appendices include the questionnaires, the replies, the test data forms, and the results.

6.2 ARJO WIGGINS APPLETON - A PROFILE

Arjo Wiggins Appleton came into being after the merger of Wiggins Appleton, a UK based manufacturer of high quality papers, and Arjomari Prioux, a French quality paper-making group. Arjo Wiggins Appleton has a commitment to market leadership in its chosen specialty areas, and its product range includes quality business stationery, carbonless copying paper, facsimile paper etc. The company is the world's largest manufacturer of carbonless paper and a leading producer of thermal paper. The number of employees worldwide is 12,000, and the turnover of the company for 1989 was £1.5

billion, with a trading profit of £201 million. The mill in Dover, which employs 250 people, produces a variety of papers with very large and technically complex paper machines. The machines are typically 50 meters long and are run twenty four hours a day by crews of three to six men.

Arjo Wiggins Appleton's focus on quality is reflected in its strong technological base and commitment to research. There are one hundred staff employed at the UK Research and Development Centre engaged in a range of activities, from process research and product development to technical engineering services. One small team of four people is concerned with specialist software development for the paper mills throughout the group. The E/S, which will be described later on, was developed by this team for the Group's mill at Dover.(1).

In 1990, the company was awarded First Prize by the Department of Trade and Industry for their "...successful appreciation of an E/S to assist plant operators identify machine faults in paper manufacture. The application is in a real manufacturing environment and has been used to solve a problem which could not be solved in any other way. By selecting the right development tool, the system was built quickly and at low cost. It has given significant production benefits and has wide applicability " (2). The E/S which was developed is considered a success. It has led to a number of E/S projects throughout the Group. The research centre team has come to regard E/S tools as standard software to be considered alongside database management systems and conventional programming languages (3).

6.2.1 The Problem, the Solution, the "Level Expert"

I) The Problem

The presentation of this section is based mainly on publications by the developers. Papermaking is a complex process, where a stock of pulp, water and chemical additives is fed onto a moving wire mesh. The water is drained away, leaving a web of paper, which is fed through presses and then a bank of drying rolls to remove further water. A surface coating is added at the size press and the paper is dried again, using a second bank of drying cylinders. The surface properties are improved by calendaring, and finally the paper is reeled up. Costs, especially energy, are high, and the process is inherently highly variable. Production of high quality paper demands a great deal of expertise from the machine operators. The problem of "bad level" is one of the main problems affecting paper machines. "Bad level" is where the finalised reel of paper does not appear perfectly cylindrical, but has uneven thickness across its width. This may be due to actual paper thickness variation, or other factors, such as varying moisture content and reel tension. There are many hundreds of aligned rotary elements in a paper machine, so tracing the cause of' bad level" is extremely difficult.

Because of the policy of very high quality standards, the paper produced with a "bad level" is recycled at the mill and does not reach the market place. Two paper machines at the Dover mill recycle several tones of paper every year because of this range of faults, and the cost of associated machine downtime is also significant. The full cost at the Dover mill is estimated to be about £80,000 a year. When a level problem occurs at Dover, the shift crew generally attempt to identify the cause and solve the problem themselves. It was recognised that operators often take actions based on their initial impressions of the problem. "Bad level" is a complex problem that needs to be considered carefully from a number of angles before accurate conclusions can be drawn about the cause. Reacting without this degree of judgment can waste time and money. Formerly, if the shift crew proved unable to solve the problem, the expert would generally be called in day or night.

The need was indicated at Dover to develop a system whereby level problems could be systematically and logically investigated to isolate the likely cause or causes. The Process Information Technology Department of the company, which has been studying E/S's for some time, was asked to investigate the potential for a system to address "bad level" at Dover.(4).

ii) **The Solution**

The expert at the Dover mill estimated that there were over two hundred possible machine faults that could cause "bad level", and that the symptoms could be described by answering about 15 structured questions. He related the fifteen - answer descriptions of each level problem to the attributes of each possible fault to isolate the likely candidates. The expert and three members of the Process Information Technology Department became the development team. The team decided that the final system had to run on a PC to achieve maximum portability. After a short period of research, it was decided to choose a PC based E/S development shell on the basis of the following points:

1) It seemed easy to use and had good functionality for the price.

2) It executed quickly and had a good graphical interface - both considered important for end- use acceptability.

3) The supplier should have a hotline support and fairly extensive training courses.

The first stage of development was for the project team to devise a systematic approach to knowledge elicitation. An appropriate structure for the knowledge was devised. The mill expert detailed each of the possible faults. He consulted other production staff, and even equipment suppliers, to obtain information. Compilation of the knowledge required approximately one man-week of effort. The Level Expert itself was developed from this information within the thirty man-days allocated. The system is technically uncomplicated, using predominately backward-charging rules to collect and evaluate responses. After a three-month trial period at Dover, the Level Expert was significantly amended, using the development environment's own database interface programme.

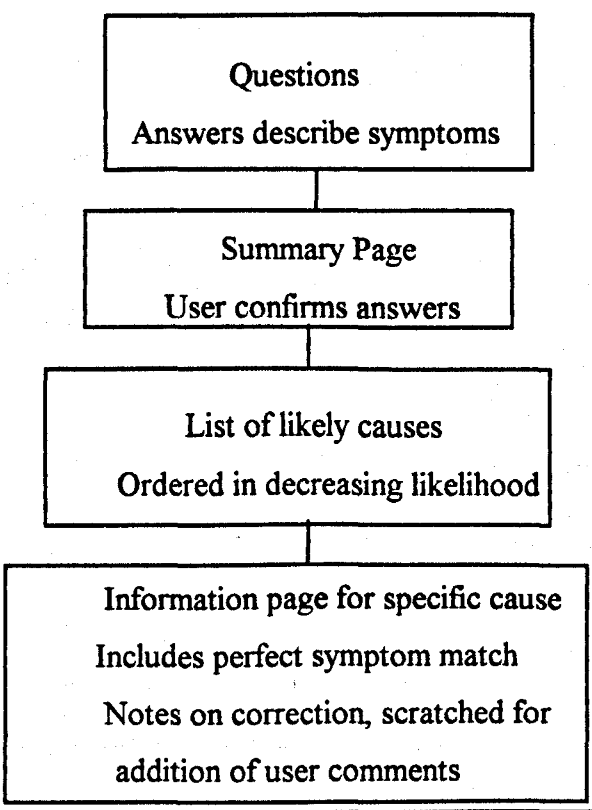
Iii) The "Level Expert"

The "Level Expert" is menu- driven and intended to be as easy to use as possible. The main menu offers choices to consult the Level Expert, edit faults or list faults. "List Faults" lists by paper machine area all the faults which could cause bad level. "Edit Faults" is password protected, offering the system manager options to add new faults, edit or delete existing faults.

When consulting the Level Expert, the user is prompted to select the most appropriate options from a series of menus, yes/no questions and sliding scales. The parameters collected describe the problems, its location on the reel, its onset and evidence from on-machine sensors. After answering these questions, a summary of all the selections is displayed and it is possible to edit any selections made. When the user is satisfied with the input, the system lists in order of probability the possible causes of the problem. Typically, the system will find about twenty five potential faults. An information page is available to users for each of the two hundred faults in the system. Users also have a facility to write comments for other users on the information page.

Diagram F.13 describes the flow of the "Level Expert":

F.13 The Flow of the "Level Expert" System



The developers describe the reaction of the users to the system as very positive. It was considered easy to use, well designed and useful as a diagnostic tool. In addition, it was found to be very useful as a training aid for new or inexperienced staff. The financial payback of the project was difficult to gauge, although it was estimated that downtime due to level problems was cut by 70% following implementation of the system (5).

6.2.2 Collection of Data

After Arjo Wiggins Appleton had expressed their willingness to allow for the testing of the model on how to audit an operating/ E/S, with some conditions. The first stage was to collect information about the Expert System developed by the organisation. Two sources of information were available: a) The periodical Manufacturing, which is published by the Department of Trade and Industry. Two articles about the "Level Expert" have been published, containing details about the development process and the uses of E/S; b) An article written by the Arjo Wiggins Appleton Research and Development Department on the subject of "KBS Case Studies".

The second stage was a meeting with two of the Level Expert developers within the Research and Development Department of Arjo Wiggins Appleton. The topics discussed at this meeting were:

- the development process
- the controls
- the uses, and
- presentation.

The author presented the proposed model and explained the next steps. He left a questionnaire with them (see Appendix F).

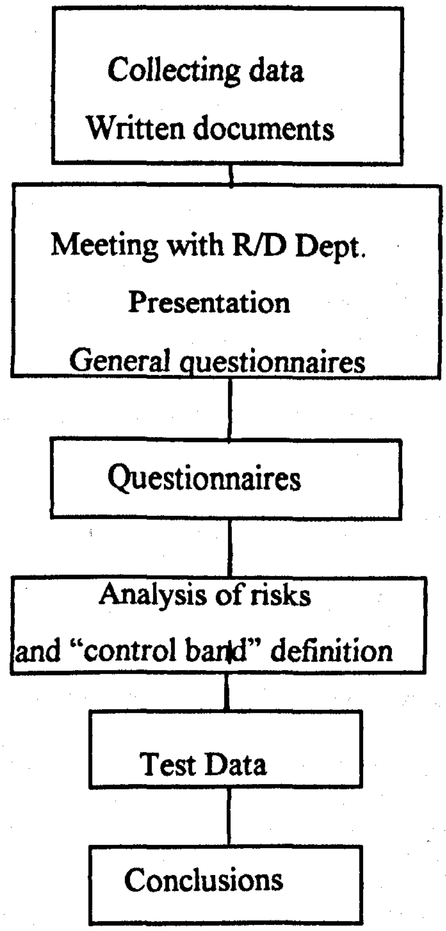
The third stage was to gather all the updated information on the "Level Expert". Then four different questionnaires were sent to Arjo Wiggins Appleton: a) the Expert; b) the Knowledge Engineer; c) the Manager; d) the User (see Appendix F). The author was not given the opportunity to visit the mill in Dover, or to interview the users, the expert, or the managers. The lack of time was a key factor in the cooperation of Arjo

Wiggins Appleton's Research and Development Department. The questionnaires and the replies are shown in Appendix F.

The fourth stage was to analyse all the available data to assess the risks of the "Level Expert" in order to define the " control band " and to prepare a proper test data. Appendices G and H show the risks, the data and the expected results of the test data.

The fifth stage is the test data; the details will be given in the next subsection. The following diagram presents the stages of auditing the "Level Expert" in Arjo Wiggins Appleton:

F.14: Auditing the "Level Expert" in Arjo Wiggins Appleton



6.2.3 The Test Data

The test data of the "Level Expert" taken on 28th June, 1994, at the premises of Arjo Wiggins was the last stage in a long process of auditing an operating E/S. It began with the first questionnaire, which produced basic and general information about the system, with the subsequent questionnaires being completed by four different functionaries within the company, who analysed the risks and performed the test data.

As emphasised several times in previous chapters, two main limitations prevented extending the level of involvement to that which should be performed by an internal auditor within an organisation: a) a lack of time in Arjo Wiggins, which affected the author's ability to meet the users, the expert, the knowledge engineer and the managers; it also limited his ability to conduct test data: b) safety steps which are quite understandable, which prevented the author from visiting the site or from suggesting an auxiliary programme which would produce "exceptions tests" (see Chapter 3, subsection 3.4.5).

Despite the above restrictions, the process of data collection analysis and testing was completed. In other words, the AOES model was carried out, although the author is not an internal auditor and a member of staff at Arjo Wiggins. The whole process of meetings, using questionnaires, and collecting information from other sources was available and proved practical. The process enabled the author to conduct the test data.

The most effective method of evaluating the controls of the "Level Expert" is to ask the expert who is still working at Arjo Wiggins to assess the results of the test data. In the absence of this opportunity and on the basis of the expected results, the author will evaluate them. Appendix H includes forty seven tests which the author has conducted. Two of them are the basis for a comparison of the expected results, and 45 are tests in which one or more factors were deliberately changed. The main conclusion, as demonstrated in Appendix I, relates to the system of listing possible causes of the "Level Expert", which is based on scoring. The top ten possible causes in the basic tests appear in the following forty seven tests in a range between 32% and 89%. In other words, these are the most common causes, which therefore receive higher scores. This is based on past experience, which proves that of the faults described in the basic test, the probability of "smoothing press surface build-up" cause is 89% (forty two out of forty seven). According to the knowledge engineer, it is indeed the most common cause. Yet, a full comparison with the actual cause could confirm the list, simply. In a different situation, i.e. when the internal auditor within the organisation is conducting the test data, it is possible. In Arjo Wiggins, the lack of time did not allow for this comparison. As explained with regard to the issue of testing the E/S, while in a conventional system in any test the results should be the same, here there is a possibility that with more tests the results will be different. This aspect could not be investigated in the test data due to the limitations of time.

According to the developer of the "Level Expert", the top ten possible causes represent the real causes. The fact that the system lists more causes is "academic". In other words, theoretically X possible causes could be the reasons for the default, but based on past experience, the top ten will include the real cause, and the shift manager will not have to continue searching for the cause throughout the test.

VISION SCREENER FOR VD USERS - CITY UNIVERSITY DEPARTMENT OF OPTOMETRY AND VISUAL SCIENCE

6.3.1 Background and the Problem

The Health and Safety (Display Screen Equipment) Regulations, 1992, which came into force on 1 January ,1993, are a direct result of European Directive No: 90/270/EEC of 29, May 1990, and are meant to set up general duties of the employer regarding the safety and health of the employees who are working with display screen equipment. Among other duties, the employer is required to: "...assess the risk to the health and safety of their employees and to anyone else who may be affected by their activities, so that the necessary preventive and protective measures can be identified; make arrangements for putting into practice the health and safety measures that follow from the risk assessment, covering planning, organisation, control, monitoring and review, in other words, the management of health and safety " (6).

The single most common health problem reported by people working at a display screen (VDU) is 'eye strain' symptoms, typically reported to include blurred vision or difficulty in focusing, double vision, burning, sore or itchy eyes and tiredness. The regulations make it the employer's responsibility to ensure that employees who 'use' display screen equipment have regular eye tests carried out by an optometrist or doctor. The cost of providing the eye tests and any spectacles that may be required for VDU work will have to be met by the employer. However, the regulations make provision for vision screening to be provided "...as a means of identifying individuals with defective vision who need a full eyesight test..." (7).

6.3.2 The Solution

" The City University Vision Screener is the product of several years' research and development at the Department of Optometry and Visual Science at City University. The system meets the requirement for screening of display screen users in a simple, appropriate cost-effective way ".(8). The E/S which was developed, carries out a comprehensive on-screen assessment of a user's visual performance. The advantage of using the display screen to present the tests is that the results obtained provide direct information about how the eyes are performing under normal VDU viewing conditions. Conventional vision screeners, which use official systems to present the test targets, cannot provide such direct information.

In addition to the vision tests, the programme includes a detailed on-line questionnaire to establish how the display is used and the nature of any problems the user may be experiencing with his/her eyes, back, neck, arms, wrists etc. The questionnaire also covers problems with the display, lighting and general layout of the work station. The system then performs an analysis of the responses to the questionnaire and the results of the vision screening and provides detailed advice about the likely causes of any problems reported, and what action should be taken to resolve the problem.(9).

The benefits of using the "Vision Screener for VDU Users", according to the developers, are various. " To the Employer': many eye problems experienced by VDU users are related to poor work station design or inappropriate work practices, rather than vision defects. It is estimated that less than 10% of users will require spectacles specifically for work with display screens. The system provides a simple and cost-effective way of identifying those users who are likely to benefit from a full eye examination by an optometrist or doctor. Those users who decide to exercise their entitlement to a full eye examination at the outset will also benefit, because the programme provides a detailed report, which will assist the optometrist or doctor in his/her examination. A complete vision screening usually takes less than fifteen minutes and can be done on site, at the employee's work station, or at dedicated health care stations.

By using the City University Vision Screener, the employer can become proactive in sight health care, and can regularly test all display screen users for a relatively small cost. The system provides detailed advice about many aspects of health and safety in relation to display screens and would lend support to health training schemes within a company or organisation. 'To the Employee': the system provides a "state of the art" assessment of visual performance while viewing a display screen. The tests are sensitive to small vision defects, and are wholly appropriate to a user's normal working environment. The employee can use the vision screener simply for reassurance or to check on perceived deterioration.

The recommendations produced by the programme can help the employee to understand many of the problems associated with display screen work and to be more aware of their own health and safety at work "(10). Generally, the advantages of this E/S lie in its health and safety aspects rather than financial aspects.

6.3.3 Vision Screener for VDU Users

The system is based on a complete programme that may be used on any PC capable of running Microsoft Windows 3.1. In addition, a red/green filter glasses and an expandable rule are required. The users, occupational nurses, doctors, optometrists, health and safety managers are supposed to use the system following the menus. step by step. The following diagram describes the stages:

Fig.15: The Flow of the Vision Screener for VDU Users:

Calibration		
	Administration Menu	Set-up Menu
	System Set-up	Screen calibration
Main Menu	Print Form	System Set-up
	File Memo	Default Units
On-line programme help		Phase 1
On-line Questionnaire		Phase 2
User details		
Display usage		
Eye symptoms		
Display screen problem)		General ergonomics
Lighting problems)		
General symptoms)		
Vision screening tests		Phase 3
Visual acuity		
Letter, Number search		
Muscle balance		
Eye coordination		
Visual fields		
Subjective screen rating		
File data on disc		
On-screen results		Phase 4
Summary of results/recommendations		
Full recommendations		
Printed reports		Phase 5
Results and recommendations (personal copy)		
Full recommendations		
Reports for the employer and the optometrist		

The calibration measures the exact size of the screen display area. It is a key factor in the optometrist's report, which is dependent on the accuracy of these measurements. The variety of reports, as shown in Phase 5, include the recommendations and are designed to cover the regulations.

6.3.4 Collection of Data

Basically, the stages of collecting data for the test data is similar to that described in subsection 6.2.2. The differences lie in the sources of information available. During the first stage of 'collecting data/written documents', the author met with Dr D Thompson, the expert and developer of the E/S. The discussion topics at these meetings were:

a) the development process
b) the controls, and
c) The users

The manual "Vision Screener for VDU Users" has great value as an information source. The author explained the principles of the proposed AOES model . He left a questionnaire with Dr THOMPSON (see appendix J).

The next stage was the meetings with the users of the E/S's. It should be pointed out that the variety of users outside the City University is important. These users are:

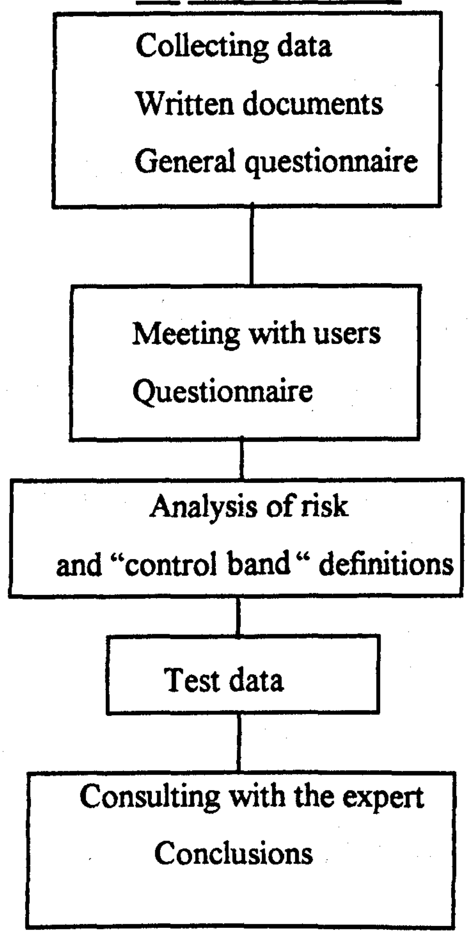
1) McDermott Engineering Europe Ltd.
2) British Rail - Occupational Health Service
3) City University Health Centre

As an exception, and due to the circumstances, Dr. Thompson answered the questionnaire for the Expert. The questionnaire for the Manager in a case where an E/S is developed and sold to outside users was not distributed at all. The author also had access to the correspondence regarding the Expert System, and a letter written by a user is shown in Appendix K. The developers of the system are conducting a survey to evaluate the use of the Vision Screener for VDU Users. The questionnaire used by the developers is shown in Appendix K.

The third stage was to analyse the risks, based on the information which was collected so far, and to define the " control band " which will enable the preparation of a proper test data. In contrast with the limitations in cooperation which the author encountered at Arjo Wiggins (see Subsection 6.2.2), at the City University, the level of cooperation was encouraging. The author had access to files, and the users also were cooperative. In Appendix K, the author has chosen some of the documents which, in his opinion, assist in presenting a wider picture of the Vision Screener for VDU Users.

The fourth stage was to test the AOES model. The tests were held on two different dates, but in the same conditions; i.e. place, computer, day-time. The author performed the eye-test on himself (see Appendix l). The fifth stage was to consult with Dr Thompson, the expert, on the results of the test data, details of which are given in the next subsection. The following diagram presents the stages of auditing the "Vision Screener for VDU Users" at the City University:

Fig.16: Auditing the "Vision Screener for VDU Users" at the City University



6.3.5 The Test-Data

The test data of the "Vision Screener for VDU Users" was obtained on 14th June and 4th July, 1994 at the Department of Optometry and Visual Science, City University, in the laboratory of Dr D Thompson and with his full help and support. As mentioned in the last subsection, the test data was just the fourth stage in the long process of auditing the "Vision Screener for VDU Users". The process started with the collection of data on the Expert System, mainly through discussions with the expert, reading the user manual on how to use the "Vision Screener for VDU Users", and through the questionnaires. In contrast to the "Level Expert" at Arjo Wiggins, the cooperation of the expert and developer, Dr. D. Thompson, was very positive and there was no distraction caused by the concern over leaking secrets of the system . Some delays occurred due to the contacts the author had with users such as British Rail and McDermott Engineering.

A decision was taken , after consultation with the expert, to carry out the tests on himself, on two different occasions. The purpose of this type of test was to eliminate a possible cause of diversity if the eye tests had been taken on two different users. The author, with the advice of the expert, Dr. D. Thompson, during these two tests kept the same factors such as room light, room temperature and seating conditions. The test results are shown in the following table:

Table 6.1: Comparing the Eye Tests

AREA	14/6/94 test	4.7/94 test
Visual Acuity:		
Both eyes	Good (89%)	Good (100%)
Right eye	Good (100%)	Good (100%)
Left eye	Good (89%)	Good (100%)
Eye coordination	Good	Good
Muscle balance	Below average (40%)	Good (93%)
Number search	Good (76%)	Good (77%)
Letter search	Good (78%)	Good (85%)
Subjective rating		
Black on White	Easy at all font sizes	Uncomfortable at medium font size

Apart from two factors: "Muscle Balance" and "Subjective Rating - Black on White", the above results have proved consistency, and the final recommendations remain similar. The rate result of first test with regard to "Muscle Balance" is probably an exception which did not affect the final recommendation. The same applies to the factor: "Subjective Rating".

In the next test, the author carried out another six eye tests; in each he changed one of the factors with regard to his personal information. The results of these tests were basically similar to the preliminary one, and the final recommendations remain similar. The network of the "If...then..." of the "Vision Screening for VDU Users" was proved to give consistent and, in the author's eye test, correct recommendations. In other words, changing the personal information could not affect the actual results of the eye tests themselves. Another aspect of the system which was tested, was access to the knowledge base in order to evaluate the exposure of the E/S to a mistaken or deliberate change of the rules "If...then...". Given the reservation of being tested as part of a research project, the results of the test data were quite satisfactory.

6.4 THE MODEL FOR AUDITING AN OPERATING EXPERT SYSTEM (AOES)-CONCLUSIONS

In Chapter III, the proposed AOES model of how to audit an operating Expert System was described. Also pointed out are the assumptions made in developing this model. In Chapter V, the difficulties experienced in testing the proposed model due to the lack of cooperation by organisations which use E/S's, and the consequent restrictions were elaborated. Chapter VI details the testing which were carried out on E/S's in daily use in Arjo Wiggins and the City University Department of Optometry and Visual Science . The process of auditing the above E/S's is described in subsections 6.2.2, 6.2.3, 6.3.4 and 6.3.5, and in Figures 14 and 16.

The main conclusion of these tests is that, despite the difficulties described in Chapter V and the fact that the author is not an internal auditor within the organisations taking part in the test, still the AOES model proved to be practical . The author succeeded in collecting important and basic information about the E/S's, in analysing the risks, conducting test data, and reaching a conclusion from the results. One can assume that an internal auditor within the organisation who is carrying out his duties without the restrictions on the information available to him could use this model more efficiently.

The second conclusion from these tests is with regard to the reliability of the model. The best way to estimate this reliability is to compare it with the real results of the E/S's, either by using the "exceptions tests" (see subsection 3.4.5), or by performing more tests. The test data was much appreciated by the knowledge engineers of both E/S's and the expert of the "Vision Screener for VDU Users". The test data success showed that the method of collecting the data in the current circumstances was sufficient to conduct the test .

The third conclusion relates to the flexibility of the model. The same model was used to audit two E/S's; one in industry and the other in medicine. The fact that the same model could be used for E/S's which encapsulate human expertise from two such different fields - industry and medicine - indicates the flexibility and feasibility of the model. It supports the author's assumption that the proposed AOES model could be used by internal auditors auditing E/S's regardless of the field they are used in; banking, industry, medicine or geology.

Another important conclusion of the tests is that the E/S is different from the conventional auditing systems. In the course of performing these audits the conclusion was reached that using a model for auditing a conventional system would have missed the real risks which are embedded in the E/S.

6.5 SUMMARY AND CONCLUSIONS

In this chapter, the environment was described in which the test on the AOES model was carried out . The profile of Arjo Wiggins and the "Level Expert" and the City University Department of Optometry and Visual Science "Vision Screener for VDU Users" were detailed. The whole process of auditing these E/S's, through the test data stage and the conclusions was then described . In subsection 6.4, the conclusions were outlined about the proposed AOES model . The main conclusion, which arose as a consequence of the test results, is that the proposed model appears to be practical for the internal auditor. Undoubtedly, a wider use of this model by internal auditors in a variety of organisations would produce some positive results which would improve the model. In the next chapter, the survey conducted regarding the AESD model will be analysed.

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1) The details about Arjo Wiggins Appleton are based on the following publications:

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   B) Manufacturing Intelligence, Award 1990, The Department of Trade and Industry, pp.5-9.

   C) Manufacturing Intelligence Inside UK Enterprise, The Department of Trade and Industry.

2) Manufacturing Intelligence, Award 1990, The Department of Trade and Industry, p.4.

3) WILTSHIRE, S.P.

4) Ibid.

5) Ibid.

6) Display Screen Equipment Work, Guidance on Regulations, Health and Safety, (Display Screen Equipment) Regulations 1992, 11/92, p.1.

) City University Vision Screener for VDU Users 1993, City Visual Systems, p.2.

8) Ibid.

9) Ibid.

10) Vision Screening for VDU Users, leaflet published by City Visual Systems Ltd.

CHAPTER VII
TESTING THE MODEL FOR AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT(AESD)

7.1 INTRODUCTION

In Chapter IV, the proposed AESD model was presented. In Chapter V, the methodology and the research design for testing the model were elaborated. The difficulties faced in trying to locate organisations which develop E/S's and which were willing to allow the author to take part in the process and to test the model were described. It was in this context that it was decided to use a questionnaire in order to test the model.

External/internal auditors were approached within organisations in six sectors of the British economy and were asked for their permission to send them the questionnaire. After their acceptance, a package, including a questionnaire, a short description of the proposed AESD model , a diagram of the model, and a list of "Evaluation Areas - Auditor's Involvement", was sent. Emphasised also in conversations with the interviewees was the author's availability to assist in submitting more information. Few of the interviewees took advantage of this opportunity. The questionnaire process was described in subsection 5.5.2.

In total, forty questionnaires were sent out during October, November and December, 1994, to internal/external auditors within organisations from six sectors: Banking, Accountants and Management Consultants, Insurance, Industry, Service and Tourism and others. In this chapter, the results of the questionnaires which comparing the various sector replies will be analysed and the conclusions from the proposed AESD model will be formulated.

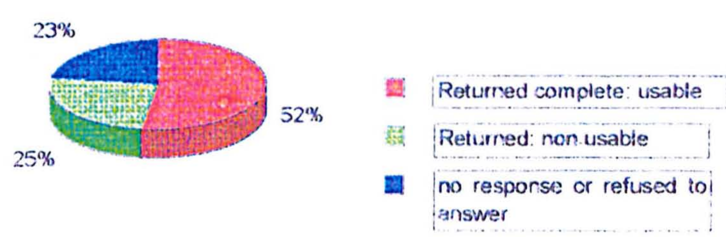
7.2 RESPONSE TO THE QUESTIONNAIRE

As mentioned in Chapter V, before sending the questionnaires to the auditors, they were telephoned , explained the aims of the questionnaire, and given answers to questions. Forty questionnaires were sent to internal/external auditors. Two weeks after the date of posting, those who had not responded were telephoned and reminded about the questionnaire. The occasion was used by the author to offer more information if needed. The following table describes the response to the questionnaire:

Table 7.1: Response to the Questionnaire

Outcome	Number	Percent
Returned complete: usable	21	52.5
Returned: non usable	10	25
No response or refused to answer	9	22.5
Total mailed	40	100

Response to the Questionnaire



"Returned complete: usable" means that the reply was completed according to the framework of the questionnaire, and therefore can be considered as "usable" for the analysis. "Returned: non-usable" means that they either refused to reply to the questions, or gave a written explanation instead. Although these comments cannot be represented in the figures, they were taken into consideration , but were not included in the following analysis. Sixteen out of twenty one respondents (seventy six percent) asked to receive the results of the survey. To some extent this indicates their interest in the AESD model .

In the above questionnaire the response rate, which includes the "Returned complete: usable" and "Returned: non-usable", was more than seventy seven percent. Table 7.2 indicates that the completion of the questionnaire by the internal auditors in the Banking sector is outstanding; sixty nine percent were returned completed and usable. Three of the internal/external auditors who did not reply were contacted and this matter was discussed with them. They explained that they are not too sure about their answers, so they preferred not to answer. One of the respondents explained that his work "...precludes him from taking part in the questionnaire...". Two others have changed their place of work and the author could not trace them. The others simply did not reply. Some of those who replied asked for more information about auditing the E/S and indicated that publications in this area are very rare. On the other hand, sixty seven percent of the "Accountants and Management Consultants" chose to reply in a letter, and twenty two percent refused to reply at all.

After receiving the replies, a sample of six external/internal auditors whose answers were "complete and usable" was chosen and these were contacted. This enabled the understanding of their views on the proposed model beyond the reply to the questionnaire. In addition, this contact was used to verify their replies. Two of these respondents were from the Insurance sector, and one was from each of the following sectors: Tourism and Services, Banking, Industry and Other. Their replies to each question was as follows:

Table 7.2: AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

ANALYSIS OF THE RESULTS OF THE SAMPLE

		Very Poor	Poor	Average	Good	Very Good	Total
1	Does the proposed model enable the internal auditor to <u>**assess the effectiveness**</u> of the internal controls within the developed Expert System?	-	-	2	4	-	6
2	Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an Expert System at each of the following stages in which the internal auditor is involved? Feasibility	1	-	1	4	-	6
	Selection	-	-	1	5	-	6
	Knowledge based design	-	-	2	3	1	6
	Build and test prototype	-	-	1	4	1	6
	Build and test operational version	1	-	-	4	1	6
	System release	-	-	2	1	1	4
	Maintenance and enhancement	1	-	1	4	-	6
3	Is the proposed model enable the internal auditor the <u>**flexibility**</u> to adjust his/her work in the development process according to the "System Development Life Cycle" which the Expert System's developers may use?	-	-	1	4	1	6

Table 7.2: AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

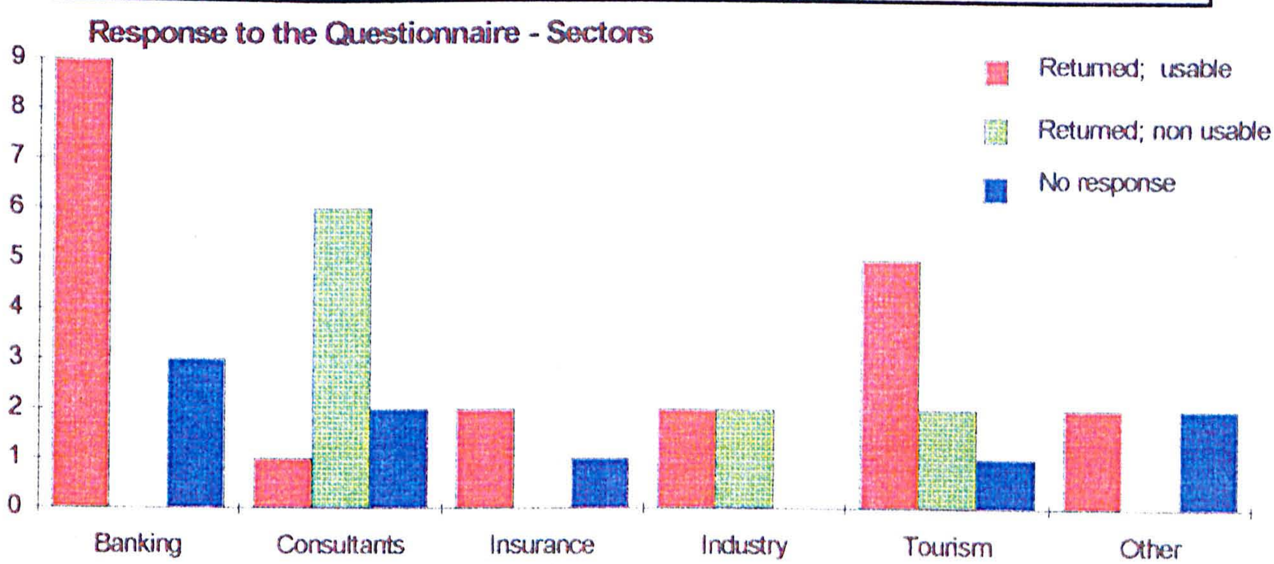
ANALYSIS OF THE RESULTS OF THE SAMPLE

		Very Poor	Poor	Average	Good	Very Good	Total
4	Is the proposed model for auditing an Expert System under development practical (contrasted with a theoretical model) for use by the internal auditor?	-	2	2	2	-	6
5	Is the proposed model for auditing an Expert System under development feasible (i.e. can it be managed by the internal auditor)?	-	-	3	1	2	6
6	Is the proposed model for auditing an Expert System under development reliable, covering all the areas that need to be audited and giving proper answers?	-	1	2	2	-	5

Comparing these marks to the total (as analysed in table 7.4) indicates small differences which are a result of the size of the sample i.e. six respondents. The following details the outcome of the mailed questionnaires according to the six sectors:

Table 7.3: Response to the Questionnaire - Sectors

Outcome	Banking	s	Accountants/ Management Insurance	y	Tourism	Other	TOTAL
Returned; complete/ usable	9	1	2	2	5	2	21
non- usable	-	6	-	2	2	-	10
No response/ refuse to answer	3	2	1	-	1	2	9
TOTAL	12	9	3	4	8	4	40



MILLER ,(1993), presents a model of outcomes from a questionnaire in which the return rates vary from three to ninety percent. He points out that the response rate of ninety percent came from high school graduates. The maximum rate within the professional group was sixty nine percent.(1) .In 1986 ,forty five questionnaires were mailed to members of regions of the EDP AUDITORS ASSOCIATION in the U.S.A who before the survey expressed their willingness to participate. Usable responses were received from thirty two respondents, being seventy percent. In the questionnaire regarding the proposed AESD model , the ratio of usable responses is more than fifty two percent.

7.3 THE SCALE OF THE QUESTIONNAIRE RESPONSE

The questionnaire included six questions and the respondent was asked to respond by ticking one of five options: very poor, poor, average, good or very good. At the end of the questionnaire, the respondent could write his/her comments. Table 7.4 and its diagram analyses the results of the twenty one replies per each question, and in Question No 2, per each stage of the "Development Life Cycle".

Table 7.4: AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

ANALYSIS OF THE RESULTS OF THE QUESTIONNAIRE

		Total Replies	Very Poor	%	Poor	%	Aver-age	%	Good	%	Very Good	%	Total
1	Does the proposed model enable the internal auditor to **assess the effectiveness** of the internal controls within the developed Expert System?	21	-	-	2	10	10	47	9	43	-	-	100
2	Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an Expert System at each of the following stages in which the internal auditor is involved? Feasibility	15	2	14	-	-	9	60	4	26	-	-	100
	Selection	21	1	5	3	14	7	33	10	48	-	-	100
	Knowledge based design	21	-	-	1	5	9	43	10	47	1	5	100
	Build and test prototype	21	-	-	1	5	6	29	11	52	3	14	100
	Build and test operational version	20	-	-	1	5	6	30	11	55	2	10	100
	System release	17	3	18	-	-	7	42	6	35	1	5	100
	Maintenance and enhancement	15	2	13	-	-	5	33	8	54	-	-	100
3	Is the proposed model enable the internal auditor the **flexibility** to adjust his/her work in the development process according to the "System Development Life Cycle" which the Expert System's developers may use?	21	1	5	3	14	6	28	10	48	1	5	100

Table 7.4: AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

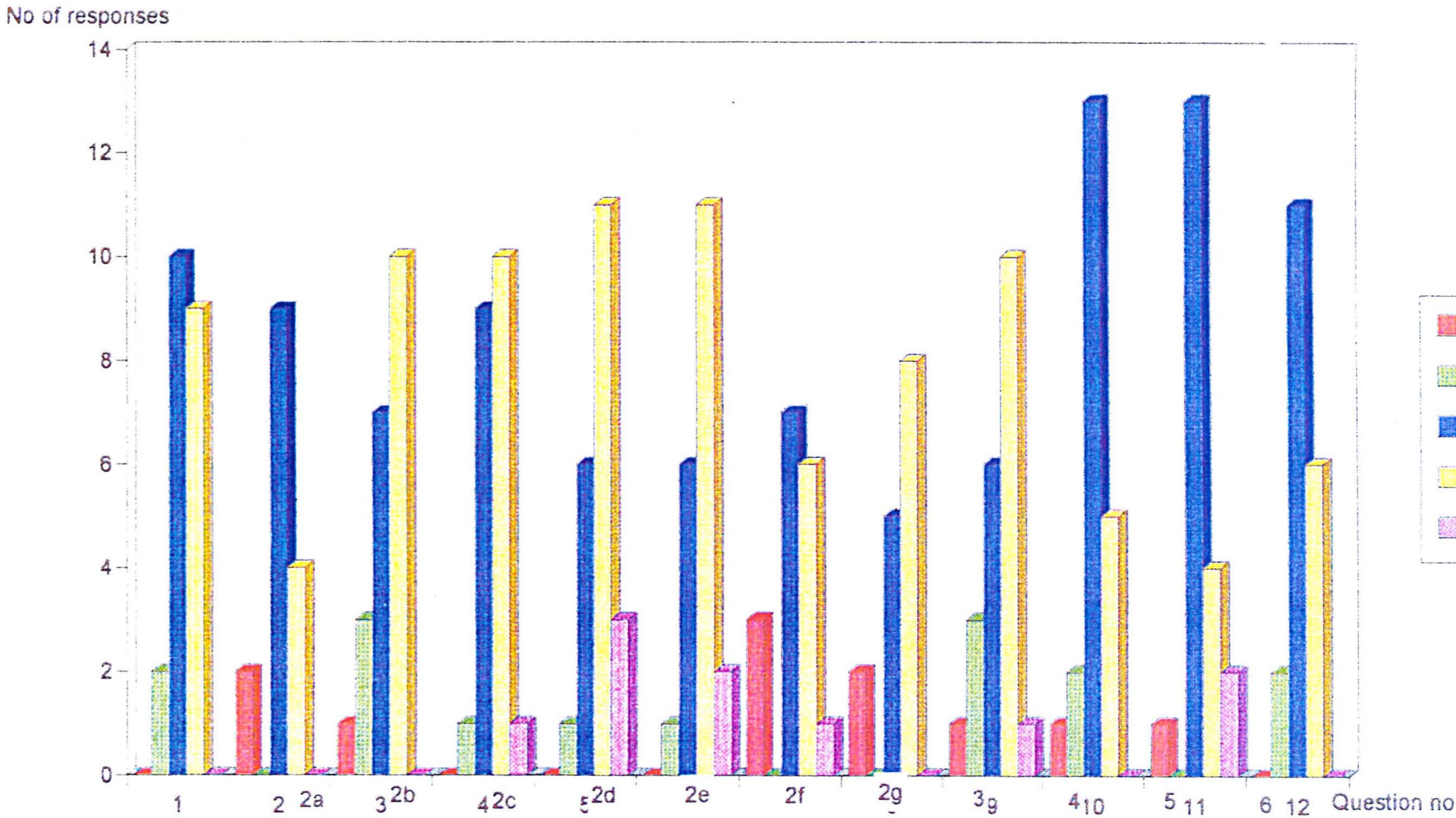
ANALYSIS OF THE RESULTS OF THE QUESTIONNAIRE (CONTINUED)

		Total Replies	Very Poor	%	Poor	%	Aver-age	%	Good	%	Very Good	%	Total
4	Is the proposed model for auditing an Expert System under development **practical** (contrasted with a theoretical model) for use by the internal auditor?	-	1	5	2	10	13	62	5	23	-	-	100
5	Is the proposed model for auditing an Expert System under development **feasible** (i.e. can it be managed by the internal auditor)?	20	1	5	-	-	13	65	4	20	2	10	100
6	Is the proposed model for auditing an Expert System under development **reliable**, covering all the areas that o be audited and giving proper answers?	19	-	-	2	10	11	58	6	32	-	-	100

NOTES

1) The percentage was rounded to the nearest figure.

2) Some of the respondents did not reply to certain questions, especially Question No.2.


No of responses
14
12
10
8
6
4
2
0
1 2 2a 3 2b 4 2c 5 2d 2e 2f 2g 3 9 4 10 5 11 6 12
Question no.
VeryPoor
Poor
Aver-age
Good
VeryGood

The first question in the questionnaire was: "...Does the proposed model enable the internal auditor to assess the effectiveness of the internal controls within the developed Expert System?...". Forty-seven percent of the replies marked "average" in response to this question, and forty three percent marked it "good". Considering the fact that the author assumed "average" as a positive response (see subsection 5.5.5), this means that , ninety percent responded positively to the proposed model in connection with assessing the effectiveness of the internal controls. Two respondents marked the questions as "Poor"; in total, ten percent. The general explanation for this mark is the fact that the documentation enclosed with the questionnaire was not detailed enough to allow them to assess the effectiveness of the proposed model. Although these replies are considered to be 'poor', it may well be that mailing more written information to these respondents could have yielded a different result. Because the other respondents had not received further written information ,a decision was taken for consistency not to send more information to those respondents who had requested it.

The second question in the questionnaire related to the risks: "...Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an E/S at each of the following stages in which the internal auditor is involved...". The interviewee was asked to specify each of the seven stages in which the internal auditor is involved. Table 7.5 specifies the marks for each stage. These marks represent a broad scope of opinions with regard to the seven stages of the development process of the E/S . It is necessary to emphasise that there is no common model of System Development Life Cycle of the E/S , and therefore it could well be a five stages model (see subsection 4.2).(The scales of the marks are shown in Table 7.4)

Table 7.5: The Results of the Questionnaire According to the Stages of the System Development Life Cycle

	Poor	Very Poor	Average	Good	Very Good	Total
Feasibility	14%	-	60%	26%	-	100%
Selection	5%	14%	33%	48%	-	100%
Knowledge Based Design	-	5%	43%	47%	5%	100%
Build and Test Prototype	-	5%	29%	52%	14%	100%
Build and Test Operational Version	-	5%	30%	55%	10%	100%
System Release	18%	-	42%	35%	5%	100%
Maintenance and Enhancement	-	13%	-	33%	54%	100%

Similar to the first question, the vast majority of the replies related to the marks "average" and "good", from eighty one percent in the "Selection" stage to ninety five percent in the "Knowledge Based Design", "Build and Test Prototype" and "Build and Test Operational Version" stages. The respondents who marked "very poor" and/or "poor" the stages "Feasibility", "System Release" and "Maintenance and Enhancement" mentioned that in these stages, the evaluation goals had not been specified: "Definition of Goals" and the "Evaluation Techniques" as had been done in the other stages.

In Chapter IV it was mentioned that the "NESDEM" evaluation model is the basis of the proposed AESD model. However, as a result of these comments, the proposed model was extended by the "Evaluation Goals", "Definition of Goals", the "Evaluation Techniques".

In the third question, the respondent was asked about the flexibility of the proposed model: "...Does the proposed model enable the internal auditor the flexibility to adjust his/her work in the development process according to the System

Twenty-eight percent of the respondents marked the flexibility of the proposed AESD model as "average". Forty-eight percent marked it "good", and five percent "very good". Again, as in the first two questions, the vast majority, eighty one percent, responded positively to this question. Just fourteen percent of the respondents consider the flexibility of the model as "poor" and five percent "very poor". One possible explanation for one of the "poor" marks is a comment made by the respondent about the necessity of supplying more information, perhaps even examples of the model. For the explanation for the "very poor" mark, see later.

The fourth question was: "...Is the proposed model for auditing an Expert System under development <u>practical</u> (in contrast with the theoretical model) for use by the internal auditor?...". With regard to the practicality of the model, sixty two percent of the responses were "average", and twenty three percent were "good", bringing the total of positive rate to eighty five percent. Similar to the previous questions, ten percent consider the practicality of the proposed model as "poor" and five percent as "very poor".

The fifth question focused on the feasibility of the proposed model: "...Is the proposed model for auditing an Expert System under development <u>feasible</u> (i.e. can it be managed by the internal auditor)?...". The scale of the responses regarding the feasibility of the proposed model indicated that sixty five percent are "average", twenty percent are "good", and ten percent are "very good". Five percent of the responses suggest the feasibility of the proposed model as "very poor"; i.e. most of the respondents regard it as manageable by internal auditors.

In the above questions, Nos. 3, 4, 5, just one respondent marked the proposed model as "very poor", and throughout the questions, it is the same respondent. The reason for this mark, as explained by him, is too much control, as a consequence of the necessity to "Sign Off" in each stage of the System Development Life Cycle. In fact, the proposed model includes the "Sign Off" as an "optional" built-in phase of the auditing process (see SubSection 4.5.2).

The last question in the questionnaire related to the reliability of the proposed model: "...Is the proposed model for auditing an Expert System under development reliable, covering all the areas that need to be audited and giving proper answers?...". Fifty-eight percent of the external/internal auditors who took part in the survey considered the reliability of the proposed model as "average", and thirty two percent estimated the reliability of the model as "good". In total, ninety percent evaluated the proposed model as reliable. Just eleven percent considered it as relatively "poor".

As mentioned earlier after analysing the results a sample of six of the respondents were contacted, among other things to verify their responses. In addition, the fact that seventy six percent of them asked to receive the results of the survey indicates their involvement and interest in the field of auditing an E/S. It strengthens the proposed view that the "Returned complete: Usable" replies are indeed reliable. The two sectors represented more than any others by "Returned Complete: Usable" replies are "Banking" and "Service and Tourism", nine and five replies respectively. Table 7.6 analyses the Banking sector replies, and Table 7.7 the Service and Tourism sector.

Table 7.6: An Analysis of the Banking Sector Replies to the Questionnaire

		Very Poor %	Poor %	Average %	Good %	Very Good %	Total
1	Does the proposed model enable the internal auditor to assess the effectiveness of the internal controls within the developed Expert System?	-	22	45	33		100
2	Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an Expert System at each of the following stages in which the internal auditor is involved? Feasibility	40		40	20		100
	Selection	14	14	58	14		100
	Knowledge based design	11	11	34	33	11	100
	Build and test prototype	-	11	34	55		100
	Build and test operational version	-	11	22	67		100
	System release	20	-	40	40		100
	Maintenance and enhancement	20	-	40	40		100
3	Is the proposed model enable the internal auditor the flexibility to adjust his/her work in the development process according to the "System Development Life Cycle" which the Expert System's developers may use?	-	11	33	56		100

Table 7.6: An Analysis of the Banking Sector Replies to the Questionnaire

		Very Poor %	Poor %	Average %	Good %	Very Good %	Total
4	Is the proposed model for auditing an Expert System under development **practical** (contrasted with a theoretical model) for use by the internal auditor?	-	-	78	22	-	100
5	Is the proposed model for auditing an Expert System under development **feasible** (i.e. can it be managed by the internal auditor)?	-	-	67	33	-	100
6	Is the proposed model for auditing an expert system under development **reliable**, covering all the areas that need to be audited and giving proper answers?	-	12.5	75	12.5	-	100

Comparing this last table with table 7.3, the analysis of the results of all the questionnaires shows that results of "Banking" sector are basically similar to the results in general.

Table 7.7 analyses the responses of the internal/external auditors from the Tourism and Services sector, in total five returned completed /usable responses.

Table 7.7: An Analysis of the "Tourism and Service" Sector

		Very Poor %	Poor %	Average %	Good %	Very Good %	Total
1	Does the proposed model enable the internal auditor to <u>assess the effectiveness</u> of the internal controls within the developed Expert System?	-	-	60	40		100
2	Does the proposed model ensure that the internal auditor covers the risks associated with the developments of an Expert System at each of the following stages in which the internal auditor is involved? Feasibility	-	-	60	40	-	100
	Selection	-	-	60	40	-	100
	Knowledge based design	-	-	60	20	20	100
	Build and test prototype	-	-	20	60	20	100
	Build and test operational version	-	-	60	40	-	100
	System release	-	-	75	25	-	100
	Maintenance and enhancement	-	-	-	50	50	100
3	Is the proposed model enable the internal auditor the <u>flexibility</u> to adjust his/her work in the development process according to the "System Development Life Cycle" which the Expert System's developers may use?	25	-	50	25	-	100

Table 7.7: An Analysis of the "Tourism and Service" Sector

		Very Poor %	Poor %	Average %	Good %	Very Good %	Total
4	Is the proposed model for auditing an expert system under development **practical** (contrasted with a t theoretical theoretical model) for use by the internal auditor?	-	-	25	75		100
5	Is the proposed model for auditing an expert system under development **feasible** (i.e. can it be managed by the internal auditor)?	20	-		40	40	100
6	Is the proposed model for auditing an expert system under development **reliable**, covering all the areas that need to be audited and giving proper answers?	-	-	100	-	-	100

The analysis of the sector indicates the general view of the respondents; the marks "average", "good" and "very good" are high, in the area of eighty to one hundred percent of the replies. Table 7.8 represents the differences between these two sectors in relation to dividing the scale of marks into two groups: "very poor" + "poor" and "average", "good" and "very good". In other words, Table 7.8 reflects the differences between these two sectors in their positive or negative approach towards the proposed model, while, for this table only, "very poor" and "poor" are considered as negative, and "average", "good" and "very good" are considered as positive:

Table 7.8: "Positive" and "Negative" Results in a Comparison of the "Banking" and "Tourism and Services" Sectors

Banking = 1

Tourism and Services = 2

Question Negative

Positive

No	Percentage 1	Percentage 2		Percentage 1	Percentage 2	Difference
1	22	-		78	100	22
2.1				60	100	40
2.2	28	-		72	100	28
2.3	22	-		78	100	22
2.4	11	-		89	100	11
2.5	11	-		89	100	11
2.6	20	-		80	100	20
2.7	20	-		80	100	20
3	11	25		89	75	14
4	-	-		-	-	100
5	-	20	100	80		20
6	12.5	-		87.5	100	12.5

Apart from Question No:2 Sub-question 2.1, which relates to the feasibility of the System Development Life Cycle, the differences between the two sectors did not exceed twenty eight percent. In Question No:2.1, one hundred percent of the "Tourism and Services" sector was positive, compared with sixty percent positive and forty percent negative in the "Banking" sector. An alternative conclusion is that, apart from Sub-question 2.1, in both sections, the rank of positive replies is between seventy five to one hundred percent. Moreover, in four questions, the "Tourism and Services" sector was one hundred percent positive, compared with the "Banking" sector which was one hundred percent positive in two questions.

7.4 THE MODEL FOR AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT(AESD)- CONCLUSIONS

In Chapter IV the proposed AESD model was detailed . This model is based on the role of the internal auditor in the process of developing an E/S, as described in "NESDEM" (see subsection 4.3). It also includes the "control band" principles, which were described in details in Chapter III. This proposed model encompasses some essential assumptions, which are the same as for the AOES model (see subsection 4.4). In contrast to the proposed AOES model , the above model requires the involvement of the internal auditor during the process of the E/S development. In Chapter V, the methodology of the research was described the difficulties of locating organisations which are developing E/S's and are willing to allow testing of the model were pointed out. This gave wise to the questionnaire being chosen as the research method for testing the proposed AESD model .

The five external/internal auditors who agreed to take part in the pre-test of the questionnaire were approached by telephone. The next stage was to telephone thirty eight other internal/external auditors within various organisations and to ask them to participate in the survey by replying to the questionnaire. In total, forty questionnaires were sent. Thirty-one respondents replied to the questionnaire, twenty one of them are usable. The efforts of the respondents should be appreciated, due to the fact that they had to learn the proposed model, which is basically a new model. Some of them contacted the author and asked for more details. The replies, including the notes, proved a high level of involvement, which was encouraging . Seventy-six percent of the respondents asked to receive the results of the survey. To some extent, this adds to the reliability of the replies.

The first and most obvious conclusion to emerge from the questionnaire is that the vast majority of the external/internal auditors who took part in the survey considered the proposed model as acceptable; it is a valuable model for testing actual process of development, either by the interviewees or by other researchers. Although it is likely that in a real test some constructive changes could be incorporated as a result of practical experience, the fact that the majority of the participants in the survey responded positively supports the view that in the future, this model could be transferred from the academic stage to actual use by external/internal auditors.

The second conclusion of the analysis of the responses relates to the assumptions which were detailed in 4.4. The proposed model, according to the views of the respondents, assesses the effectiveness of the internal controls within the process of the development of an E/S, and covers the risks associated with this process. It appears to be a flexible, practical and feasible model for auditing. Moreover, a majority of external/internal auditors who took part in the questionnaires considered it a reliable AESD model . Considering the fact that the questionnaire was sent to professionals from a variety of British organisations, the results are considered robust.

A careful reading of the notes of the interviewees, while explaining the marks or those replies which were non-usable, suggests that in a live test of the model some minor changes, mainly in the techniques, would be integrated. In other words, in using the proposed model for auditing an E/S under development, the external/internal auditors may put different emphasis on different stages according to the environment in which they are operating. The skeleton of the proposed model was accepted by the majority of the professionals who took part in the survey. Changes in the future as a result of real use of this model could take place on the margins of the model.

7.5 SUMMARY AND CONCLUSIONS

In this chapter, the results of the forty questionnaires which were mailed to internal/external auditors in U.K were explained in detail. Also analysed were the results according to sectors and questions. On the whole the vast majority of the respondents ranged from average to very good.

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CHAPTER VIII
SUMMARY, CONCLUSIONS, RECOMMENDATIONS OF THE STUDY AND RECOMMENDATIONS FOR FURTHER RESEARCH

8.1 INTRODUCTION

This final chapter combines the following subsections: (i) a summary of study comprising the summary of the two models AOES and AESD, the methodologies used to conduct the research, and the results; (ii) a summary of the conclusions based on the analysis of the data collected in the test data and in the questionnaires; (iii) recommendations of the study, mainly with regard to the implementation of the audit of E/S's; (iv) recommendations for further research in the field of auditing an E/S.

8.2 SUMMARY OF THE STUDY

8.2.1 Summary of the Model of How to Audit an Operating Expert System (AOES)

Before developing the AOES model, a few important and necessary assumptions were made which, clarify the foundation of the model. It was essential to assume that the internal auditor was not an expert in the audited field, and never will be. He/she has limited resources, and 'needs' an available, applicable and practical method for auditing E/S's. To avoid a possible misunderstanding, the author assumed that the internal auditor has not taken part in the development of the E/S. According to the current literature and based on visits to organisations which use E/S's, it was assumed that the documentation of the E/S is not yet standardised, and so not complete, and that the methodology of the System Development Life Cycle of the Expert System is still not standardised.

The proposed model is based on the "control band", which basically is bound to reduce the risks of the E/S's in comparison with conventional systems. The internal auditor collects information on the given E/S through documentation, interviews and questionnaires completed by the manager, the knowledge engineer, the expert and the user. The next stage is to assess the risks of using the E/S and to define the "control band". The principle behind it reflects the concept that if the results of the control band prove themselves as secured, then the controls "lock the black box" and its risks are then under control, as are the risks of other conventional systems. The next stage is to perform testing using test data to evaluate the controls of the system, just as has been done in this research. In parallel, use could be made of the "exceptions test". During the operating of the E/S, and in accordance with the definitions of the control band, "exceptions" will be kept in a special file for the internal auditor's investigation.

8.2.2 Summary of the Model of how to Audit an Expert System Under Development(AESD)

The AESD model confronted a primary obstacle in the lack of an existing and common methodology for the System Development Life Cycle of the E/S. To some extent this blurred the role of the internal auditor within the process. After reviewing the literature, "NESDEM" was chosen as a model for evaluating the development of an E/S, as the basis for the proposed AESD model . "NESDEM" elaborates seven phases and forty-one methodological steps for the System Development Life Cycle of an E/S, together with an evaluation of the definitions of the goals and techniques of each step. It also indicate the phases in which the internal auditor should be involved.

On this basis, the principles of the "control band" are integrated into the "NESDEM" model, and a AESD model is proposed . The type of auditing technique for each stage of the internal auditor's involvement is defined; administrative technique, self-operational or co-operational. Thereby the model allows flexibility, but does not neglect the necessity for a clearly defined technical layout in order to avoid confusion The diagram shown in subsection 4.5.3 describes the AESD model from the first stage of "Feasibility Study" to the last stage of "Maintenance and Enhancement". This model allows a maximum of flexibility when the developer chooses another System Development Life Cycle for the given E/S. It also expresses the undoubted importance of testing the E/S in two stages,. the first after building the prototype and the second after testing the operational version . In the view of the author, the proposed model gives the internal auditor a clear picture of the his role in the process of the development of an E/S.

8.2.3 Summary of the Methodology

After consolidating his proposed AOES and AESD models , the author approached organisations and asked their permission to test his models on their E/S's. The response was very poor. The main reason was the concern of these organisations that secrets could be leaked. In a way it supported the proposition of the importance of the E/S to the UK organisations.

The author, with the assistance of his supervisor, approached the Department of Trade and Industry, which encourages research into the E/S's within the UK. After many efforts, two organisations which use E/S's agreed to co-operate with the author under certain restrictions; Arjo Wiggins Appleton, which had developed its own E/S for its mill in Dover, and the City University Department of Optometry and Visual Science, which had developed, together with an outside company, for eye tests. The AOES model was tested in these two organisations over a period of four months. The results were positive and the conclusions are shown in Chapter VI.

After consistent efforts to locate an organisation which is in the process of developing an E/S and would agree to allow for the testing of the AESD model ended without success , it was decided to use the questionnaire as a research method. A pilot questionnaire was sent to five external/internal auditors. The next stage was to contact external/internal auditors within organisations from six sectors in the UK, and to ask them to take part in the survey. Forty of them agreed, and questionnaires which included a short description of the model, a diagram, and a short description of the "NESDEM" model were sent to them. The analysis of the replies suggested positive feed-back to the AESD model . The conclusions are shown in Chapter VII.

8.3 SUMMARY OF RESULTS AND CONCLUSIONS

Both the tests conducted by the author in Arjo Wiggins Appleton and the City University Department of Optometry and Visual Science supported the conclusion that the AOES model is practical and manageable by the internal auditor. Despite the difficulties caused by the fact that the author is not an internal auditor in those organisations, and his access was therefore limited, the model enabled him to collect the necessary data on the E/S's, to permit him to define the risks and to conduct successful test data, which was appreciated by their developers.

The second conclusion regarding this model relates to its reliability. The fact that the author was not allowed to use the "exceptions method" deprived him of the opportunity to assess the reliability of the model more accurately. Yet the proposed model was tested in two different sectors, industry and medicine, and showed sufficient flexibility.

A very important conclusion is the support for the view that E/S's are different from conventional systems in many aspects; concept, development process and risks, and therefore require a different audit approach.

With respect to the AESD model the results of the questionnaires led to the first conclusion, that the proposed model was proved to be acceptable by a variety of external/internal auditors from various sectors within the UK. The fact that so far no alternative model is in existence makes AESD clearly necessary and inevitably contributes to it's acceptability by practitioners. Most of the respondents, (more than eighty three percent), considered the proposed AESD model to be reliable, with the required flexibility and practicality. The vast majority of the respondents also estimate that the proposed model enables the internal auditor to assess the effectiveness of the internal controls within the developed E/S, and also covers all the areas that need to be audited. Yet, the notes of the participants in this survey which covered marginal aspects of the model, indicate that it's "live" test will contribute to clear and more solid view. The philosophy behind the model, the basic assumptions and the techniques were not contested.

8.4 CONCLUSIONS AND RECOMMENDATIONS OF THE STUDY

The following conclusions and recommendations of the study are based on the data gathered after conducting the tests within Arjo Wiggins Appleton and analysis of the questionnaire responses, and are subject to the limitations of the sampling method used (see sub-section 5.5.2):

(A) The proposed AOES model is a practical model which could be used in any sector . Internal auditors who do not have restricted access to information within the organisation could benefit by using it.

(B) The proposed AOES model was proved to be manageable in very restricted environments. Small units of internal and external auditors in small organisations with limited resources could benefit from both the proposed models for auditing E/S's.

(C) The AESD model was proved to be acceptable by a wide range of external/internal auditors. Most of the internal auditors from within the banking sector who took part in this survey gave a positive response to the model. They also evaluated that the model covered all the areas that needed to be audited .

(D) The AESD model , according to external/internal auditors who took part in the survey, gives the internal auditor the flexibility to adjust his/her work in the development process according to the "System Development Life Cycle" which the E/S's developers may use. It is a practical model which can be managed by the internal auditor. The above characteristics are essential for any model of auditing, and particularly for a model of auditing for software as sophisticated as an Expert System.

(E) The AESD model still needs to be tested under live use in the actual environment of a developing E/S. Thereby, it could be shaped and modified in order to include constructive improvements . The author submits that some changes could be integrated into the proposed model, but only after a "live" run of the model.

(F) Organisations in the UK consider the E/S to be a very sophisticated and powerful tool, which is necessary for effectively competing in the market -place.

Those who were approached by the author refused to allow the testing of the models due to concern over the leaking of secrets.

(G) In the first two chapters the view was expressed that awareness of the unique risks of the E/S in comparison with other conventional systems is very low. One of the reasons for this was the existence of those internal auditors who preferred not to audit the E/S at all. Although there was no specific question in the questionnaire regarding this issue, in the face-to-face discussions, it was clarified that so far , on the whole, internal auditors have ignored this necessity . Some of them expressed their concern with this situation and their hope of employing the proposed model in the future.

(H) None of the respondents, either in the discussion or in their reply, mentioned other models for auditing an operating Expert System or an Expert System under development. It can be assumed that there are no such models in the UK, which therefore prohibits the making of a comparison . In the future, the possible emergence of other models will enable the users - the external/internal auditors and the researchers - to compare and evaluate the advantages and disadvantages of a selection of models within this field.

(I) A few assumptions with regard to internal auditors have been detailed; a lack of knowledge in the auditing of E/S's, resources, documentation, and methodology for the System Development Life Cycle. During visits to a variety of organisations in the UK, meetings with external/internal auditors, the test data conducted and the discussions, on a sample basis with respondents, it was realised that with regard to some external/internal auditors the assumptions about insufficient knowledge of the subject were correct.

(J) One final conclusion arises out of the responses (especially the notes, the explanations in the attached letters and the discussions with the author) relating to the research in this domain. It was surprising to note the lack of research in the area of the auditing E/S's . It is very important and almost essential for the practitioners of internal audit to increase the number of research projects in this area, and, as a consequence, the publications. The author considers his models of AOES and AESD as a first step in that direction.

8.5 RECOMMENDATIONS FOR FURTHER RESEARCH

The lack of research and publications in the field of auditing the E/S has been mentioned . In this section, suggestions of a few topics for further research are made:

(A) The AOES model was tested in different sectors. However, further tests are needed in order to prove its reliability, universality and its adjustability to other sectors which use E/S's.

(B) The AESD model was not tested in a "live" development process. The interviewees replied to the questions and related to it positively. However, "live" use is essential both for its approval and in order to suggest changes and/or improvements which could emerge from real environments.

(C) The restrictions on free access to information and documentation has not enabled precise assessment of the risks of using or developing E/S's. Failures are not publicised, although there are rumors in the field about some substantial failures. It is proposed that research on a case study basis be devoted to investigating these risks and their possible damage.

(D) It is strongly encouraged for other approaches which might lead to other models for auditing an E/S to be put forward. The current situation in which there are no other models does not allow for mutual enrichment and is not beneficial for the internal audit profession. Further research in this field would increase the number of models for auditing an E/S, and so provide for the refinement of existing models.

(E) Research into the auditability of state of the art IT capabilities and the consequent models to facilitate such auditing is required. The current situation, in which the use of E/S's is becoming more widespread coupled with internal auditors who do not have sufficient tools(such as basic methodology for professionally auditing an E/S, as they do in other fields) is disturbing. In order to avoid a similar phenomenon in other emerging IT environments , such as neural computers, it is strongly recommended that further research be conducted in those fields in order to investigate the necessity for specific auditing models.

Such an approach as this could help to boost the internal audit profession. It would develop interactively with state of the art technology and in conjunction with its users ; making the audit model development stage significantly easier and more effective. This then would be a far improved strategy, both for the professional image and for meeting the technical auditing challenge faced. Failing to do so and reacting at a later stage when users have discovered their inability to effectively contend with such technology would be falling into ,what is regrettably common trap.

Appendices

APPENDIX A

EXPERT SYSTEM AUDITING - QUESTIONNAIRE

CHARACTERISTICS OF THE GENERAL LEVEL OF CONTROL

Expert System Notes:

This questionnaire is used to collect data for the prime survey on the subject of using the Expert System. This information can be collected from several sources: other internal auditors, users, documentation, colleagues and observations. If part of the information is unobtainable, there is no need to collect it at all. This information is collected to give the internal auditor a primary knowledge of the E/S and its controls. On the other hand, the fact that the information is easily obtained is probably indicative of a good control system.

A GENERAL

1) Prepare a list (or scheme) of the main computer equipment in the organisation. Include the peripheral equipment which is connected directly or indirectly to the Expert System process.

2) Prepare a list of the Expert System applications.

3) Note the names and positions of the managers involved in operating the Expert System.

4) Prepare a flow-chart of the Expert System performance: starting point, input of data; ending point, using the output.

5) Find out the following details:

5.1) When was the Expert System purchased and who supplied it?
When was the Expert System developed internally and by whom?

5.2) Who is the current supporter of the Expert System and when was his last visit to the organisation?

5.3) Who are the other users of the Expert System?

5.4) Who is/are the expert(s) backing up this Expert System?

6) Is there a formal separation of the functions of the users, the knowledge engineer, and the supporter (if the supporter is still in the organisation)?

B USING THE EXPERT SYSTEM

1) Indicate the names of the departments using the Expert System

2) Is access to the system restricted?

3) Is there use of passwords? Other access controls?

4) Are the users satisfied with the performance of the Expert System?

5) What are the controls on the input stage?

6) Is the output of the Expert System considered as advice or as a decision to be taken? (Distinguish between the management instructions and the "field reality")

7) Are there specific instructions on the use of the output aimed at eliminating the risk of using incorrect output?

8) Are there periodic checks of the output results?

APPENDIX B:1

EXPERT SYSTEM AUDITING QUESTIONNAIRE - THE USER

A INTRODUCTION:

This questionnaire is a part of research in which a model for auditing an operational expert system has been developed. The information in the questionnaire will be kept in strict confidence and will be used solely for this research. When the information has been collected from all the questionnaires, a test will be carried out to evaluate the controls of the system.

B AIM OF THE QUESTIONNAIRE:

The answers in the questionnaire will be the basis for the definitions of the risks involved in using "The Expert System". The test will examine the controls which were built into the system in order to minimise or eliminate these risks.

C NOTES:

If you think that there are other risks, especially with regard to input and output, about which you have not been asked, then please add the details at the end of this questionnaire.

D GENERAL DETAILS:

Name: ....

Title: ....

No. of years in the Group: ....

E QUESTIONS:

1) Have you been involved in the development process of "The Expert System" system? If yes, please state in which stages.

....

....

2) How long has this system been in use? ....

3) Are you satisfied with the system? Please indicate on the scale (e.g., 0 = No, 5 = Very satisfied)

0	1	2	3	4	5
|	|	|	|	|	|

4) Did you find any problems with using the system so far? If yes, please describe them?

....

....

....

5) Have you had results from the system in the past which at a later stage were identified as being incorrect? If yes, please describe them.

....

....

....

6) Are you using a manual or other written guidelines when using "The Expert System"?

....

7) Is there any information that you should omit from the system altogether? describe it.

....

....

....

8) Based on your experience, what are the factors which differentiate the final results?

....

....

....

9) Based on your experience, what are the factors the system "is asking for"? And what answers are indecisive?

....

....

....

10) Based on your experience, what changes in the system do you recommend?

....

....

....

11) What results are not reasonable?

....

....

....

12) What results, or combination of results, from the system are not relevant, and why?

....

....

....

13) How do you consider the result of "The Expert System": as advice, or as a decision to be taken? ....

14) What are the risks of misusing the system?

....

....

....

15) Would you like to add more details regarding the risks of this system?

....

....

....

Date:...........................

APPENDIX B:2

EXPERT SYSTEM AUDITING QUESTIONNAIRE - THE MANAGER

A INTRODUCTION:

This questionnaire is a part of research in which a model for auditing an operational expert system has been developed. The information in the questionnaire will be kept in strict confidence and will be used solely for this research.

When the information has been collected from all the questionnaires, a test will be carried out to evaluate the controls of the system.

B AIM OF THE QUESTIONNAIRE:

The answers in the questionnaire will be the basis for the definitions of the risks involved in using "The Expert System". The test will examine the controls which were built into the system in order to minimise or eliminate these risks.

C NOTES:

If you think that there are other risks, especially with regard to input and output, about which you have not been asked, then please add the details at the end of this questionnaire.

D GENERAL DETAILS:

Name: ....

Title: ....

No. of years in the Group: ....

E QUESTIONS:

1) Have you been involved in the development process of "The Expert System" system? If yes, please state in which stages.

....

....

2) How long has this system been in use? ....

3) Are you satisfied with the system? Please indicate on the scale (e.g., 0 = No, 5 = Very satisfied)

0 1 2 3 4 5

| | | | | |

4) Did you find any problems with using the system so far? If yes, please describe them?

....

....

....

5) Do you know if there were results from the system in the past which at a later stage were identified as being incorrect? If yes, please describe them.

....

....

....

6) Did you issue a manual or other written guidelines when using "The Expert System"?

....

7) Is there any information that the user should omit from the system altogether? Describe it.

....

....

....

8) Based on your experience and knowledge, what are the factors which differentiate the final results?

....

....

....

9) Based on your experience and knowledge, what are the factors the system "is asking for"? And what answers are indecisive?

....

....

....

10) Based on your experience, what changes in the system do you recommend?

....

....

....

11) What results are not reasonable?

....

....

....

12) What results, or combination of results, from the system are not relevant and why?

....

....

12A) Does "The Expert System" ever produce advice/decisions which clash with your policy?

....

13) How do you consider the result of "The Expert System": as advice, or as a decision to be taken?

....

14) What are the risks of misusing the system?

....

....

....

15) Would you like to add more details regarding the risks of this system?

....

....

....

Date.................................

APPENDIX B:3

EXPERT SYSTEM AUDITING QUESTIONNAIRE - THE KNOWLEDGE ENGINEER

A INTRODUCTION:

This questionnaire is a part of research in which a model for auditing an operational expert system has been developed. The information in the questionnaire will be kept in strict confidence and will be used solely for this research.

When the information has been collected from all the questionnaires, a test will be carried out to evaluate the controls of the system.

B AIM OF THE QUESTIONNAIRE:

The answers in the questionnaire will be the basis for the definitions of the risks involved in using "The Expert System". The test will examine the controls which were built into the system in order to minimise or eliminate these risks.

C NOTES:

If you think that there are other risks, especially with regard to input and output, about which you have not been asked, then please add the details at the end of this questionnaire.

D GENERAL DETAILS:

Name: ....

Title: ....

No. of years in the Group: ....

E QUESTIONS:

1) Have you been involved in the development process of "The Expert System" system? If yes, please state in which stages.

....

....

1A) Did you use any methodology for the development? If yes, please describe briefly the stages of the methodology.

....

....

1B) How did you test the system?

....

....

1C) Are you in charge of maintaining the system?

....

2) How long has this system been in use?

....

3) Are you satisfied with the system? Please indicate on the scale (e.g., 0 = No, 5 = Very satisfied)

0 1 2 3 4 5

| | | | | |

4) Did you find any problems with using the system so far? If yes, please describe them?

....

....

....

5) Have you had results from the system in the past which at a later stage were identified as being incorrect? If yes, please describe them.

....

....

....

6) Have you issued a manual or other written guidelines when using "TheExpert System"? ....

7) Is there any information that the user should omit from the system altogether? Describe it.

....

....

....

7A) What type of information should "The Expert System" not accept at all?

....

....

8) Based on your experience, what are the factors which differentiate the final results?

....

....

....

9) Based on your experience, what are the factors the system "is asking for"? And what answers are indecisive?

....

....

....

10) Based on your experience, what changes in the system do you recommend?

....

....

....

11) What results are not reasonable?

....

....

....

11A) What results of the system are not permissible according to the design of the inference engine?

....

....

....

12) What results, or combination of results, from the system are not relevant,and why?

12A) What are the controls with regard to input/output?

....

....

....

12B) What are the controls with regard to present unauthorised access?

....

....

....

13) How do you consider the result of "The Expert System": as advice, or as a decision to be taken?

....

14) What are the risks of misusing the system?

....

....

....

14A) How do you define the risky areas of the system?

....

....

....

15) Would you like to add more details regarding the risks of this system?

....

....

....

Date: ....

APPENDIX B:4

EXPERT SYSTEM QUESTIONNAIRE - THE EXPERT

A INTRODUCTION:

This questionnaire is a part of research in which a model for auditing an operational expert system has been developed. The information in the questionnaire will be kept in strict confidence and will be used solely for this research.

When the information has been collected from all the questionnaires, a test will be carried out to evaluate the controls of the system.

B AIM OF THE QUESTIONNAIRE:

The answers in the questionnaire will be the basis for the definitions of the risks involved in using "The Expert System". The test will examine the controls which were built into the system in order to minimise or eliminate these risks.

C NOTES:

If you think that there are other risks, especially with regard to input and output, about which you have not been asked, then please add the details at the end of this questionnaire.

D GENERAL DETAILS:

Name: ....

Title: ....

No. of years in the Group: ....

E QUESTIONS:

1) Have you been involved in the development process of "The Expert System" system? If yes, please state in which stages.

....

....

1A) Were you involved in the testing of the system?

....

2) How long has this system been in use?

....

3) Are you satisfied with the system? Please indicate on the scale (e.g., 0 = No, 5 = Very satisfied)

0 1 2 3 4 5

| | | | | |

4) Did you find any problems with using the system so far? If yes, please describe them?

....

....

....

5) Have you had results from the system in the past which at a later stage were identified as being incorrect? If yes, please describe them.

....

....

....

5A) Is it possible that since the development of the system other factors/possibilities not included in the system have emerged?

....

6) Were you involved in the production of a manual or other written guidelines when using "The Expert System"?

....

7) Is there any information that the user should omit from the system altogether? Describe it.

....

....

....

7A) Is there an input to the system which, based on your expertise, should not be in the system at all because:

a) the input is not relevant?

b) the input is not possible?

c) the input would damage the process of reasoning of the system?

....

8) Based on your experience, what are the factors which differentiate the final results?

....

....

....

9) Based on your experience, what are the factors the system "is asking for"? And what answers are indecisive?

....

....

....

10) Based on your experience, what changes in the system do you recommend?

....

....

....

11) What results are not reasonable? Why?

....

....

....

12) What results, or combination of results, from the system are not relevant, and why?

....

....

....

12A) What is the output that the user should not use at all? Why?

....

....

13) How do you consider the result of "The Expert System": as advice, or as a decision to be taken?

....

14) What are the risks of misusing the system? Please define them in general terms.

....

....

....

15) Would you like to add more details regarding the risks of this system?

....

Date.....................

APPENDIX C:"NESDEM" EVALUATION AREAS - AUDITOR'S INVOLVEMENT

Phase	Methodological Step	Evaluation goals	Definition of goals	Evaluation techniques
Feasibility	Commercial feasibility	Necessity	The study encompasses all aspects and proves the necessity of the system	Meeting/checking the study
Selection	Problem definition	Correctness	The prototype/system provides the correct functions to describe the application area	Prototype/system demonstrations or interactive sessions
		Functions are Covered in depth	Each function provided by the prototype/system is adequately implemented in that it includes sufficient details	Meetings/conference
Knowledge base design	Prototype/system's performance	Quick response	The prototype is quick to respond to your reports	Validation with test cases
		Reliability	The system is reliable, i.e., it consistently achieves accurate results and it is therefore dependable and performs the test accurately over time without breaking down or failing	Prototype testing by developer(s) using the same set of test data Prototype/system demonstrations or interactive sessions (with auditors)

Source: JAMIESON, R. and CHING, M. (1989), Evaluation of Knowledge-based Systems Under Development, University of New South Wales

Phase	*Methodological Step*	*Evaluation goals*	*Definition of goals*	*Evaluation techniques*
				Regular use of ES in working environment with development team in stand-by
Knowledge base	Prototype/system's performance	Low resource usage	The prototype/system uses an accepatable level of resources such as memory and disc space	Direct examination by developers Regular use of ES in working environment with development team in stand-by
		Correctness	The solutions and conclusions given by the prototype/system are (in the expert's opinion) correct	Validation with test cases Prototype/system demonstrations or interactive sessions with auditor Regular use of ES in working environment with development team in stand-by
		Graceful degradation	The system degrades gracefully at the boundaries, i.e., if it does not provide all the required functions it will advise the user to seek expert advice elsewhere before returning to the appropriate screen	Validation with test cases Prototype/system demonstrations or interactive sessions with auditor

Phase	*Methodological* Step	Evaluation goals	Definition of goals	*Evaluation* techniques
				Regular use of E/S in working environment with development team in stand by
Build and test prototype	Acceptability of prototype/system	Testability	System is easily tested & evaluated according to the aforementioned procedures. System is also modular in that it is written in a structured manner which allows for speedy testing, analysis and isolation of errors	Meetings/conferences
		Survivability	System is designed to last for reasonable length of time. The knowledge incorporated is not unadaptable to changes and the system likely to be popular in the function it performs and the technology it employs	Regular use of ES in working environment, with development team in stand-by
		Extendability	The system is easily extendable to include more facts and rules, and to cover more functions	Demonstrations and trial sessions held by the developer to indicate capabilities
		Modifiability	System is easily modified if required, i.e. the facts & rules are easily changed	Meetings/conferences

Phase	*Methodological Step*	*Evaluation goals*	*Definition of goals*	*Evaluation techniques*
Build and test	Acceptability of prototype/system	Maintainability	System is easily maintained, ie, irregularities and system problems are easily isolated and correctet, not only by the original developers	Regular use of ES in working environment with development team in stand by
		Security	The information contained in the system is secure and attempts to break into the knowledge box fraught with difficulties	Examination by auditors
		Integrity	When system fails or is corrupted, there are adequate back-up facilities & alarm signals, and the required data is retained as uncorrupted as possible	Presentations by developers Field test-validations by users Regular use of ES in working environment with development in stand-by
	User interface	Adequate instructions and system responses given	The prototype/system gives you instructions and responses when you require them	Prototype/system demonstrations for interactive sessions with auditors
		Understandability of the system responses	The prototype/system gives you instructions/responses which you can understand	Regular use of ES in working team on team on stand-by

Phase	Methodological Step	Evaluation goals	Definition of goals	Evaluation techniques
Build and test operational version	Documentation	User's manual:		
		Ease of use:		
		Finding the appropriate section	You can find the appropriate sections in the user's manual quickly and easily	Allow evaluators to read through the user's manual
		Understandability of instructions understand	The user's manual instructions are easy to	Use the user's manual in a trial session
		instructions are concise	The user's manual instructions are concise, i.e., the instructions are "to the point and do not contain redundant information	Regular use of user's manual in ES working environment with development team on stand-by
		System's documentation (Help facility):		
		Ease of use: Availability of system's documentation	The system's documentation is available when the user requires it	Demonstrate system's documentation to evaluators
		Time required for response	Help instructions are displayed quickly after they have been requested	Let evaluators use the system
		Understandability of instructions	The help instructions provided by the system are easy to understand	Regular use of ES in working environment with development team on stand-by

Phase	***Methodological Step***	***Evaluation goals***	***Definition of goals***	***Evaluation techniques***
System release	final evaluation of the system	understandability of instructions	The user's manual instructions are easy to understand	Use the user's manual in a trial session
		Finding the appropriate section	Finding the section in the manual easily and quickly	Reading the manual
	Post implementation review	Correctness	The final version is not changed	Validation with test cases
Maintenance and enhancements	Maintenance and necessary changes to system	Proper documentation of the changes	The changes are authorised and recorded	Checking the documentation
	Integrate E/S with Other applications	Availability and flexibility of the E/S	To ensure its co-ordination with the other systems	Validation with test cases

APPENDIX D:

LIST OF COLLEAGUES TO WHOM THE MODELS WERE PRESENTED AND DISCUSSED

In UK:

Mr J M Court
Secretary - The Institute of Chartered Accountants in England and Wales

Mr J Hunter CPA
Member of the Editorial Board of "DATAWATCH"
Kidsons Impey

Mr S P Wiltshire
Arjo Wiggins Appleton

Mr P Drew
Advanced Technology Manager, Girobank Plc

Mrs S Blackburn
EDP Auditor, Sainsbury

Mr I Neale
Research Fellow
Aries at City, Dept of Business Computing

Mr D Mallock
EDP Auditor, Safeway

Mr J Burnham
Expert Systems Group
Ernst & Young

Mr P Brown
Group Information Systems Technology
Barclays Bank Plc
Developer of FRAUDWATCH - a KBS for detecting credit card fraud

Mr V Smith / Mr N Silbey
Management Control/TSB PLC

Mr R Baker

Itemplus Consulting

In Israel:

Mr Z Fry

Former President of "The Israeli EDP Auditors' Association

Deputy Managing Director - Kesselman Consultancy Services Ltd

Mr S Mordchai

Secretary of "The Israeli EDP Auditors' Association

Head of EDP Audit Department of Bank Leumi Ltd

Mrs Y Shaim

Head of EDP Audit Team of Israeli Electricity Company

In Germany

Miss N Sery

EDP Auditor

APPENDIX E:

AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

E:1 A QUESTIONNAIRE

E:2 A SHORT DESCRIPTION

3 AUDITING AN E/S UNDER DEVELOPMENT, "NESDEM" EVALUATION AREAS - AN AUDITOR'S INVOLVEMENT

APPENDIX E:1:

AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT

A QUESTIONNAIRE

A) General Details

Name: ....

Title: ....

Name of Employer: ....

B) Questions

Please indicate your response by ticking the appropriate column on the scale.

On the scale there are 5 options ranked from 1 (Very Poor), 2 (Poor), 3 (Average), 4 (Good), and 5 (Very Good).

	1	2	3	4	5
	poor	very poor	average	good	very good
1) Does the proposed model enable the internal auditor to assess the effectiveness of the internal controls within the developed Expert System? If the answer is Poor or Very Poor please explain why.					
2) Does the proposed model ensure that the internal auditor covers the isks associated with the developments of an Expert System at each of the following stages in which the internal auditor is involved? If the answer is Poor or Very Poor please explain why.					

- Feasibility ....
- Selection ....
- Knowledge based design ....

	1	2	3	4	5
		very			very
	poor	poor	average	good	good

- Build and test prototype ....
- Build and test operational version ....
- System release ....
- Maintenance and enhancement ....

3) Does the proposed model enable the internal auditor the flexibility to adjust his/her work in the development process according to the "System Development Life Cycle" which the Expert System's developers may use? If the answer is Poor or Very Poor please explain why.

4) Is the proposed model for auditing an expert system under development practical (contrasted with a theoretical model) for use by the internal auditor? if the answer is Poor or Very Poor please explain why.

5) Is the proposed model for auditing an expert system under development feasible (i.e. can it be managed by the internal auditor)? If the answer is Poor or Very Poor please explain why.

	1	2	3	4	5
	poor	very poor	average	good	very good
6) Is the proposed model for auditing an expert system under development reliable, covering all the areas that need to be audited and giving proper answers? If the answer is Poor or Very Poor please explain why.					

If the answer to one or more of the questions is POOR or VERY POOR please explain why below:

....

....

....

....

....

Would you like to add any comments? YES / NO

If Yes, please add them below:

....

....

....

....

....

Would you like a copy of this survey? YES / NO

Thank you very much for your help by answering this questionnaire.

H COHEN
City University Business School
Centre of Internal Auditing

APPENDIX E:2: AUDITING AN EXPERT SYSTEM UNDER DEVELOPMENT - A SHORTDESCRIPTION

Expert Systems have expanded tremendously in the last few years. In 1990, the expert Systems market was estimated at one billion Dollars. Expert Systems, often called "Knowledge Based Systems", became useful in the commercial world: banks, insurance companies, industry, etc.

The development process of an Expert System has still not been consolidated; recently, there have been some publications suggesting models of the Systems Development Life Cycle for the Expert System. The most common aspect is the important necessity of testing such models in Expert Systems. At the same time, there is no clear definition of the role of the Internal Auditor in this process, nor the method of auditing such a process.

Do we really need a separate approach to auditing an Expert System under development? An Expert System, as a very powerful and sophisticated software, has unique risks, such as inefficient solutions generated, over-reliance on E/S and expensive solutions to an area of concern. Considering the risks involved in the Expert System, the involvement of the internal auditor in the process is important.

Due to research being carried out at City University Business School Centre for Internal Auditing, a model for auditing an E/S under development was developed.It is based on the "NESDEM", a model of an Expert System development which elaborated, among other functions, the role of the internal auditor. Forty-one steps are divided into nine main stages of the process, of which the internal auditor is involved in the following seven:

Feasibility
Selection
Knowledge-based design
Build and test prototype
Build and test operational version
System release
Maintenance and enhancement

Into the "NESDEM" the author integrates the "Control Band"; this Band distinguishes the Expert System from a conventional system.. The internal auditor's task, after the process of reading documents, interviewing and/or distributing questionnaires, is collecting data on the risks of the system, and then checking the controls of the risks. If the results show that the controls are functioning well, then this means that the risks of the E/S are reduced to the level of other conventional software. In addition, the author defines the following types of auditing techniques:

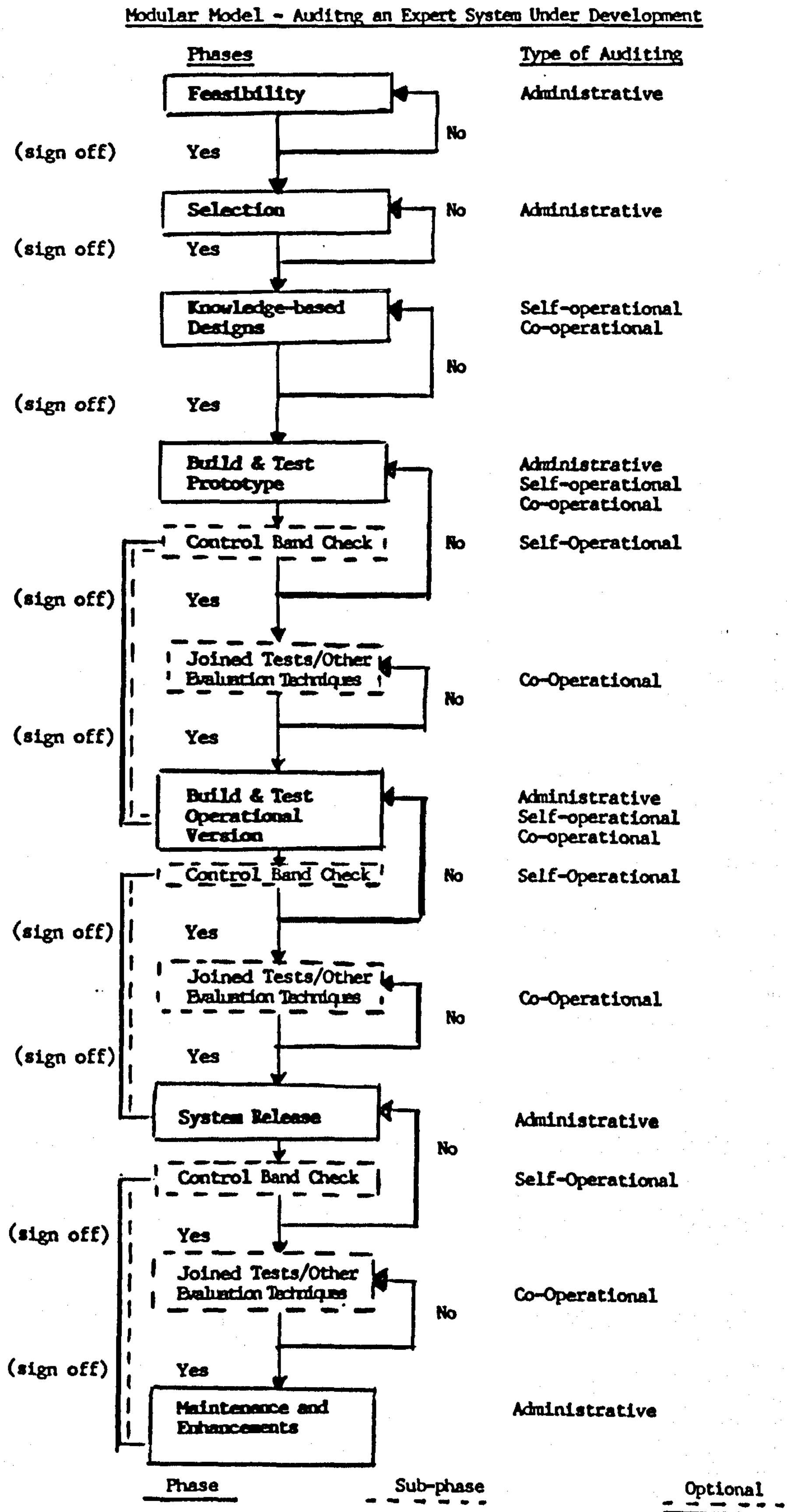
Administrative techniques: all the methods which do not include direct involvement in the programming steps, such as reading documents etc.

Self-operational: all the methods which lead to direct examination of the programming computerised means, such as test data, test cases etc.

Co-operational: the same methods as in self-operation, but performed and controlled by others, and the internal auditor is part of the process.

The principles of the proposed model for auditing an E/S under development are based on the need to produce a practical, flexible and reliable model for the internal auditor, allowing him/her to tackle the challenge of auditing an Expert System, sometimes with limited resources.

The following diagram presents the model schematically:



The evaluation of goals and techniques for each stage of the development process are shown in the attached document. This includes both validation and assessment of the Expert System.

APPENDIX E3:"NESDEM" EVALUATION AREAS - AUDITOR'S INVOLVEMENT

Phase	Methodological Step	Evaluation goals	Definition of goals	Evaluation techniques
Feasibility	Commercial feasibility	Necessity	The study encompasses all aspects and proves the necessity of the system	Meeting/checking the study
Selection	Problem definition	Correctness	The prototype/system provides the correct functions to describe the application area	Prototype/system demonstrations or interactive sessions
		Functions are Covered in depth	Each function provided by the prototype/system is adequately implemented in that it includes sufficient details	Meetings/conference
Knowledge base design	Prototype/system's performance	Quick response	The prototype is quick to respond to your reports	Validation with test cases
		Reliability	The system is reliable, i.e., it consistently achieves accurate results and it is therefore dependable and performs the test accurately over time without breaking down or failing	Prototype testing by developer(s) using the same set of test data Prototype/system demonstrations or interactive sessions (with auditors)

Source: JAMIESON, R. and CHING, M. (1989), Evaluation of Knowledge-based Systems Under Development, University of New South Wales

Phase	*Methodological Step*	*Evaluation goals*	*Definition of goals*	*Evaluation techniques*
				Regular use of ES in working environment with development team in stand-by
Knowledge base	Prototype/system's performance	Low resource usage	The prototype/system uses an accepatable level of resources such as memory and disc space	Direct examination by developers Regular use of ES in working environment with development team in stand-by
		Correctness	The solutions and conclusions given by the prototype/system are (in the expert's opinion) correct	Validation with test cases Prototype/system demonstrations or interactive sessions with auditor Regular use of ES in working environment with development team in stand-by
		Graceful degradation	The system degrades gracefully at the boundaries, i.e., if it does not provide all the required functions it will advise the user to seek expert advice elsewhere before returning to the appropriate screen	Validation with test cases Prototype/system demonstrations or interactive sessions with auditor

Phase	Methodological Step	Evaluation goals	Definition of goals	Evaluation techniques
				Regular use of E/S in working environment with development team in stand by
Build and test prototype	Acceptability of prototype/system	Testability	System is easily tested & evaluated according to the aforementioned procedures. System is also modular in that it is written in a structured manner which allows for speedy testing, analysis and isolation of errors	Meetings/conferences
		Survivability	System is designed to last for reasonable length of time. The knowledge incorporated is not unadaptable to changes and the system likely to be popular in the function it performs and the technology it employs	Regular use of ES in working environment, with development team in stand-by
		Extendability	The system is easily extendable to include more facts and rules, and to cover more functions	Demonstrations and trial sessions held by the developer to indicate capabilities
		Modifiability	System is easily modified if required, i.e. the facts & rules are easily changed	Meetings/conferences

Phase	*Methodological Step*	*Evaluation goals*	*Definition of goals*	*Evaluation techniques*
Build and test	Acceptability of prototype/system	Maintainability	System is easily maintained, ie, irregularities and system problems are easily isolated an d correctet, not only by the original developers	Regular use of ES in working environment with development team in stand by
		Security	The information contained in the system is secure and attempts to break into the knowledge box fraught with difficulties	Examination by auditors
		Integrity	When system fails or is corrupted, there are adequate back-up facilities & alarm signals, and the required data is retained as uncorrupted as possible	Presentations by developers Field test-validations by users Regular use of ES in working environment with development in stand-by
	User interface	Adequate instructions and system responses given	The prototype/system gives you instructions and responses when you require them	Prototype/system demonstrations for interactive sessions with auditors
		Understandability of the system responses	The prototype/system gives you instructions/responses which you can understand	Regular use of ES in working team on team on stand-by

Phase	***Methodological Step***	**Evaluation goals**	**Definition of goals**	**Evaluation techniques**
Build and test operational version	Documentation	User's manual: Ease of use: Finding the appropriate section	You can find the appropriate sections in the user's manual quickly and easily	Allow evaluators to read through the user's manual
		Understandability of instructions understand	The user's manual instructions are easy to	Use the user's manual in a trial session
		instructions are concise	The user's manual instructions are concise, i.e., the instructions are "to the point and do not contain redundant information	Regular use of user's manual in ES working environment with development team on stand-by
		System's documentation (Help facility): Ease of use: Availability of system's documentation	The system's documentation is available when the user requires it	Demonstrate system's documentation to evaluators
		Time required for response	Help instructions are displayed quickly after they have been requested	Let evaluators use the system
		Understandability of instructions	The help instructions provided by the system are easy to understand	Regular use of ES in working environment with development team on stand-by

Phase	*Methodological Step*	*Evaluation goals*	*Definition of goals*	*Evaluation techniques*
System release	final evaluation of the system	understandability of instructions	The user's manual instructions are easy to understand	Use the user's manual in a trial session
		Finding the appropriate section	Finding the section in the manual easily and quickly	Reading the manual
	Post implementation review	Correctness	The final version is not changed	Validation with test cases
Maintenance and enhancements	Maintenance and necessary changes to system	Proper documentation of the changes	The changes are authorised and recorded	Checking the documentation
	Integrate E/S with Other applications	Availability and flexibility of the E/S	To ensure its co-ordination with the other systems	Validation with test cases

APPENDIX G:

ARJO WIGGINS - THE "LEVEL EXPERT" TEST DATA

G:1	RANDOM FACTORS
G:2	INPUT
G:3	INPUT
G:4	INPUT
G:5	INPUT
G:6	INPUT
G:7	INPUT
G:8	INPUT

APENDIX G:1:

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

RANDOM FACTORS

General Risks : A Case Study

Type: **Ridge** Where:

F/E	F/C	C	B/C	B/E
X	✓	X	✓	X

Orientation: Raised

Width: 5-50 mm

Onset: Sudden

Stability: Steady

Machine Stretch: None

Suspect Areas: Head box

APPENDIX G:2:

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: **Raised**

Width: 5-100 mm

Onset: Sudden

Stability: Steady

Machine Stretch: None

Suspect Areas: Headbox

* The emphasised line is the factor which has been changed.

APPENDIX G:3:

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: **Raised**

Width: 5-100 mm

Onset: Sudden

Stability: Steady

Machine Stretch: None

Suspect Areas: Headbox

* The emphasised line is the factor which has been changed.

APPENDIX G:4

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where:

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: Raised

Width: **0-50 mm**

Onset: Unknown/Unscaled

Stability: Steady

Machine Stretch: None

Suspect Areas: Headbox

* The emphasised line is the factor which has been changed.

APPENDIX G:5:

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where:

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: Raised

Width: 0-50 mm

Onset: **Sudden**

Stability: Unknown/Unscaled

Machine Stretch: None

Suspect Areas: Headbox

* The emphasised line is the factor which has been changed.

APPENDIX G:6

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: Raised

Width: 0-50 mm

Onset: Sudden

Stability: **Steady**

Machine Stretch: Unknown

Suspect Areas: Headbox

* The emphasised line is the factor which has been changed.

APPENDIX G:7

ARJO WIGGINS - "LEVEL EXPERT" TEST DATA

INPUT

General Risks : A Case Study

Type: Ridge

Where:

F/E	F/C	C	B/C	B/E
X	√	X	√	X

Orientation: Raised

Width: 0-50 mm

Onset: Sudden

Stability: Steady

Machine Stretch: **None**

Suspect Areas: Unknown/Unscaled

* The emphasised line is the factor which has been changed.

APPENDIX H:

ARJO WIGGINS TEST DATA - RESULTS

Name of the Expert System:	The Level Expert
Date of the test data:	28.6.94
Place:	Arjo Wiggins, Beaconsfield
By:	H Cohen
Attending:	Mr H Wiltshire

28/06/199
10:48:18

DOVER LEVEL EXPERT - Session Printout
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User :

Session Information :

SUMMARY
ëëëëëëëë

Type .. Edge Fault

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. None

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• X • « • « • « • « •
âáF/EáâáF/CáâááCááâáB/CáâáB/Eáì

	Accuray	Aggreement
Substance	ïÔÔÔÔÔÔ	ï
Moisture	ïÔÔÔÔÔÔ	ï
Thickness	ïÔÔÔÔÔÔ	ï
Pre-SP Mois	ïÔÔÔÔÔÔ	ï
	none	exact

Possible causes (36 found).

	Cause	Score	« or X
HB15	Slice damage	124	• •
HB12	Slice -poor adjustment	115	• •
SM09	Smoothing press surface build up	115	• •
WI13	Wire sprays blocked	115	• •
WI10	Wire shake	113	• •
MB02	MB dryer felts damaged	107	• •
AD03	Afterdryer felt damaged	104	• •
MB07	MB dryer felt not covering paper	104	• •
PR26	Press hp sprays not oscillating	102	• •
PR25	Press hp sprays blocked	101	• •
AD08	Afterdryer felt not cover paper	99	• •
SP07	Size press roll damage	94	• •
PR28	Press lp sprays -too much water	92	• •
WI06	Wire fabric edges -ridge	90	• •
HB21	Slice edge bleed adjustment	88	• •
WI09	Deckle wedges	88	• •
MB08	MB cylinders -surface streak	88	• •
AD09	Afterdryer cyl. surface streak	84	• •
CA07	Calender roll damage	82	• •
CA13	Calender doctor not clean	81	• •
MB04	MB dryer felts -streak/crease	78	• •
AD05	Afterdryer felt streak/crease	75	• •
SP08	Size press roll build up	73	• •
AD16	Afterdryer cyl. -paper over edge	73	• •
SP12	Size press doctor not clean	72	• •
HB23	New cause for audit !	70	• •
CA19	Calender draw tight	68	• •

DOVER LEVEL EXPERT - Session Printout 11:07:05
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks

SUMMARY
ëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

```
Where ..Öááááá ôááááá ôááááá ôááááá ôááááá ôááááá Ç
        •   «   •   X   •   X   •   «   •   X   •
        ââF/EáêâF/CáêââCáâêâB/CáêâB/Eâì

          Accuray Aggreement
Substance    ï                       ï
Moisture     ï                       ï
Thickness    ï                       ï
Pre-SP Mois  ï                       ï
             none                exact
```

Possible causes (36 found). « or X

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
HB15	Slice damage	114	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
SP08	Size press roll build up	97	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
HB12	Slice -poor adjustment	94	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
MB02	MB dryer felts damaged	89	• •
MB08	MB cylinders -surface streak	89	• •
SP22	Size press camber roll build up	88	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •

The above can be used as a checklist i.e. for «'s or X's

```
User : cohen   eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee

Session Information : test data   general risks   1

SUMMARY
ëëëëëëëë
Type    ..  Variable              Where   ..ÖááááááôááááááôááááááôááááááôááááááÇ
                                            •   «   •   X   •   X   •   «   •   X   •
Orientation  ..  N/A                         ââF/EáêâF/CáêááCááêâB/CáêâB/Eál
Width   ..  5-50 mm                                  Accuray Aggreement
Onset   ..  Sudden                Substance     ï                      ï
Stability   ..  Steady            Moisture      ï                      ï
                                  Thickness     ï                      ï
                                  Pre-SP Mois   ï                      ï
Machine Stretch   ..  None                      none               exact
Suspect areas   ..  Headbox
Possible causes (19 found).                                          « or X
ÖááááááááááááááááááááááááááááááááááááááááááááááááááScoreáôááááááÇ
•  SM09    Smoothing press surface build up            109  •      •
•  CA13    Calender doctor not clean                    97  •      •
•  SP08    Size press roll build up                     87  •      •
•  CA19    Calender draw tight                          85  •      •
•  SM05    Smoothing press -lump in roll                84  •      •
•  SP22    Size press camber roll build up              83  •      •
•  PR28    Press lp sprays -too much water              81  •      •
•  AD15    Afterdryer cylinder -leak                    81  •      •
•  PR27    Press hp sprays -too much water              80  •      •
•  PR05    Lump on bottom press roll                    72  •      •
•  SP24    Sizepress camber roll cover loose            65  •      •
•  MB13    Leak on mb cylinders                         63  •      •
•  HB11    Headbox spray not rotating                   63  •      •
•  HB06    Holey roll -excess seal water                63  •      •
•  WI09    Deckle wedges                                59  •      •
•  WI06    Wire fabric edges -ridge                     57  •      •
•  WI10    Wire shake                                   55  •      •
•  HB05    Approach flow dist holes blocked             53  •      •
•  WI08    Breast roll doctor leak                      50  •      •
•                                                           •      •
•                                                           •      •
•                                                           •      •
•                                                           •      •
•                                                           •      •
•                                                           •      •
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•                                                           •      •
•                                                           •      •
•                                                           •      •
ââááááááááááááááááááááááááááááááááááááááááááááááááááááááááêáááááál
```

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:15:25

DOVER LEVEL EXPERT - Session Printout
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks 2

SUMMARY
ëëëëëëëëë

Type .. Edge Fault

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCáááêáB/CáêáB/Eáì

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X	
HB23	New cause for audit !	148	•	•
AD08	Afterdryer felt not cover paper	127	•	•
SM09	Smoothing press surface build up	119	•	•
MB07	MB dryer felt not covering paper	107	•	•
HB15	Slice damage	104	•	•
HB21	Slice edge bleed adjustment	104	•	•
AD03	Afterdryer felt damaged	101	•	•
CA13	Calender doctor not clean	97	•	•
HB12	Slice -poor adjustment	94	•	•
CA07	Calender roll damage	93	•	•
AD16	Afterdryer cyl. -paper over edge	93	•	•
AD29	Afterdryer load roll surface dirt	91	•	•
SP07	Size press roll damage	91	•	•
MB02	MB dryer felts damaged	89	•	•
MB28	MB load rolls -surface build up	85	•	•
CA19	Calender draw tight	85	•	•
WI10	Wire shake	85	•	•
AD15	Afterdryer cylinder -leak	81	•	•
SP12	Size press doctor not clean	81	•	•
AD09	Afterdryer cyl. surface streak	81	•	•
WI09	Deckle wedges	79	•	•
SP08	Size press roll build up	77	•	•
SP20	Size press lead roll build up	77	•	•
PR25	Press hp sprays blocked	73	•	•
SP22	Size press camber roll build up	73	•	•
AD05	Afterdryer felt streak/crease	71	•	•

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:17:20

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 3

SUMMARY

Type .. Wavy

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
âáF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Orientation .. N/A

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (41 found).

Code	Cause	Score	« or X	
SM09	Smoothing press surface build up	119	•	•
CA13	Calender doctor not clean	107	•	•
SP08	Size press roll build up	107	•	•
HB12	Slice -poor adjustment	104	•	•
AD08	Afterdryer felt not cover paper	97	•	•
SP12	Size press doctor not clean	96	•	•
HB15	Slice damage	94	•	•
CA07	Calender roll damage	93	•	•
HB11	Headbox spray not rotating	93	•	•
AD29	Afterdryer load roll surface dirt	91	•	•
SP07	Size press roll damage	91	•	•
CA19	Calender draw tight	85	•	•
MB28	MB load rolls -surface build up	85	•	•
WI10	Wire shake	85	•	•
SM05	Smoothing press -lump in roll	84	•	•
SM08	Smoothing press roll damage	84	•	•
MB07	MB dryer felt not covering paper	77	•	•
PR05	Lump on bottom press roll	72	•	•
AD09	Afterdryer cyl. surface streak	71	•	•
PR26	Press hp sprays not oscillating	71	•	•
AD03	Afterdryer felt damaged	71	•	•
AD05	Afterdryer felt streak/crease	71	•	•
WI13	Wire sprays blocked	69	•	•
WI06	Wire fabric edges -ridge	67	•	•
PR09	Press doctors-excess lub water	64	•	•
PR25	Press hp sprays blocked	63	•	•
HB05	Approach flow dist holes blocked	63	•	•
AD16	Afterdryer cyl. -paper over edge	63	•	•
PR28	Press lp sprays -too much water	61	•	•
AD15	Afterdryer cylinder -leak	61	•	•

The above can be used as a checklist i.e. for «'s or X's

28/06/1994

User : cohen

Session Information : test data general risks 4

SUMMARY

Type .. Step

Orientation .. N/A

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where .. « X X « X
F/E F/C C B/C B/E

Accuray Aggreement

	none	exact
Substance		
Moisture		
Thickness		
Pre-SP Mois		

Possible causes (45 found). « or X

		Score	
SM09	Smoothing press surface build up	129	
AD08	Afterdryer felt not cover paper	117	
SM08	Smoothing press roll damage	114	
CA07	Calender roll damage	113	
SP07	Size press roll damage	111	
HB15	Slice damage	104	
SM05	Smoothing press -lump in roll	104	
AD29	Afterdryer load roll surface dirt	101	
CA13	Calender doctor not clean	97	
MB07	MB dryer felt not covering paper	97	
SP08	Size press roll build up	97	
MB28	MB load rolls -surface build up	95	
CA19	Calender draw tight	95	
PR05	Lump on bottom press roll	92	
AD09	Afterdryer cyl. surface streak	91	
AD31	Afterdryer doctor -broke on sheet	91	
AD03	Afterdryer felt damaged	91	
SP12	Size press doctor not clean	91	
SP22	Size press camber roll build up	88	
SP20	Size press lead roll build up	87	
MB30	MB doctors -broke touching sheet	85	
HB12	Slice -poor adjustment	84	
AD16	Afterdryer cyl. -paper over edge	83	
AD05	Afterdryer felt streak/crease	81	
MB08	MB cylinders -surface streak	79	
MB02	MB dryer felts damaged	79	
WI06	Wire fabric edges -ridge	77	
PR08	Press damage	76	
PR25	Press hp sprays blocked	73	
HB11	Headbox spray not rotating	73	

The above can be used as a checklist i.e. for «'s or X's

User : cohen

Session Information : test data general risks 5

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..

«	X	X	«	X
F/E	F/C	C	B/C	B/E

Accuray Aggreement

	none	exact
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	129	
AD08	Afterdryer felt not cover paper	127	
CA07	Calender roll damage	123	
SP07	Size press roll damage	121	
CA19	Calender draw tight	115	
HB15	Slice damage	114	
CA13	Calender doctor not clean	112	
MB07	MB dryer felt not covering paper	107	
AD29	Afterdryer load roll surface dirt	106	
AD03	Afterdryer felt damaged	101	
AD09	Afterdryer cyl. surface streak	101	
MB28	MB load rolls -surface build up	100	
SP08	Size press roll build up	97	
AD31	Afterdryer doctor -broke on sheet	96	
HB12	Slice -poor adjustment	94	
AD16	Afterdryer cyl. -paper over edge	93	
SP20	Size press lead roll build up	92	
PR26	Press hp sprays not oscillating	91	
AD05	Afterdryer felt streak/crease	91	
SP12	Size press doctor not clean	91	
MB30	MB doctors -broke touching sheet	90	
MB02	MB dryer felts damaged	89	
MB08	MB cylinders -surface streak	89	
SP22	Size press camber roll build up	88	
WI06	Wire fabric edges -ridge	87	
MB17	Paper over mb cylinder edge	81	
WI13	Wire sprays blocked	79	
PR25	Press hp sprays blocked	78	
MB04	MB dryer felts -streak/crease	77	
WI10	Wire shake	75	

The above can be used as a checklist i.e. for «'s or X's

User : cohen

Session Information : test data general risks 6

SUMMARY
ëëëëëëëëë

Type .. Slope

Orientation .. N/A

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

```
Where  ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
         •   «   •   X   •   X   •   «   •   X   •
         ââF/EáêâF/CáêááCááêâB/CáêâB/Eáì

                  Accuray Aggreement
Substance     i                    ï
Moisture      i                    i
Thickness     i                    i
Pre-SP Mois   i                    i
              none             exact
```

Possible causes (24 found).

		Score	« or X
SM09	Smoothing press surface build up	109	
HB12	Slice -poor adjustment	94	
SP07	Size press roll damage	91	
CA19	Calender draw tight	85	
HB15	Slice damage	84	
HB21	Slice edge bleed adjustment	84	
SM08	Smoothing press roll damage	84	
SP12	Size press doctor not clean	81	
SP08	Size press roll build up	77	
HB11	Headbox spray not rotating	73	
AD03	Afterdryer felt damaged	71	
HB16	Slice lump	63	
HB06	Holey roll -excess seal water	63	
AD15	Afterdryer cylinder -leak	61	
MB02	MB dryer felts damaged	59	
WI06	Wire fabric edges -ridge	57	
WI10	Wire shake	55	
HB05	Approach flow dist holes blocked	53	
WI08	Breast roll doctor leak	50	
PR09	Press doctors-excess lub water	49	
WI09	Deckle wedges	49	
WI13	Wire sprays blocked	49	
PR08	Press damage	46	
MB13	Leak on mb cylinders	43	

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The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:25:47

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 7

SUMMARY
ëëëëëëëëë

Type .. Curve

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..Öááááááôáááááôáááááôáááááôáááááç
• « • X • X • « • X •
ââF/EáêâF/CáêááCááêâB/CáêâB/Eá1

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (15 found). « or X

Code	Cause	Score		
SM09	Smoothing press surface build up	109	•	•
HB12	Slice -poor adjustment	94	•	•
HB21	Slice edge bleed adjustment	94	•	•
SP07	Size press roll damage	91	•	•
CA19	Calender draw tight	85	•	•
HB15	Slice damage	84	•	•
SP12	Size press doctor not clean	81	•	•
WI09	Deckle wedges	79	•	•
SP08	Size press roll build up	77	•	•
WI10	Wire shake	75	•	•
WI06	Wire fabric edges -ridge	67	•	•
AD15	Afterdryer cylinder -leak	61	•	•
PR09	Press doctors-excess lub water	49	•	•
WI13	Wire sprays blocked	49	•	•
MB13	Leak on mb cylinders	43	•	•

28/06/199-
11:27:21

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 8

SUMMARY
ëëëëëëëëë

Type .. Variable

Orientation .. N/A

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêááCááêâB/CáêâB/Eâì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (19 found).

		Score	« or X
SM09	Smoothing press surface build up	109	• •
CA13	Calender doctor not clean	97	• •
SP08	Size press roll build up	87	• •
CA19	Calender draw tight	85	• •
SM05	Smoothing press -lump in roll	84	• •
SP22	Size press camber roll build up	83	• •
PR28	Press lp sprays -too much water	81	• •
AD15	Afterdryer cylinder -leak	81	• •
PR27	Press hp sprays -too much water	80	• •
PR05	Lump on bottom press roll	72	• •
SP24	Sizepress camber roll cover loose	65	• •
MB13	Leak on mb cylinders	63	• •
HB11	Headbox spray not rotating	63	• •
HB06	Holey roll -excess seal water	63	• •
WI09	Deckle wedges	59	• •
WI06	Wire fabric edges -ridge	57	• •
WI10	Wire shake	55	• •
HB05	Approach flow dist holes blocked	53	• •
WI08	Breast roll doctor leak	50	• •

28/06/1994
11:29:51

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 9

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Dipped

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
âáF/EáêáF/CáêááCáâêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	i	i
Moisture	i	i
Thickness	i	i
Pre-SP Mois	i	i
	none	exact

Possible causes (44 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	139	• •
SM05	Smoothing press -lump in roll	135	• •
SM08	Smoothing press roll damage	135	• •
CA19	Calender draw tight	125	• •
CA07	Calender roll damage	123	• •
PR05	Lump on bottom press roll	123	• •
HB15	Slice damage	114	• •
CA13	Calender doctor not clean	112	• •
SP07	Size press roll damage	111	• •
AD29	Afterdryer load roll surface dirt	106	• •
HB05	Approach flow dist holes blocked	104	• •
HB11	Headbox spray not rotating	104	• •
HB16	Slice lump	104	• •
AD09	Afterdryer cyl. surface streak	101	• •
AD03	Afterdryer felt damaged	101	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
HB15	Slice damage	89	• •
MB08	MB cylinders -surface streak	89	• •
MB02	MB dryer felts damaged	89	• •
SP22	Size press camber roll build up	88	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •
AD15	Afterdryer cylinder -leak	71	• •

28/06/1994
11:31:11

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 10

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Both

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCáááêáB/CáêáB/Eáì

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (34 found). « or X

		Score	« or X
CA07	Calender roll damage	133	• •
SM09	Smoothing press surface build up	129	• •
CA13	Calender doctor not clean	122	• •
CA19	Calender draw tight	115	• •
HB15	Slice damage	114	• •
AD03	Afterdryer felt damaged	111	• •
AD09	Afterdryer cyl. surface streak	111	• •
SP07	Size press roll damage	111	• •
MB28	MB load rolls -surface build up	110	• •
SP08	Size press roll build up	107	• •
AD31	Afterdryer doctor -broke on sheet	106	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD16	Afterdryer cyl. -paper over edge	103	• •
SP20	Size press lead roll build up	102	• •
PR26	Press hp sprays not oscillating	101	• •
AD05	Afterdryer felt streak/crease	101	• •
SP12	Size press doctor not clean	101	• •
MB30	MB doctors -broke touching sheet	100	• •
MB08	MB cylinders -surface streak	99	• •
MB02	MB dryer felts damaged	99	• •
SP22	Size press camber roll build up	98	• •
HB12	Slice -poor adjustment	94	• •
MB17	Paper over mb cylinder edge	91	• •
PR25	Press hp sprays blocked	88	• •
MB04	MB dryer felts -streak/crease	87	• •
WI06	Wire fabric edges -ridge	87	• •
WI10	Wire shake	85	• •
AD15	Afterdryer cylinder -leak	81	• •
SP24	Sizepress camber roll cover loose	80	• •
WI13	Wire sprays blocked	79	• •

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:32:22

DOVER LEVEL EXPERT - Session Printout

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:33:45

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 11

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

```
Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
        •  «  •  X  •  X  •  «  •  X  •
        ááF/EáêáF/CáêááCáááêáB/CáêáB/Eáì
```

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	
AD08	Afterdryer felt not cover paper	127	
CA07	Calender roll damage	123	
SP07	Size press roll damage	121	
CA19	Calender draw tight	115	
HB15	Slice damage	114	
CA13	Calender doctor not clean	112	
MB07	MB dryer felt not covering paper	107	
AD29	Afterdryer load roll surface dirt	106	
AD03	Afterdryer felt damaged	101	
AD09	Afterdryer cyl. surface streak	101	
MB28	MB load rolls -surface build up	100	
SP08	Size press roll build up	97	
AD31	Afterdryer doctor -broke on sheet	96	
HB12	Slice -poor adjustment	94	
AD16	Afterdryer cyl. -paper over edge	93	
SP20	Size press lead roll build up	92	
PR26	Press hp sprays not oscillating	91	
AD05	Afterdryer felt streak/crease	91	
SP12	Size press doctor not clean	91	
MB30	MB doctors -broke touching sheet	90	
MB02	MB dryer felts damaged	89	
MB08	MB cylinders -surface streak	89	
SP22	Size press camber roll build up	88	
WI06	Wire fabric edges -ridge	87	
MB17	Paper over mb cylinder edge	81	
WI13	Wire sprays blocked	79	
PR25	Press hp sprays blocked	78	
MB04	MB dryer felts -streak/crease	77	
WI10	Wire shake	75	

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:34:53

DOVER LEVEL EXPERT - Session Printout

User : cohen ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

Session Information : test data general risks 12

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 50-150 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..Öáááááôáááááôáááááôáááááôáááááç
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (43 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	• •
CA22	Calender coil pad fault	123	• •
AD08	Afterdryer felt not cover paper	117	• •
HB13	Slice bent	114	• •
HB15	Slice damage	114	• •
CA07	Calender roll damage	113	• •
AD03	Afterdryer felt damaged	111	• •
SP07	Size press roll damage	111	• •
AD31	Afterdryer doctor -broke on sheet	106	• •
CA13	Calender doctor not clean	102	• •
SP20	Size press lead roll build up	102	• •
PR26	Press hp sprays not oscillating	101	• •
AD05	Afterdryer felt streak/crease	101	• •
SP16	Size jets blocked	101	• •
MB30	MB doctors -broke touching sheet	100	• •
MB02	MB dryer felts damaged	99	• •
SP22	Size press camber roll build up	98	• •
MB07	MB dryer felt not covering paper	97	• •
SP08	Size press roll build up	97	• •
WI06	Wire fabric edges -ridge	97	• •
AD29	Afterdryer load roll surface dirt	96	• •
HB12	Slice -poor adjustment	94	• •
RU08	Reel up tension too high	93	• •
CA26	Calender coil edgepad not covered	93	• •
SP12	Size press doctor not clean	91	• •
SP17	Size jet position	91	• •
MB28	MB load rolls -surface build up	90	• •
WI13	Wire sprays blocked	89	• •
PR25	Press hp sprays blocked	88	• •

MB04	MB dryer felts -streak/crease	87	•	•

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:39:37

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 13

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 150-300 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..

• «	• X	• X	• «	• X	•
F/E	F/C	C	B/C	B/E	

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (41 found).

	Cause	Score	« or X	
SM09	Smoothing press surface build up	129	•	•
HB15	Slice damage	124	•	•
HB13	Slice bent	114	•	•
CA22	Calender coil pad fault	113	•	•
SP16	Size jets blocked	111	•	•
SP08	Size press roll build up	107	•	•
HB12	Slice -poor adjustment	104	•	•
RU08	Reel up tension too high	103	•	•
CA13	Calender doctor not clean	102	•	•
AD03	Afterdryer felt damaged	101	•	•
SP12	Size press doctor not clean	101	•	•
SP22	Size press camber roll build up	98	•	•
RU06	Reel up lead roll alignment	97	•	•
AD29	Afterdryer load roll surface dirt	96	•	•
MB09	MB cylinders -suface dirty	95	•	•
SP20	Size press lead roll build up	92	•	•
AD10	Afterdryer cylinder surface dirty	91	•	•
SP17	Size jet position	91	•	•
MB28	MB load rolls -surface build up	90	•	•
MB02	MB dryer felts damaged	89	•	•
MB11	Broke on mb cylinder	88	•	•
WI10	Wire shake	85	•	•
AD12	Afterdryer cylinder -broke wrap	84	•	•
HB09	Headbox spray blocked	84	•	•

28/06/199
11:40:58

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 14

SUMMARY
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Type .. Ridge

Orientation .. Raised

Width .. 300-500 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..Öááááá Ôááááá Ôááááá Ôááááá Ôááááá Ôááááá Ç
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eál

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (28 found).

Code	Cause	Score	« or X
HB13	Slice bent	124	• •
SM09	Smoothing press surface build up	119	• •
MB09	MB cylinders -suface dirty	105	• •
RU08	Reel up tension too high	103	• •
AD10	Afterdryer cylinder surface dirty	101	• •
SP16	Size jets blocked	101	• •
SP17	Size jet position	101	• •
RU06	Reel up lead roll alignment	97	• •
HB12	Slice -poor adjustment	94	• •
HB09	Headbox spray blocked	94	• •
AD24	Afterdryer -broke on pv piprs	89	• •
MB22	MB -broke on pv pipes	85	• •
PR23	Press condition boxes dirty	85	• •
MB11	Broke on mb cylinder	78	• •
AD12	Afterdryer cylinder -broke wrap	74	• •
PR22	Press condition boxes blocked	73	• •
CA23	Calender coil control fault	73	• •
CA25	Calender coil not on auto	73	• •
WI17	Dandy setting	73	• •

28/06/1994
11:42:45

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 15

SUMMARY
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Type .. Ridge

Orientation .. Raised

Width .. Fullwidth

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..Öáááááôááááááôááááááôááááááôááááááç
• « • X • X • « • X •
ââF/EáêâF/CáêââCâââêâB/CáêâB/Eál

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (20 found). « or X

Code	Cause	Score	« or X
AD24	Afterdryer -broke on pv piprs	99	• •
MB09	MB cylinders -suface dirty	95	• •
HB12	Slice -poor adjustment	94	• •
RU08	Reel up tension too high	93	• •
AD10	Afterdryer cylinder surface dirty	91	• •
RU06	Reel up lead roll alignment	87	• •
CA23	Calender coil control fault	83	• •
CA25	Calender coil not on auto	83	• •
MB11	Broke on mb cylinder	78	• •
MB22	MB -broke on pv pipes	75	• •
AD12	Afterdryer cylinder -broke wrap	74	• •
PR22	Press condition boxes blocked	73	• •
PR10	Press doctors-incorrect setting	73	• •
WI17	Dandy setting	73	• •
SP25	Paper too wet into size	63	• •
AD01	Afterdryer felt -wrong type	61	• •
WI16	Table alignment	55	• •
PR12	Press felt-wrong type -compaction	51	• •
WI19	Bag box alignment	43	• •
WI18	Wire draw (wet)	39	• •

The above can be used as a checklist i.e. for «'s or X's

28/06/1994

DOVER LEVEL EXPERT - Session Printout 11:44:55
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks 16

SUMMARY
ëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. Don't Know

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááÔááááááÔááááááÔááááááÔáááááá Ç
• « • X • X • « • X •
âáF/EáâáF/CáâáâCáâáâB/CáâáB/Eá1

Accuray Aggreement

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (64 found). « or X

ÖáááScoreáÒááááá Ç

		Score	« or X
SM09	Smoothing press surface build up	109	• •
AD08	Afterdryer felt not cover paper	107	• •
HB13	Slice bent	104	• •
HB15	Slice damage	104	• •
CA07	Calender roll damage	103	• •
CA22	Calender coil pad fault	103	• •
SP07	Size press roll damage	101	• •
CA19	Calender draw tight	95	• •
CA13	Calender doctor not clean	92	• •
AD03	Afterdryer felt damaged	91	• •
SP16	Size jets blocked	91	• •
MB07	MB dryer felt not covering paper	87	• •
SP08	Size press roll build up	87	• •
AD31	Afterdryer doctor -broke on sheet	86	• •
AD29	Afterdryer load roll surface dirt	86	• •
MB09	MB cylinders -suface dirty	85	• •
HB12	Slice -poor adjustment	84	• •
RU08	Reel up tension too high	83	• •
SP20	Size press lead roll build up	82	• •
AD05	Afterdryer felt streak/crease	81	• •
AD10	Afterdryer cylinder surface dirty	81	• •
PR26	Press hp sprays not oscillating	81	• •
AD09	Afterdryer cyl. surface streak	81	• •
SP12	Size press doctor not clean	81	• •
SP17	Size jet position	81	• •
MB28	MB load rolls -surface build up	80	• •
MB30	MB doctors -broke touching sheet	80	• •
AD24	Afterdryer -broke on pv piprs	79	• •
MB02	MB dryer felts damaged	79	• •
SP22	Size press camber roll build up	78	• •

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The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout 28/06/1994 11:45:02
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The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:46:29

DOVER LEVEL EXPERT - Session Printout
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks 17

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCááêâB/CáêâB/Eál

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X

Code	Cause	Score		
SM09	Smoothing press surface build up	129	•	•
AD08	Afterdryer felt not cover paper	127	•	•
CA07	Calender roll damage	123	•	•
SP07	Size press roll damage	121	•	•
CA19	Calender draw tight	115	•	•
HB15	Slice damage	114	•	•
CA13	Calender doctor not clean	112	•	•
MB07	MB dryer felt not covering paper	107	•	•
AD29	Afterdryer load roll surface dirt	106	•	•
AD03	Afterdryer felt damaged	101	•	•
AD09	Afterdryer cyl. surface streak	101	•	•
MB28	MB load rolls -surface build up	100	•	•
SP08	Size press roll build up	97	•	•
AD31	Afterdryer doctor -broke on sheet	96	•	•
HB12	Slice -poor adjustment	94	•	•
AD16	Afterdryer cyl. -paper over edge	93	•	•
SP20	Size press lead roll build up	92	•	•
PR26	Press hp sprays not oscillating	91	•	•
AD05	Afterdryer felt streak/crease	91	•	•
SP12	Size press doctor not clean	91	•	•
MB30	MB doctors -broke touching sheet	90	•	•
MB02	MB dryer felts damaged	89	•	•
MB08	MB cylinders -surface streak	89	•	•
SP22	Size press camber roll build up	88	•	•
WI06	Wire fabric edges -ridge	87	•	•
MB17	Paper over mb cylinder edge	81	•	•
WI13	Wire sprays blocked	79	•	•
PR25	Press hp sprays blocked	78	•	•
MB04	MB dryer felts -streak/crease	77	•	•
WI10	Wire shake	75	•	•

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:46:58

DOVER LEVEL EXPERT - Session Printout

11:48:49

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 18

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Gradual over 1 day

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCáâêâB/CáêâB/Eâì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	129	• •
RU07	Reel up lead roll build up	123	• •
AD08	Afterdryer felt not cover paper	117	• •
CA07	Calender roll damage	113	• •
CA13	Calender doctor not clean	112	• •
AD09	Afterdryer cyl. surface streak	111	• •
SP07	Size press roll damage	111	• •
CA19	Calender draw tight	105	• •
HB12	Slice -poor adjustment	104	• •
HB15	Slice damage	104	• •
AD05	Afterdryer felt streak/crease	101	• •
MB08	MB cylinders -surface streak	99	• •
SP22	Size press camber roll build up	98	• •
MB07	MB dryer felt not covering paper	97	• •
AD29	Afterdryer load roll surface dirt	96	• •
AD03	Afterdryer felt damaged	91	• •
MB28	MB load rolls -surface build up	90	• •
WI12	Return coated rolls (wire part)	88	• •
MB04	MB dryer felts -streak/crease	87	• •
SP08	Size press roll build up	87	• •
WI06	Wire fabric edges -ridge	87	• •
AD16	Afterdryer cyl. -paper over edge	83	• •
SP20	Size press lead roll build up	82	• •
AD15	Afterdryer cylinder -leak	81	• •
PR26	Press hp sprays not oscillating	81	• •
SP12	Size press doctor not clean	81	• •
MB02	MB dryer felts damaged	79	• •
MB17	Paper over mb cylinder edge	71	• •

28/06/199·
11:50:20

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 19

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Very Gradual

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..Öááááá Ôááááá Ôááááá Ôááááá Ôááááá Ôááááá Ç
• « • X • X • « • X •
ââF/EáêâF/CáêááCááêâB/CáêâB/Eáî

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (18 found).

		Score	« or X
SM09	Smoothing press surface build up	119	
RU07	Reel up lead roll build up	113	
AD11	Afterdryer cly. surface groove	111	
SM02	Smoothing press roll worn	105	
WI14	Vacuum boxes worn	103	
CA13	Calender doctor not clean	102	
WI04	Wire fabric edges worn	101	
WI06	Wire fabric edges -ridge	97	
HB12	Slice -poor adjustment	94	
AD05	Afterdryer felt streak/crease	91	
MB10	MB cylinder -surface groove	87	
WI01	Wire fabric dirty	79	
WI12	Return coated rolls (wire part)	78	
MB04	MB dryer felts -streak/crease	77	
PR02	Press roll worn	71	
PR11	Press doctors worn	63	
SP24	Sizepress camber roll cover loose	60	
PR09	Press doctors-excess lub water	39	

28/06/1994
11:51:28

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 20

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. On and Off

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCââêâB/CáêâB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (7 found).

		Score	« or X
SM09	Smoothing press surface build up	119	
SP22	Size press camber roll build up	88	
WI12	Return coated rolls (wire part)	88	
SP08	Size press roll build up	87	
SP20	Size press lead roll build up	82	
SP24	Sizepress camber roll cover loose	60	
PR09	Press doctors-excess lub water	49	

28/06/1994
11:52:43

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 21

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Don't Know

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCââêâB/CáêâB/Eâì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (46 found).

		Score	« or X
SM09	Smoothing press surface build up	109	• •
AD08	Afterdryer felt not cover paper	107	• •
CA07	Calender roll damage	103	• •
RU07	Reel up lead roll build up	103	• •
SP07	Size press roll damage	101	• •
CA19	Calender draw tight	95	• •
HB15	Slice damage	94	• •
CA13	Calender doctor not clean	92	• •
AD09	Afterdryer cyl. surface streak	91	• •
AD11	Afterdryer cly. surface groove	91	• •
MB07	MB dryer felt not covering paper	87	• •
AD29	Afterdryer load roll surface dirt	86	• •
SM02	Smoothing press roll worn	85	• •

The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 22

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
âáF/EáêáF/CáêááCáááêáB/CáêáB/Eál

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	
AD08	Afterdryer felt not cover paper	127	
CA07	Calender roll damage	123	
SP07	Size press roll damage	121	
CA19	Calender draw tight	115	
HB15	Slice damage	114	
CA13	Calender doctor not clean	112	
MB07	MB dryer felt not covering paper	107	
AD29	Afterdryer load roll surface dirt	106	
AD03	Afterdryer felt damaged	101	
AD09	Afterdryer cyl. surface streak	101	
MB28	MB load rolls -surface build up	100	
SP08	Size press roll build up	97	
AD31	Afterdryer doctor -broke on sheet	96	
HB12	Slice -poor adjustment	94	
AD16	Afterdryer cyl. -paper over edge	93	
SP20	Size press lead roll build up	92	
PR26	Press hp sprays not oscillating	91	
AD05	Afterdryer felt streak/crease	91	
SP12	Size press doctor not clean	91	
MB30	MB doctors -broke touching sheet	90	
MB02	MB dryer felts damaged	89	
MB08	MB cylinders -surface streak	89	
SP22	Size press camber roll build up	88	
WI06	Wire fabric edges -ridge	87	
MB17	Paper over mb cylinder edge	81	
WI13	Wire sprays blocked	79	
PR25	Press hp sprays blocked	78	
MB04	MB dryer felts -streak/crease	77	
WI10	Wire shake	75	

The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:56:12

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 23

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Variable

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (11 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	
SP08	Size press roll build up	87	
SP20	Size press lead roll build up	82	
AD15	Afterdryer cylinder -leak	81	
SP12	Size press doctor not clean	81	
SP24	Sizepress camber roll cover loose	80	
SP22	Size press camber roll build up	78	
WI10	Wire shake	65	
MB13	Leak on mb cylinders	63	
PR28	Press lp sprays -too much water	61	
PR09	Press doctors-excess lub water	59	

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
11:57:09

DOVER LEVEL EXPERT - Session Printout

The above can be used as a checklist i.e. for ...

DOVER LEVEL EXPERT - Session Printout 28/06/1994 11:58:32

User : cohen

Session Information : test data general risks 24

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Don't Know

Machine Stretch .. None

Suspect areas .. Headbox

Where ..

```
• « • X • X • « • X •
áF/EáêáF/CáêááCááêáB/CáêáB/Eá
```

Accuray Aggreement

	Accuray	Aggreement
Substance	i	i
Moisture	i	i
Thickness	i	i
Pre-SP Mois	i	i
	none	exact

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	109	
AD08	Afterdryer felt not cover paper	107	
CA07	Calender roll damage	103	
SP07	Size press roll damage	101	
CA19	Calender draw tight	95	
HB15	Slice damage	94	
CA13	Calender doctor not clean	92	
MB07	MB dryer felt not covering paper	87	
AD29	Afterdryer load roll surface dirt	86	
AD03	Afterdryer felt damaged	81	
AD09	Afterdryer cyl. surface streak	81	
MB28	MB load rolls -surface build up	80	
SP08	Size press roll build up	77	
AD31	Afterdryer doctor -broke on sheet	76	
HB12	Slice -poor adjustment	74	
AD16	Afterdryer cyl. -paper over edge	73	
SP20	Size press lead roll build up	72	
PR26	Press hp sprays not oscillating	71	
AD05	Afterdryer felt streak/crease	71	
SP12	Size press doctor not clean	71	
MB30	MB doctors -broke touching sheet	70	
MB02	MB dryer felts damaged	69	
MB08	MB cylinders -surface streak	69	
SP22	Size press camber roll build up	68	
WI06	Wire fabric edges -ridge	67	
MB17	Paper over mb cylinder edge	61	
AD15	Afterdryer cylinder -leak	61	
SP24	Sizepress camber roll cover loose	60	
WI13	Wire sprays blocked	59	
PR25	Press hp sprays blocked	58	

The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout 28/06/1994 11:58:59

Session Information : test data general risks 25

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááÔááááááÔááááááÔááááááÔáááááá¢
• « • X • X • « • X •
ââF/EáâáF/CáêááCááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
HB15	Slice damage	114	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
SP08	Size press roll build up	97	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
HB12	Slice -poor adjustment	94	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
MB02	MB dryer felts damaged	89	• •
MB08	MB cylinders -surface streak	89	• •
SP22	Size press camber roll build up	88	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •

The above can be used as a checklist i.e. for «'s or X's

28/06/199·
12:01:57

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 26

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. Slight

Suspect areas .. Headbox

Where ..ÖáááááôááááááôááááááôááááááôááááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCáâêâB/CáêâB/Eâì

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X

Code	Cause	Score		
SM09	Smoothing press surface build up	121	•	•
AD08	Afterdryer felt not cover paper	119	•	•
CA19	Calender draw tight	119	•	•
CA07	Calender roll damage	115	•	•
SP07	Size press roll damage	113	•	•
AD29	Afterdryer load roll surface dirt	112	•	•
HB15	Slice damage	106	•	•
MB28	MB load rolls -surface build up	106	•	•
CA13	Calender doctor not clean	104	•	•
AD16	Afterdryer cyl. -paper over edge	103	•	•
AD31	Afterdryer doctor -broke on sheet	102	•	•
SP20	Size press lead roll build up	102	•	•
MB07	MB dryer felt not covering paper	99	•	•
SP22	Size press camber roll build up	98	•	•
MB30	MB doctors -broke touching sheet	96	•	•
AD09	Afterdryer cyl. surface streak	93	•	•
AD03	Afterdryer felt damaged	93	•	•
MB17	Paper over mb cylinder edge	89	•	•
SP08	Size press roll build up	89	•	•
HB12	Slice -poor adjustment	86	•	•
PR26	Press hp sprays not oscillating	83	•	•
SP12	Size press doctor not clean	83	•	•
AD05	Afterdryer felt streak/crease	83	•	•
MB08	MB cylinders -surface streak	81	•	•
MB02	MB dryer felts damaged	81	•	•
SP24	Sizepress camber roll cover loose	80	•	•
WI06	Wire fabric edges -ridge	79	•	•

28/06/1994
12:03:01

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 27

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. Moderate

Suspect areas .. Headbox

Where ..ÖáááááôáááááôáááááôáááááôáááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCáááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X

Öáá Scoreáôáááááá Ç

		Score	« or X	
CA19	Calender draw tight	123	•	•
AD29	Afterdryer load roll surface dirt	118	•	•
AD16	Afterdryer cyl. -paper over edge	113	•	•
SM09	Smoothing press surface build up	113	•	•
MB28	MB load rolls -surface build up	112	•	•
SP20	Size press lead roll build up	112	•	•
AD08	Afterdryer felt not cover paper	111	•	•
AD31	Afterdryer doctor -broke on sheet	108	•	•
SP22	Size press camber roll build up	108	•	•
CA07	Calender roll damage	107	•	•
SP07	Size press roll damage	105	•	•
MB30	MB doctors -broke touching sheet	102	•	•
HB15	Slice damage	98	•	•
MB17	Paper over mb cylinder edge	97	•	•
CA13	Calender doctor not clean	96	•	•
MB07	MB dryer felt not covering paper	91	•	•
SP24	Sizepress camber roll cover loose	90	•	•
AD09	Afterdryer cyl. surface streak	85	•	•
AD03	Afterdryer felt damaged	85	•	•
SP08	Size press roll build up	81	•	•
HB12	Slice -poor adjustment	78	•	•
PR26	Press hp sprays not oscillating	75	•	•
SP12	Size press doctor not clean	75	•	•
AD05	Afterdryer felt streak/crease	75	•	•
MB02	MB dryer felts damaged	73	•	•
MB08	MB cylinders -surface streak	73	•	•
WI06	Wire fabric edges -ridge	71	•	•
WI13	Wire sprays blocked	63	•	•
PR25	Press hp sprays blocked	62	•	•
MB04	MB dryer felts -streak/crease	61	•	•

ááêááááááì

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
12:08:59

DOVER LEVEL EXPERT - Session Printout
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks 28

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. Severe

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
âáF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (10 found). « or X

		Score	
CA19	Calender draw tight	127	
AD29	Afterdryer load roll surface dirt	124	
AD16	Afterdryer cyl. -paper over edge	123	
SP20	Size press lead roll build up	122	
MB28	MB load rolls -surface build up	118	
SP22	Size press camber roll build up	118	
AD31	Afterdryer doctor -broke on sheet	114	
MB30	MB doctors -broke touching sheet	108	
MB17	Paper over mb cylinder edge	105	
SP24	Sizepress camber roll cover loose	100	

The above can be used as a checklist i.e. for «'s or X's

28/06/1994

Session Information : test data general risks 29

SUMMARY
ëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááôáááááôáááááôáááááôáááááÇ
 • « • X • X • « • X •
 ââF/EáêâF/CáêââCáâêâB/CáêâB/Eâì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
HB15	Slice damage	114	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
SP08	Size press roll build up	97	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
HB12	Slice -poor adjustment	94	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
MB02	MB dryer felts damaged	89	• •
MB08	MB cylinders -surface streak	89	• •
SP22	Size press camber roll build up	88	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
12:14:54

DOVER LEVEL EXPERT - Session Printout
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

User : cohen

Session Information : test data general risks 30

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖáááááÔáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêââCááêâB/CáêâB/Eâî

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Wire Part

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
HB15	Slice damage	114	• •
CA13	Calender doctor not clean	112	• •
WI06	Wire fabric edges -ridge	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
WI13	Wire sprays blocked	104	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
WI10	Wire shake	100	• •
SP08	Size press roll build up	97	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
HB12	Slice -poor adjustment	94	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
MB02	MB dryer felts damaged	89	• •
MB08	MB cylinders -surface streak	89	• •

DOVER LEVEL EXPERT - Session Printout 12:16:15

User : cohen

Session Information : test data general risks 31

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox, Wire Part, 1st/2nd Press

Where .. « X X « X
F/E F/C C B/C B/E

	Accuray	Aggreement
Substance	i	i
Moisture	i	i
Thickness	i	i
Pre-SP Mois	i	i
	none	exact

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	129	
AD08	Afterdryer felt not cover paper	127	
CA07	Calender roll damage	123	
SP07	Size press roll damage	121	
PR26	Press hp sprays not oscillating	116	
CA19	Calender draw tight	115	
HB15	Slice damage	114	
CA13	Calender doctor not clean	112	
WI06	Wire fabric edges -ridge	112	
MB07	MB dryer felt not covering paper	107	
AD29	Afterdryer load roll surface dirt	106	
WI13	Wire sprays blocked	104	
PR25	Press hp sprays blocked	103	
AD03	Afterdryer felt damaged	101	
AD09	Afterdryer cyl. surface streak	101	
MB28	MB load rolls -surface build up	100	
WI10	Wire shake	100	
SP08	Size press roll build up	97	
AD31	Afterdryer doctor -broke on sheet	96	
HB12	Slice -poor adjustment	94	

28/06/1994
12:17:57

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 32

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Where .. « X X « X
F/E F/C C B/C B/E

	Accuray	Aggreement
Substance		
Moisture		
Thickness		
Pre-SP Mois		
	none	exact

Suspect areas .. Headbox, Wire Part, 1st/2nd Press, Suction Press Roll

Possible causes (36 found).

		Score	« or X	
SM09	Smoothing press surface build up	129	•	•
AD08	Afterdryer felt not cover paper	127	•	•
CA07	Calender roll damage	123	•	•
SP07	Size press roll damage	121	•	•
PR26	Press hp sprays not oscillating	116	•	•
CA19	Calender draw tight	115	•	•
HB15	Slice damage	114	•	•
CA13	Calender doctor not clean	112	•	•
WI06	Wire fabric edges -ridge	112	•	•
MB07	MB dryer felt not covering paper	107	•	•
AD29	Afterdryer load roll surface dirt	106	•	•
WI13	Wire sprays blocked	104	•	•
PR25	Press hp sprays blocked	103	•	•
AD03	Afterdryer felt damaged	101	•	•
AD09	Afterdryer cyl. surface streak	101	•	•
MB28	MB load rolls -surface build up	100	•	•
WI10	Wire shake	100	•	•
SP08	Size press roll build up	97	•	•
AD31	Afterdryer doctor -broke on sheet	96	•	•
HB12	Slice -poor adjustment	94	•	•
AD16	Afterdryer cyl. -paper over edge	93	•	•
SP20	Size press lead roll build up	92	•	•
SP12	Size press doctor not clean	91	•	•
AD05	Afterdryer felt streak/crease	91	•	•
MB30	MB doctors -broke touching sheet	90	•	•
MB02	MB dryer felts damaged	89	•	•
MB08	MB cylinders -surface streak	89	•	•
SP22	Size press camber roll build up	88	•	•
MB17	Paper over mb cylinder edge	81	•	•
MB04	MB dryer felts -streak/crease	77	•	•

The above can be used as a checklist i.e. for «'s or X's

The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout 28/06/1994 12:19:47
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User : cohen

Session Information : test data general risks 33

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Smoothing Press

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCáááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	154	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
SP08	Size press roll build up	97	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
SP20	Size press lead roll build up	92	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
SP12	Size press doctor not clean	91	• •
MB30	MB doctors -broke touching sheet	90	• •
HB15	Slice damage	89	• •
MB08	MB cylinders -surface streak	89	• •
MB02	MB dryer felts damaged	89	• •
SP22	Size press camber roll build up	88	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •
AD15	Afterdryer cylinder -leak	71	• •

The above can be used as a checklist i.e. for «'s or X's

DOVER LEVEL EXPERT - Session Printout 28/06/1994 12:20:38

28/06/199·
12:22:06

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 34

ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Main Bank Dryers

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X

		Score
MB07	MB dryer felt not covering paper	132
SM09	Smoothing press surface build up	129
AD08	Afterdryer felt not cover paper	127
MB28	MB load rolls -surface build up	125
CA07	Calender roll damage	123
SP07	Size press roll damage	121
CA19	Calender draw tight	115
MB30	MB doctors -broke touching sheet	115
MB02	MB dryer felts damaged	114
MB08	MB cylinders -surface streak	114
CA13	Calender doctor not clean	112
AD29	Afterdryer load roll surface dirt	106
MB17	Paper over mb cylinder edge	106
MB04	MB dryer felts -streak/crease	102
AD03	Afterdryer felt damaged	101
AD09	Afterdryer cyl. surface streak	101
SP08	Size press roll build up	97
AD31	Afterdryer doctor -broke on sheet	96
AD16	Afterdryer cyl. -paper over edge	93
SP20	Size press lead roll build up	92
PR26	Press hp sprays not oscillating	91
AD05	Afterdryer felt streak/crease	91
SP12	Size press doctor not clean	91
HB15	Slice damage	89
SP22	Size press camber roll build up	88
WI06	Wire fabric edges -ridge	87
WI13	Wire sprays blocked	79
PR25	Press hp sprays blocked	78
MB13	Leak on mb cylinders	78
WI10	Wire shake	75

The above can be used as a checklist i.e. for «'s or X's

28/06/1994
12:24:48

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 35

SUMMARY
ëëëëëëëë

Type .. Ridge

Where ..ÖááááâÔááááâÔááááâÔááááâÔááááâÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Suspect areas .. Size Press

Possible causes (36 found).

		Score	« or X
SP07	Size press roll damage	146	• •
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP08	Size press roll build up	122	• •
SP20	Size press lead roll build up	117	• •
SP12	Size press doctor not clean	116	• •
CA19	Calender draw tight	115	• •
SP22	Size press camber roll build up	113	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
AD31	Afterdryer doctor -broke on sheet	96	• •
SP24	Sizepress camber roll cover loose	95	• •
AD16	Afterdryer cyl. -paper over edge	93	• •
PR26	Press hp sprays not oscillating	91	• •
AD05	Afterdryer felt streak/crease	91	• •
MB30	MB doctors -broke touching sheet	90	• •
HB15	Slice damage	89	• •
MB02	MB dryer felts damaged	89	• •
MB08	MB cylinders -surface streak	89	• •
WI06	Wire fabric edges -ridge	87	• •
MB17	Paper over mb cylinder edge	81	• •
WI13	Wire sprays blocked	79	• •
PR25	Press hp sprays blocked	78	• •
MB04	MB dryer felts -streak/crease	77	• •
WI10	Wire shake	75	• •

The above can be used as a checklist i.e. for «'s or X's

28/06/199
12:26:22

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 36

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. After Dryers

Where ..Öááááááôááááááôááááááôááááááôááááá¢
• « • X • X • « • X •
ââF/EáêâF/CáêââCááêâB/CáêâB/Eá1

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found). « or X
ÖááScoreáôáááááá¢

		Score		
AD08	Afterdryer felt not cover paper	152	•	•
AD29	Afterdryer load roll surface dirt	131	•	•
SM09	Smoothing press surface build up	129	•	•
AD09	Afterdryer cyl. surface streak	126	•	•
AD03	Afterdryer felt damaged	126	•	•
CA07	Calender roll damage	123	•	•
AD31	Afterdryer doctor -broke on sheet	121	•	•
SP07	Size press roll damage	121	•	•
AD16	Afterdryer cyl. -paper over edge	118	•	•
AD05	Afterdryer felt streak/crease	116	•	•
CA19	Calender draw tight	115	•	•
CA13	Calender doctor not clean	112	•	•
MB07	MB dryer felt not covering paper	107	•	•
MB28	MB load rolls -surface build up	100	•	•
SP08	Size press roll build up	97	•	•
AD15	Afterdryer cylinder -leak	96	•	•
SP20	Size press lead roll build up	92	•	•
PR26	Press hp sprays not oscillating	91	•	•
SP12	Size press doctor not clean	91	•	•
MB30	MB doctors -broke touching sheet	90	•	•
MB02	MB dryer felts damaged	89	•	•
HB15	Slice damage	89	•	•
MB08	MB cylinders -surface streak	89	•	•
SP22	Size press camber roll build up	88	•	•
WI06	Wire fabric edges -ridge	87	•	•
MB17	Paper over mb cylinder edge	81	•	•
WI13	Wire sprays blocked	79	•	•

28/06/199
12:27:35

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 37

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. After Dryers

Where ..ÕáááááÔáááááÔáááááÔáááááÔáááááÇ
• « • X • X • « • X •
ââF/EáâáF/CáâááCáááâB/CáâáB/Eál

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X	
AD08	Afterdryer felt not cover paper	152	•	•
AD29	Afterdryer load roll surface dirt	131	•	•
SM09	Smoothing press surface build up	129	•	•
AD09	Afterdryer cyl. surface streak	126	•	•
AD03	Afterdryer felt damaged	126	•	•
CA07	Calender roll damage	123	•	•
AD31	Afterdryer doctor -broke on sheet	121	•	•
SP07	Size press roll damage	121	•	•
AD16	Afterdryer cyl. -paper over edge	118	•	•
AD05	Afterdryer felt streak/crease	116	•	•
CA19	Calender draw tight	115	•	•
CA13	Calender doctor not clean	112	•	•
MB07	MB dryer felt not covering paper	107	•	•
MB28	MB load rolls -surface build up	100	•	•
SP08	Size press roll build up	97	•	•
AD15	Afterdryer cylinder -leak	96	•	•
SP20	Size press lead roll build up	92	•	•
PR26	Press hp sprays not oscillating	91	•	•
SP12	Size press doctor not clean	91	•	•
MB30	MB doctors -broke touching sheet	90	•	•
MB02	MB dryer felts damaged	89	•	•
HB15	Slice damage	89	•	•

28/06/199-
12:28:52

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 38

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Calender

Where ..ÖááááááÔááááááÔááááááÔááááááÔááááááÇ
• « • X • X • « • X •
ââF/EáêâF/CáêááCááêâB/CáêâB/Eáì

Accuray Aggreement

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X	
CA07	Calender roll damage	148	•	•
CA19	Calender draw tight	140	•	•
CA13	Calender doctor not clean	137	•	•
SM09	Smoothing press surface build up	129	•	•
AD08	Afterdryer felt not cover paper	127	•	•
SP07	Size press roll damage	121	•	•
MB07	MB dryer felt not covering paper	107	•	•
AD29	Afterdryer load roll surface dirt	106	•	•
AD03	Afterdryer felt damaged	101	•	•
AD09	Afterdryer cyl. surface streak	101	•	•
MB28	MB load rolls -surface build up	100	•	•
SP08	Size press roll build up	97	•	•
AD31	Afterdryer doctor -broke on sheet	96	•	•
AD16	Afterdryer cyl. -paper over edge	93	•	•
SP20	Size press lead roll build up	92	•	•
AD05	Afterdryer felt streak/crease	91	•	•
PR26	Press hp sprays not oscillating	91	•	•

28/06/1994
12:30:00

DOVER LEVEL EXPERT - Session Printout
ëë

User : cohen

Session Information : test data general risks 40

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Reel Up

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
• « • X • X • « • X •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eá1

Accuray Aggreement

Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

Code	Cause	Score	« or X
SM09	Smoothing press surface build up	129	• •
AD08	Afterdryer felt not cover paper	127	• •
CA07	Calender roll damage	123	• •
SP07	Size press roll damage	121	• •
CA19	Calender draw tight	115	• •
CA13	Calender doctor not clean	112	• •
MB07	MB dryer felt not covering paper	107	• •
AD29	Afterdryer load roll surface dirt	106	• •
AD03	Afterdryer felt damaged	101	• •
AD09	Afterdryer cyl. surface streak	101	• •
MB28	MB load rolls -surface build up	100	• •
SP08	Size press roll build up	97	• •

Session Information : test data general risks 41

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SUMMARY
ëëëëëëëëë
Type .. Ridge                    Where  ..ÖáááááÔááááááÔááááááÔááááááÔááááááÔáááááÇ
                                          •  «  •  «  •  «  •  «  •  «  •
Orientation .. Raised                    âáF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Width .. 5-50 mm                                   Accuray Aggreement

Onset .. Sudden                   Substance   ïôôôôôôôôôôôô            ï
                                  Moisture    ïôôôôôôôôô               ï
Stability .. Steady               Thickness   ïôôôôôôôôôôôôôôô         ï
                                  Pre-SP Mois ïôôôôôôôôôôôôôô          ï
Machine Stretch .. None                       none                 exact

Suspect areas .. Headbox

Possible causes ( 6 found).                               « or X
ÖááááááááááááááááááááááááááááááááááááááááááááááScoreáÔáááááÇ
• HB15    Slice damage                              202 •      •
• HB12    Slice -poor adjustment                    181 •      •
• WI13    Wire sprays blocked                       167 •      •
• WI10    Wire shake                                145 •      •
• WI06    Wire fabric edges -ridge                  125 •      •
• WI09    Deckle wedges                             101 •      •
âáááááááááááááááááááááááááááááááááááááááááááááááááááááêáááááì
```

The above can be used as a checklist i.e. for «'s or X's

28/06/199·
12:47:18

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 42

SUMMARY
ëëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
• « • « • « • « • « •
ááF/EáêáF/CáêááCááêáB/CáêáB/Eáì

Accuray Aggreement

Substance ï ï
Moisture ïôôôôôôôôô ï
Thickness ïôôôôôôôôôôôôôôô ï
Pre-SP Mois ïôôôôôôôôôôôôôô ï
none exact

Possible causes (16 found). « or X
ÖááScoreáôááááááÇ

HB15	Slice damage	174	
PR26	Press hp sprays not oscillating	163	
HB12	Slice -poor adjustment	154	
PR25	Press hp sprays blocked	149	
MB07	MB dryer felt not covering paper	143	
MB08	MB cylinders -surface streak	143	
MB02	MB dryer felts damaged	143	
WI13	Wire sprays blocked	139	
MB04	MB dryer felts -streak/crease	137	
PR28	Press lp sprays -too much water	123	
WI10	Wire shake	117	
MB17	Paper over mb cylinder edge	117	
MB13	Leak on mb cylinders	101	
WI06	Wire fabric edges -ridge	98	
PR09	Press doctors-excess lub water	95	
WI09	Deckle wedges	73	

28/06/1994
12:48:23

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 43

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..
F/E F/C C B/C B/E

	Accuray	Aggreement
Substance		
Moisture		
Thickness		
Pre-SP Mois		
	none	exact

Possible causes (16 found).

		Score	« or X
HB15	Slice damage	166	
HB12	Slice -poor adjustment	146	
PR26	Press hp sprays not oscillating	143	
PR25	Press hp sprays blocked	136	
WI13	Wire sprays blocked	131	
MB08	MB cylinders -surface streak	123	
MB02	MB dryer felts damaged	123	
MB07	MB dryer felt not covering paper	123	
MB04	MB dryer felts -streak/crease	117	
WI10	Wire shake	109	
PR28	Press lp sprays -too much water	103	
WI06	Wire fabric edges -ridge	102	
MB17	Paper over mb cylinder edge	97	
PR09	Press doctors-excess lub water	83	
MB13	Leak on mb cylinders	81	
WI09	Deckle wedges	65	

28/06/1994
12:49:22

DOVER LEVEL EXPERT - Session Printout

User : cohen

Session Information : test data general risks 44

SUMMARY

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..F/E F/C C B/C B/E

Accuray Aggreement

Substance
Moisture
Thickness
Pre-SP Mois

none exact

Possible causes (18 found).

Code	Cause	Score	« or X
HB15	Slice damage	153	
HB12	Slice -poor adjustment	133	
PR26	Press hp sprays not oscillating	130	
WI13	Wire sprays blocked	118	
PR25	Press hp sprays blocked	117	
MB08	MB cylinders -surface streak	110	
MB07	MB dryer felt not covering paper	110	
MB02	MB dryer felts damaged	110	
WI06	Wire fabric edges -ridge	108	
MB04	MB dryer felts -streak/crease	104	
MB28	MB load rolls -surface build up	103	
WI10	Wire shake	96	
MB30	MB doctors -broke touching sheet	93	
PR28	Press lp sprays -too much water	90	
MB17	Paper over mb cylinder edge	84	
PR09	Press doctors-excess lub water	70	

28/06/1994
12:50:42

DOVER LEVEL EXPERT - Session Printout
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User : cohen

Session Information : test data general risks 45

SUMMARY
ëëëëëëëë

Type .. Ridge

Orientation .. Raised

Width .. 5-50 mm

Onset .. Sudden

Stability .. Steady

Machine Stretch .. None

Suspect areas .. Headbox

Where ..ÖááááááôááááááôááááááôááááááôááááááÇ
âáF/EáêáF/CáêááCááêáB/CáêáB/Eáì

	Accuray	Aggreement
Substance	ï	ï
Moisture	ï	ï
Thickness	ï	ï
Pre-SP Mois	ï	ï
	none	exact

Possible causes (36 found).

		Score	« or X
SM09	Smoothing press surface build up	156	• •
HB15	Slice damage	141	• •
CA07	Calender roll damage	132	• •
SP07	Size press roll damage	130	• •
CA19	Calender draw tight	124	• •
CA13	Calender doctor not clean	121	• •
HB12	Slice -poor adjustment	121	• •
PR26	Press hp sprays not oscillating	118	• •
AD29	Afterdryer load roll surface dirt	115	• •
WI06	Wire fabric edges -ridge	114	• •
AD08	Afterdryer felt not cover paper	112	• •

APPENDIX I:

ANALYSIS OF TEST DATA RESULTS

	Possible Causes	No of Tests	Appearance in Top 10	Percentage
1)	SM09	47	42	0.89
2)	AD08	47	25	0.53
3)	CA07	47	29	0.62
4)	SP07	47	27	0.57
5)	CA19	47	27	0.57
6)	HB15	47	28	0.60
7)	CA13	47	27	0.57
8)	MB07	47	17	0.36
9)	AD29	47	20	0.43
10)	AD03	47	15	0.32

Notes: * The ten top possible causes were taken from the first test before the factors were changed.

** The score of the possible causes and their order is not analysed. According to the developer of the "Level Expert", it is likely that the true possible causes appeared in the top ten.