The implementation of knowledge based systems into organizations

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The Implementation of Knowledge Based Systems into Organizations

by

P M Wadsworth

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the award of

Doctor of Philosophy
of the Loughborough University of Technology

(January 1991)

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ABSTRACT

A knowledge based system in applied physiology was developed over a period of four years for the Ministry of Defence. It was intended for use by the Applied Physiology (AP) Division of the Army Personnel Research Establishment (APRE), Farnborough, Hampshire. The system was named MAPS (Modular Applied Physiology System).

The aim was both to develop MAPS, and to produce guidelines on the implementation of knowledge based systems into organizations, based on the experiences gained during the project. The main body of the document is therefore a case study, providing details of the decisions made at each stage of development.

MAPS was developed on-site, using existing computer hardware and software. The design plan adopted was an initial early demonstration system, followed by an iterative process of prototype development. Particular attention was paid to the collection of user feedback, and user participation from the outset of the project. There were three systems during the development cycle, the demonstration system (MAPS1), and two full prototypes (MAPS2 and 3). The user interface evolved gradually over the three versions, the criteria being to develop an interface suitable for infrequent, and computer naive, users.

MAPS was evaluated before the introduction of each subsequent version. A selection of example enquiries was required to be answered using MAPS. The evaluations of MAPS1 and MAPS2 were intended to serve a dual purpose, performing the additional role of a tutorial. A questionnaire containing 7 point adjective scales and open ended questions was used to collect subjective views from the users.

The results are tabulated, and presented graphically. Their implications for systems design are discussed. Potential pitfalls during development were identified, in particular: assessing the level of computer knowledge possessed by the users; keeping users up to date on a constantly expanding knowledge base; and aids to navigation through the tree structure of such knowledge.

The thesis concludes by proposing a range of ten broad guidelines aimed at helping future software developers, when faced with a similar task. They are intended for a wide audience, and are appropriately general, and largely non-technical.
STATEMENT

Sections of the research presented in this thesis were conducted for the Army Personnel Research Establishment (agreement 2170/109) and have been published by Loughborough University of Technology as a series of reports. These sections are incorporated here with the permission of the Ministry of Defence. The author was responsible for the planning and execution of all the research presented in this thesis, with the exception of the following. Some of the individual knowledge units referred to in the knowledge trees in chapter 6 were coded into FORTRAN under the close supervision of the author. Similarly, the standard knowledge program interface, described in section 8.8, was coded into FORTRAN under the direction of the author. The 'spell-checker', 'on-screen calculator', and 'label printer', referred to in section 7.3.2.7. were produced for MAPS by Dr R A Haslam of Loughborough University.
ACKNOWLEDGEMENTS

I would like to thank the Department of Human Sciences, Loughborough University of Technology and the Army Personnel Research Establishment (APRE) for enabling this research to be undertaken. In addition, my appreciation goes to Dr K C Parsons as my supervisor, Dr M F Haisman as a keen supporter at APRE, and both as colleagues and friends. The MAPS knowledge based system could never have been completed without the close cooperation and interest shown by the staff of the Applied Physiology Division of APRE. Thanks also go to Caroline Kerr, for checking this document in order to ensure the correct use of the English language. The key to the completion of this research and thesis lies with my wife Karen, who stood alongside me when I most needed encouragement.
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The Implementation of Knowledge Based Systems into Organizations
CHAPTER 1
1.0. INTRODUCTION

1.1 Project Background

The Army Personnel Research Establishment (APRE) is the Human Factors Institute for the British Army. The Applied Physiology (AP) division of the APRE is concerned with the physiological limitations of the soldier and his interaction with the environment, his/her equipment, protective clothing, and his/her performance.

To fulfil this role they are often asked to answer enquiries from other Ministry of Defence (MoD) establishments, or external organizations. At the commencement of this project, this was fulfilled by accessing a large body of information held within APRE, relating to past work or recognised guidelines.

It had for some time been identified by management within the applied physiology division that the method of accessing and processing the large array of knowledge held was both labour intensive and wasteful of experts time. Having become aware of the growing area of Expert Systems technology, they felt that this type of software may help improve their situation.

Consequently, an agreement was formulated between the APRE and The Human Sciences Department of Loughborough University to both explore the possibility and create a
working expert/knowledge based system to help improve the handling of day to day enquiries. Additionally, this was recognised by the Human Sciences Department as an opportunity to study the entire process relating to the implementation of knowledge based systems into organizations. This would be achieved through the experiences gained in fulfilling the implementation of a practical 'real life' system, with its associated constraints and requirements.

1.2. Technical Background

Knowledge based, or expert, systems are computer programs embodying expert knowledge in a particular field, together with a method of applying that knowledge to help solve problems. They may either be used to distribute knowledge to individuals not familiar with the field, or to help experts themselves to apply their knowledge more efficiently.

With any new technology, it takes several years for a structured approach to the implementation of such advances into practical situations to be developed. The delay in the appearance of a logical methodology may be due to the rapid development in the technology itself. The pace may be such that the temptation is to concentrate on technical issues in order to stay in touch with the competition.

Given that knowledge based, or expert, systems have only
been in existence in any significant numbers for around ten years (since 1980), it is perhaps not surprising that all aspects of the introduction of such systems have not been adequately covered. Technical design has featured strongly, with rapid development bringing knowledge based system (KBS) technology to more people.

1.3. Project Aims

There were two distinct aims for this project and the resulting thesis, as follows:-

Part 1

The design, development, and implementation of a knowledge based system for use by The Army Personnel Research Establishment (APRE) in Farnborough Hampshire. The system was to be called MAPS (Modular Applied Physiology System), and designed to help experts in the field of applied physiology to use their knowledge, and the knowledge stored in MAPS, to answer day to day enquiries.

Part 2

To produce guidelines on the implementation of knowledge based systems into organizations.

The intention was to contribute towards an increased awareness about the issues appertaining to the
introduction of KBS systems into an organization, the strongest emphasis being on methods of including the end users in the design process.

It was hoped that the reader would be given an insight into the problems associated with matching the functional and organizational requirements of an expert in a particular field with a tool to aid in applying their expertise to answer enquiries. If this goal is achieved, then the resulting guidelines may be applied in full, in part, or simply be considered, in similar projects in the future.

1.4. Stages of the Design Methodology

The aim of this section is to outline the design process adopted for the development and implementation of MAPS into the APRE (AP) division organization. The chapters that follow later expand on each phase of the design methodology described here. The intention is to illustrate the planning involved at the outset of the project. The methods chosen reflect the findings during a review of methods and projects already completed or in progress, presented in chapter 2.

What follows is a list of the design stages finally adopted for the MAPS project. The reasons for this structure will be discussed under the appropriate headings.
(1) Survey of existing research and applications
(2) Study of the APRE existing enquiry handling system
(3) Definition of the role to be played by MAPS
(4) Early demonstration system, (MAPS1)
(5) Evaluation of the demonstration system
(6) Strategy for the knowledge base development
(7) The first prototype, (MAPS2)
(8) Evaluation of the first prototype
(9) The second prototype, (MAPS3)
(10) Final evaluation

The structure, although appearing linear when itemised as above, was essentially an iterative prototype process, suggested to be suitable for knowledge based system development by several authors, as discussed in chapter 2. It must be emphasised that throughout the project, the option to change any of the stages remained open, the important factor being that, should the second prototype have proved to be still unsuitable for the application, the process of evaluation and prototyping could have continued to another level. It was simply useful to manage the time and funding available by anticipating the approximate stages of development, and when these could be expected to be delivered. The extent of user involvement should become apparent to the reader during the chapters that follow (chapters 3 - 9). This was greatly facilitated by the majority of the development work taking place 'on-site' at APRE.
1.4.1. Survey of Existing Research and Applications

As part of the MAPS project, approximately two months were spent gathering literature, company leaflets, and meeting individuals currently working in the area. The results of this can be seen in chapter 2.

The aim of this stage was to identify an appropriate methodology, hence ensuring that time and money was not wasted developing components which already existed off the shelf, or pursuing research directions that had already been found to be inappropriate.

1.4.2. Study of the APRE Existing Enquiry Handling System

Before any new software could be planned and developed, it was vital to find the appropriate slot within the existing system. This included examining the flow of information, documenting the existing software and hardware, and noting the performance of each component. Points highlighted were those where either resources existed but were being under used, or where there was a need for new facilities. This study is described in chapter 3.

1.4.3. Definition of the role to be played by MAPS

As a result of the study presented in chapter 3, a plan could be drawn up identifying areas in which the MAPS knowledge based system could help. These included improvements in information flow, new facilities where
required, and improved interfaces to existing software. This stage of the project also involved a careful assessment of the user population profile, the expected frequency of use, and the types of enquiries. This work is discussed in chapter 4.

1.4.4. Early demonstration system (MAPS1)

In order to initialize a form of early user feedback, before any major commitment had been made as to software tools and interface design, a short demonstration system was produced (MAPS1) (Wadsworth and Parsons 1988). To collect data on usage, an automatic report mechanism was written into the software, so that all session lengths, names of users and keystrokes, were recorded. The interface was simple, and knowledge was included on the basis of it being useful to one or two key members of staff. MAPS1 is described in chapter 5.

1.4.5. Evaluation of the Demonstration System

MAPS1 was evaluated using a series of exercises. Twenty users/potential users were asked to answer the exercises using the system. The tasks were graded so that the first one gave all the keystrokes required to answer the enquiry, and the last one only stated the problem. In this way, the evaluation also acted as a tutorial for those who were not yet familiar with MAPS1. The evaluation is described in chapter 5 section 4.
1.4.6. Strategy for the Knowledge Base Development

As detailed earlier (section 1.4.4), the knowledge base for MAPS1 had only a limited structure, and individual knowledge units were included depending on their need by a particular user, and on the ease by which they could be computerised.

Throughout the project, knowledge elicitation did not follow any one recognised method, instead a combination was used, and this is detailed in chapter 6 section 4.

A structured method of producing individual knowledge units was developed for use in MAPS2 and then further refined, with an improved standard user interface, for the final prototype MAPS3. The final user interface is described in chapter 8 section 8.

1.4.7. The first prototype, (MAPS2)

The introduction of MAPS2 involved a reappraisal of the methods used for MAPS1, and an examination of the results of the evaluation. Improvements were made in areas such as interface design, links with existing software, and expansion of the knowledge base. MAPS2 is described in more detail in chapter 7.

1.4.8. Evaluation of the First Prototype

The evaluation of MAPS2 is described in chapter 7 section
4. The method used was a slight refinement over the method for MAPS1, in the light of experience in conducting the evaluation, and from comments made by the subjects.

1.4.9. The Second Prototype, (MAPS3)

It was envisaged that MAPS3 (Wadsworth and Parsons 1989) would be the final system, together with modifications that may be required after the evaluation. MAPS3 was to include a close look at the design of the individual knowledge programs, in particular the user interface. This was developed after examination of the previous two evaluations (see Wadsworth et al 1990). A description of both MAPS3 and the knowledge program interface can be found in chapter 8.

1.4.10. Final Evaluation

The final evaluation was a logical progression from the design of the MAPS1 and 2 evaluations. The aim was to be more objective, so the sessions were conducted by an independent observer. However, in the light of the scale results obtained earlier, it was decided that a comparison between all three evaluations, together with a reevaluation of MAPS1 at the time of the final evaluation, would highlight changes in the expectations of the user population. A description of the final evaluation can be found in chapter 9, together with an analysis of the usage of the MAPS systems over the full duration of the project.
1.5. Chapter Summary

The MAPS project followed the procedure described in this chapter. The structure was determined after the initial survey of existing theory and applications described in chapter 2. Small aspects of the methodology were changed in the light of events throughout the project. The intention was not to follow a rigid structure regardless of extenuating circumstances, but to fine tune the methodology at each stage.

The emphasis from the outset was on adopting a strongly user-centred design methodology, with careful consideration of the organizational and job design needs of both APRE and the experts. MAPS was developed through a demonstration system and two prototypes, with careful examination of the design ideas at each stage through comprehensive user feedback.

The success or otherwise of this approach will be analysed in the discussion in chapter 10, and presented as ten broad guidelines in chapter 11. Chapter 12 will outline further work required in this area.

The first stage in the design process is described in the following chapter, with a detailed look at the history and current 'state of the art' in the associated subject area.
2.0 EXISTING THEORY AND APPLICATIONS

2.1. Introduction

Before any development work could start on a new knowledge based system, it was essential to study the progress that had been made in the preceding years, in order to utilize the experiences of others. The following sections review firstly progress made in the general area of computer software, and secondly in the area of knowledge based systems. It was intended that this would also give the reader the required foundation to judge the progress made, and the value of the resulting recommendations, during the current project described in chapters 3 through to 12.

2.2. The Technical Story

The use of electronic computers spread fairly rapidly during the 1950’s, but progress during the 1970’s and 80’s was phenomenal. One of the major landmarks in the development of computers was the introduction of the transistor and microchip to replace valves. As a consequence, computers became progressively smaller, more powerful, and cheaper.

As methods of storing and retrieving large volumes of textual and numeric data became available, along with the ability to manipulate such data, a new term emerged:

'Information Technology'
The reduction in purchase price of mini and micro computers has brought them within the reach of many more businesses and organizations. Facilities now widely available include Word processors, Statistical packages, graphical packages, data bases, spread sheets, drawing packages, and a range of high level programming languages.

2.3. The Organizational Story

If we now look at the implementation of new computer technology into organizations, and the effects from the development of information technology, we find a gap between the progress of the technical, and the organizational, system. This problem is identified and discussed by Eason (1988). In too many cases, new technology is either being misused or under used.

The temptation to invest in computer technology, purely to keep pace with rival organizations, is often strong enough to ignore the existing system whether or not the new technology is in fact an improvement over the old.

2.4. The Role of Information Systems

At the heart of most organizations is 'data'. Eason (1988) identifies data, or more generally information, as the basis for many human endeavours. Examples given include international stock dealing, which prior to information technology was only at a national level.
Capron (1986) talks about the commonly used media phrase, "explosion of data". This suggests that more data exists than a particular organization can handle. In this context, the role of a 'computer' system is to store, process and retrieve data in a useful form.

The overall organizational information system, of which the computer system is a subset, takes in input, and produces output required to fulfil the purpose of the organization in question.

It is vital to recognise the information system as covering the whole organization, including its personnel as well as its technical facilities.

2.5. The Development of Design Strategies

If we now look at the development of design strategies, from the first introduction of computer technology into the organization to present day thinking, patterns emerge in the main focus of the design.

2.5.1. Technical Design Methods

The major hurdle for system developers in the early years of computer technology was to overcome technical problems in making programs and hardware work. As a result, many systems were designed with the computer at the centre, and taking top priority. Systems were judged on the accuracy
and speed of their computer programs, rather than on their ease of use. Virtually all the development work took place away from the client’s premises, with installation of the final system at the end of the project. The result of this approach, which does not consider the human as part of the system, was a large percentage of ‘off target’ systems. The only client contact was to confirm costs and delivery dates. No consideration was given to the organization.

2.5.2. Structured Design Methods

As designers became more aware of the need to include the users in the design process, structured design methods emerged. These are particularly popular for large scale systems. An example is SSADM (Structured Systems Analysis and Design Methodology) (see Downs et al 1988). The basic concept behind this type of method is to consider the users of the system as the customer. At each stage of the process, meetings take place with the ‘customer’. The stages adopted include the analysis of the present system, and the specification of the new system. The customer has the power to dictate changes in specification.

Structured design methods are a relatively new approach, and there is very little evidence to suggest whether or not they produce a system tailored to the user. Several possible pitfalls with the methods have been identified, these were documented by Eason (1988).
The users, or the 'customers', are asked to review proposals by computer system experts. The aforementioned proposals are generally technically based, which can leave the customer unable to comprehend what is being presented. User representatives are often expected to outline user requirements, they will need to supply a detailed account of how they carry out their tasks. It is often difficult for individuals who perform a task to describe their actions objectively.

More importantly, Eason (1988) suggests that although it had been hoped that such structured methods would lead to good organizational design, and procedures for change, this has not been the case. As the discussions taking place with the users are with technical experts, the conversation has a tendency to centre on technical design considerations. Eason goes on to point out that the documentation attached to these methods does not cover job design and organizational change. It is therefore largely a method of producing a technical system.

2.5.3. Participative Design Methods

These are methods which hope to tackle the problem of the organization, as well as the technical systems. These aim to give the user the strongest role in the design process. Their goal is to match together the social needs and the technical needs. One example is the ETHICS method (Mumford and Weir 1979). Eason (1988) identifies two major problems
with methods in this category. Firstly, the methods are complex and difficult for users unfamiliar with design processes to master and contribute to. Secondly, it seems difficult to integrate the methods fully with existing technical design procedures. There seems to be few points in the process where the technical and social designs come together.

2.5.4. Do it Yourself Design Methods

With easy availability of low cost micro computers, and a wide range of commercial software, some users may be tempted to design their own system without expert help. In some cases this may be appropriate, and this will be discussed in later sections. However, in most cases, the user population may be missing out on the experience gained by experts in past projects. It will also be shown later, by reference to the particular case discussed in this thesis, that shortcomings may be found in off the shelf software that only become apparent at a late stage in the development cycle.

2.5.5. Socio-Technical Design Methods

The common factor in all the methods so far described is that they fall down in their considerations of the user and/or the organization. A new term emerging is that of 'Socio-Technical design'. This is described by Eason (1988). The philosophy is to consider the broader implications of
the introduction of new technology. For a new system to be a success, the users need to feel that the tools supplied are worth using, and will enhance their working environment. The system needs to fulfil the aims of the organization, but not at the expense of good job design for the user.

2.5.6. Summary of Current Design Methods

In summary, there is a need for good user-centred design. Put in simple terms, the users need to be involved in the design process from the outset. It will be shown in later chapters, and discussions, that this can be achieved with the use of a series of prototypes, with user consultation at each stage. There is no shortage of methods for technical design, and these have reached a complex level, but there have been only a few attempts at producing an easy to apply, user-centred design methodology.

To illustrate the extent of the problem: in a recent book entitled ‘Reliability in Computer System Design’ (Dhillon 1987), the users of such systems are barely mentioned as a component influencing reliability. Reliability is only recognised as a technical issue, it states that user requirements should be declared in a document known as a ‘requirements specification’. Dhillon goes on to state:-

"Erroneous requirements are the cause of 15% of the errors in software systems. The design phase is
probably the most crucial phase of the software life cycle, being concerned with translating the problem and its associated specifications into solution blueprints."

There is no mention of user involvement during the design phase. He references a typical software life cycle as having six 'distinct' phases, as follows:-

i. requirement definition
ii. preliminary design
iii. detail design
iv. coding
v. integration and testing
vi. maintenance

Later on Dhillon (1987) says:-

"Maintenance is the last phase of the software life cycle. This is concerned with rectifying errors, making modifications required by the user, etc."

This is the first and last significant mention of the user. Making modifications required by the user at the maintenance stage of a project could work out very costly in both time and money.

Although it could be argued that the author in question only aimed to tackle the technical issues in software reliability, the example is not unique amongst computer reference books.
2.6. Usability and Evaluation

2.6.1. What is Usability?

Many attempts have been made to formalise evaluation or define usability. As a starting point, Shackel (1986) defines usability as:-

"The capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfil the specified range of tasks, within the specified range of environmental scenarios."

Shackel continues to identify weaknesses in using definitions similar to the one above, in that they are generalised in form, and do not specify usability in a quantifiable or measurable form. Shackel (1986) proposes an "operationalised definition of usability" based on four operational criteria: effectiveness, learnability, flexibility, and attitude. He suggests goals can be set for these four criteria.

Chapanis (1981) identifies three components contributing to ease of use: the software, the user, and the task. Chapanis also identifies a distinct lack of good evaluations published in the literature.

2.6.2. Evaluation of Usability

Shackel (1986) gives three types of measurement for the
evaluation of usability: dimensional criteria (eg. physical, anthropometric), performance, and attitude. It is clear that dimensions other than simple performance or objective measures are important in the assessment of usability. In particular Shackel (1986) states that in the case of usability, attitude measures are probably of greatest importance because it is the human user who must express the judgement of this characteristic. Performance measures alone do not measure usability, because although the user may be able to perform a given task, he/she may find the software difficult to use, and may choose to use a slower but more convenient package instead.

Chapanis (1981) suggests that it is important to look at the reason for the evaluation of a particular item of software. If the purpose is improvement of existing software "you do not need to conduct an elaborate, carefully controlled experiment with rigorous statistical analysis of data. Much simpler methodologies will work quite well". He names direct observations of subjects using the software and questionnaires as two appropriate methods.

2.6.3. Automated Software Monitoring Systems

In general, the less a method of evaluation interferes with the normal working environment and decision making of an individual, the better the quality of the results.
Eason (1984) points out that a major measure of usability is whether a system is used, therefore if an evaluation forces a person to use the system and then measures performance, the results will be affected. The problem in measuring usability is therefore to formulate a method which does not remove the freedom of the user to exercise discretion, which makes it difficult to produce data which can easily be quantified.

In line with this goal, the use of software monitoring systems may supply a useful source of data. These are discussed in Teubner and Vaske (1988). The most common type found in multi-user computer systems records information on frequency and duration of use, and was originally intended for accounting purposes. These could now be applied to the problem of usability, returning to the principle that if a software package is easy to use, and the users have the option of not using it, its popularity may be a good measure of its success.

The use of this type of monitoring system for evaluation purposes was demonstrated during the MAPS project, and is described in section 5.3.5, along with the utilization of attitude measurements in the form of a questionnaire.

For a review of alternative approaches to evaluation, and methods used at different stages of a project, readers are referred to Christie and Gardiner (1990).
2.7. Knowledge Based Systems

2.7.1. Introduction

If data is the main resource of organizations, and after manipulation of that data, it then becomes information, then the next logical step is to develop software that can utilize that information to generate and distribute knowledge. Systems that aim to do this are known as Expert, or Knowledge Based, systems. Alty and Coombs (1984) state that "Expert systems have their origins in traditional data processing. They are the result of continuous attempts to improve and extend the automation of some aspects of human information processing". The purpose of this section is to review progress in this area and to examine current methods of designing, and implementing, knowledge based systems. This will provide a basis for determining the methodology used to implement the MAPS knowledge based system into the APRE organization.

2.7.2. Brief History

It is often difficult to define a knowledge based or expert system, or to identify appropriate applications, although there is no shortage of suggested definitions. On a broad level,

"An expert system contains a knowledge base relating to the experience of a human expert in a selected subject, and a system of applying this knowledge to help solve problems in that subject area."
The knowledge base is commonly in the form of numerous rules about a subject, or, in computing terms, IF THEN statements. The expert system has the ability, having derived facts from the user, to produce a solution by applying these rules. The rules, and the mechanism for applying them, are separate entities, and the rule base can be expanded independently.

The difference between conventional software and an expert system to some extent lies in the organization and structure of the knowledge base. An expert or knowledge based system asks questions of the user specific to a particular topic, and then, based on the answers given, offers advice or a solution to a problem. They generally offer the facility to ask the system how the solution was reached. They will then illustrate the answers the user has given at each stage, and why this results in the given solution, by reference to the rules induced.

This particular area of computing has seen rapid development over the past ten to fifteen years. Its origins lie in the earlier field of artificial intelligence, or AI. It soon became apparent that it would be many years, if ever, before a computer could match the reasoning power of the human mind. The idea of a truly intelligent machine became a dream rather than a solution to everyday problems. It could be said that expert systems are the practical application of some AI techniques.
The very first expert system was known as 'Dendral' and goes back as far as 1965, but it was a long time before interest reached any significant level. The first practical applications of expert systems were in the medical field, being used to aid medical diagnosis. Such a system was MYCIN, described by Van Melle (1978).

The growth cycle accelerated rapidly from about 1980 onwards. This was highlighted by an analysis of the growth of the British Computer Society Specialist Group on Expert Systems, over the period 1980-1986 (In Bramer 1986). At its outset, the specialist group was possibly seen as a fringe area of computing with very few applications, but by 1986 it had grown into a software field with working applications in nearly all commercial environments. This had been greatly helped by the availability of software and hardware tools to speed up the development process.

2.7.3. Technical Development

When knowledge based systems first found applications within organizations, they were largely one off custom built packages, in many cases developed using existing software technology. The main challenge, as with early conventional computer systems, was to make them technically functional. As more interest was generated in the systems, and demand from industry and commerce increased, investment was made in creating software tools to shorten the development time.
2.7.3.1. Languages

The first step taken in advancing the technical facilities available, was the production of languages specifically tailored towards the development of knowledge based systems. These were first created for the larger field of artificial intelligence, of which knowledge based systems are a subset. The first two were LISP (see Holtz 1985) and PROLOG (see Clocksin and Mellish 1981). They are particularly well suited to creating rule based systems. PROLOG is fundamentally different from most other high level languages. A PROLOG program has a database of facts about objects, these are built up using simple syntax supplied by the language. Once a database is established, it can be queried by use of PROLOG commands. Although it allows the development of simple programs at an early stage in learning, Taylor and Duboulay (1986) found that PROLOG had similar drawbacks to conventional languages. The main point made was that although it may appear to be more tolerant in the syntax it will accept, after instilling confidence in the beginner, it can then become very particular.

2.7.3.2. Development Environments

Following the introduction of the special purpose languages, the next step was to market development environments. These are essentially packages which help the user to implement systems written in the
aforementioned languages. They also offer the facility to write different parts of a system in different languages, allowing the best one to be used in each component of the total package. In this way, they can allow links to be made with conventional software. An example of a knowledge based system development environment is POPLOG (System Designers 1986). These are relatively expensive systems to purchase, and in many cases, offer a poor interface to the user. They require an aptitude towards programming, and an understanding of the computer.

2.7.3.3. Expert System Shells

Recent advances in the area of knowledge based and expert systems, have resulted in numerous expert system shells. The philosophy behind this category of tool is to bring the development of expert systems within the grasp of non programmers. Among those available at the outset of this present study are the following:-

Expertech Xi - Expertech Ltd.
ESP Advisor - Expert Systems International
Savoir - ISI Ltd.
KES - Software Architecture and Engineering Ltd.
ENVISAGE - Systems Designers Plc.
SAGE - Systems Designers Plc.

Allwood et al (1985) carried out a review of all of the above shells and their applicability to problems in the
construction industry. Their report is a good guide to the shells in any area of application. At the time of writing, there were several other shells available, but these were not on the market at the outset of this project.

As opposed to special languages, shells allow several different knowledge bases to be developed, using the same interface to the user. The task of entering rules into the knowledge base is made easier, and the system will normally generate the appropriate questions required to take the quickest route to the solution.

Allwood et al (1985) highlight some general disadvantages with shells. Given that a user should be able to expect the facility to respond "why" to any question, a lot of the shells tested either responded with poorly presented text, not easily understood by a non-programmer, or simply did not allow the actual word "why" to be input as a legal response to a question. The second observation is that the knowledge base itself is often presented in such a way that makes it impossible for a non-computer expert to expand, or update, it. It is also noted that large knowledge bases easily become badly structured, in a similar way to long BASIC programs.

The shells selected for testing were found to be susceptible to misuse, and were not as robust as other modern application programs such as word processors.
2.7.4. Interface Design For Knowledge Based Systems

2.7.4.1. General Issues

Although interface design for conventional software has been extensively investigated and documented, it seems to be applied in only a handful of expert systems. Many good sources of information on interface design are available, for example Brown and Cunningham (1989). There would appear to be two possible reasons for this situation. Firstly, due to the rapid progress made in knowledge based systems technology, the emphasis has been placed on technical design in order to keep pace with the competition. Secondly, it could be that some of the existing standards and guidelines for interface design either do not fully cover this new area, or are inappropriate.

Over the last two to three years (1987-1990), interface development work has started to pay attention to the particular case of knowledge based systems and associated data bases. Many examples can be found in the literature. Jerrams-Smith (1989) pays particular attention to the conversation that takes place between an expert and a questioner. She states that "communication with expert systems is currently rather primitive". She suggests that it would be helpful to think in terms of designing expert systems so that they can behave like good advisors. By studying conversations that take place between experts and
novices, better explanation facilities may be offered in knowledge based systems. This would reap benefits in the traditional rule based expert system, more than in decision support type systems. Posey and Eberts (1989) look at the possibility of representing rules in an expert system graphically, as opposed to textually. It is suggested that a pictorial rule editor could be adopted. Logical connections between rules, as well as truth and value attributes are represented by graphical symbols. This may be on the fringe of research work, but it demonstrates creative thought in interface design for knowledge based systems.

In a later section (2.7.5.), the suitability of prototyping for the design of knowledge based systems is discussed and supported. Langen et al (1989) also see prototyping as a tool to improve interface design for these systems. They propose an object oriented tool box to aid in the development of successive prototypes. The theory is that if you supply a set of so called reusable "software IC's" (program units) that fulfil standard interface programming functions, the developer does not need to be concerned with how these "ICs" work, but in how they can be linked together to build the interface. To support user-centred design (see 2.7.5.), Langen et al suggest "graphical interface description language (IDL)". This method creates a language which may be understood by both the programmer and the user, therefore allowing the
user to be involved closely with the development and final programming of the interface.

2.7.4.2. Interface Design and New Technology

Many new methods for interface design are becoming available due to the introduction of new technology, in particular graphical interfaces and multi media systems. Advances in hardware also take their part.

A great many of these topics are discussed by Shneiderman (1989). He talks about new application areas such as home automation. In this case home computers could be used to control heating, video timing, curtains, lighting, garden watering and security. Some new technologies are already here, and can be applied to knowledge based systems, such as 'hypertext' (see Conklin 1987). Roles for new technology will be detailed in later discussions, and in the light of experience gained during the project covered in this thesis.

2.7.4.3. Guidelines

There have been a number of attempts to improve the quality of interface design for conventional software by producing readily available design guideline documents. In general, there appears to be a problem in producing a document which allows rapid access to major issues without the need to digest several pages of a large manual. The
better known guidelines are directed at general software, and not specifically knowledge based systems. One particular document of value to the designer was produced by Smith and Mosier (1984), initially directed towards military applications, but later publicised as a general tool. The document is split into six functional areas of interface design: data entry, data display, sequence control, user guidance, data transmission, and data protection. It contains a total of 679 guidelines, and the document is logically laid out. Each guideline gives concise examples of its application and any possible exceptions to the rule. They are presented in a manner which should be readily understood by individuals outside the computer field. The document concludes with a list of guidelines titles and reference numbers, grouped together under the six areas for quick reference. Also included is a useful glossary and comprehensive index.

Although not directed at knowledge based systems, many of the guidelines proposed by Smith and Mosier are simply common sense and can be readily applied to many branches of software development.

Another guideline document, again directed primarily to military areas was in draft form only at the beginning of the MAPS project, this being a proposed NES (Naval Engineering Standard) entitled "Human Factors in the Design of Military Computer-based Systems". At the outset
of this current project, it was only distributed for comment, and did not appear to be in a suitable form for application to knowledge based systems. It seemed less 'readable' than the Smith and Mosier offering, covered a large subject area, and needed appropriate background knowledge before reading. Work was continuing on the document and future releases may have proved more suitable.

In general, it could be observed that there appeared to be a need for a concise and easy to apply document of considerably shorter length. Such a document would ideally complement the detailed guidelines presented by Smith and Mosier, and cover other organizational areas in addition to interface design, relevant to knowledge based systems.

2.7.5. Organizational Development and The User

Until very recently, the emphasis has been strongly biased towards the technical system, with very little attention being paid to organizational and user issues. Parallels can be drawn with the early days of conventional computer systems in organizations, where traditional system design procedures centred on technical design.

Some interest has been centred on the organizational issues associated with knowledge based systems, in particular Green et al (1989), who clearly identify a need for further work in this area. They suggest that it is a
particularly complex and difficult subject to research. Other thoughts on the subject of systems design relating to expert systems can be found in Born (1989). Born suggests that the most appropriate design methodology for expert systems is iterative prototyping. This is illustrated well via flow diagrams, but user involvement in the process is not clear, and would appear to be limited to one representative from the client. Evaluation appears to be predominantly on a technical performance basis. It does, however, highlight the need to identify organizational goals.

A project promising large resources dedicated to the development of an expert systems methodology has been initiated by the government, and started in 1988. This has been given the name GEMINI (Montgomery and Crispin 1989, Montgomery 1988). Montgomery and Crispin describe a feasibility study which included a survey of current practice, requirements analysis, and an outline of a future methodology. The basic concept is to produce a method which can be applied not only in government departments, but across industry and commerce. It should be cost effective and easily learnt. It is also aimed to utilize and integrate with existing methodologies, including SSADM (Downs et al 1988). As with Born (1989), Montgomery and Crispin identify iterative prototyping as contributing to the design process. It is envisaged that the conclusion of the GEMINI project will result in a
user-centred, and not technically centred, design process. However, user participation in trials of prototypes and reviewing is only mentioned briefly under 'future development'.

The GEMINI feasibility study points out some of the advantages of a formal method for designing knowledge based and expert systems. Amongst those named are:

* Reduced maintenance costs
* Staff productivity
* Competition of suppliers against a published open standard

Sainfort et al (1989) take the view that if the emphasis in the evaluation of decision support or expert systems is towards organizational aspects, then ultimately this will lead to better methodologies for the design and implementation of such systems. They propose that more effort should be directed towards assessing whether or not a decision support or expert system facilitates work tasks and decision making. The evaluation of an expert system serves three vital purposes. Firstly, it assesses whether or not delivered systems perform the task for which they were intended. Secondly, better evaluation methods should lead to better design, development and implementation of systems. Thirdly, work in this area should extend our knowledge of how people make decisions. Sainfort et al suggest that currently, in many cases, engineers design
expert systems simply to help individuals make decisions or solve problems. Sainfort et al intend to be concerned with individuals making decisions within work organizations. They state that most expert or decision support systems are horizontal, in that they are relevant to many divisions or departments of an organization. However, most organizations are divided into vertical functions. They suggest that the impact of horizontal technologies on vertical organizations is an important area requiring further research.

Another way forward would be to formulate methods of assessing whether expert system technology is appropriate to a particular organization, before the commencement of technical development work. Horn et al (1989) propose a methodology for performing this task, known as The Domain Suitability Analysis Tool (DSAT). It takes the form of a three part questionnaire. The end result, still in the development stage, will be to produce a domain suitability index, to quantify the suitability of expert system technology for a particular problem/organization.

Comprehensive research has been, and is being, conducted by Bradley (1989). In line with comments made by Eason (1988) on socio-technical design in information technology (see 2.5.5.), Bradley focuses attention on both the organizational and psychological aspects of the introduction of knowledge based systems. The views
expressed by Bradley include the following.

(1) The successful implementation of knowledge based systems depends greatly on motivational and psycho-social issues.

(2) The introduction of knowledge based systems affects the psycho-social work environment higher up in the organization than conventional computer systems.

(3) Knowledge based systems affect the distribution of power, influence, and authority in an organization.

Bradley aims to construct principles for the development and implementation of knowledge based systems, based on knowledge about the relationship between such systems and the psycho-social work environment.

2.8. Knowledge Elicitation Techniques

One of the major bottlenecks in the development of knowledge based, or expert systems, is the transfer of knowledge from the expert to the computer. This has been recognised for some time, and well documented (See Boose 1984, Davies & Hakiel 1988, Olson & Rueter 1987, Kitto & Boose 1989). It is the purpose of the following sections to review the available methods, as a foundation for choosing the method to be adopted in the current project.
2.8.1. Identifying The Problem

One distinction between conventional software and a knowledge based system is in the structure of the knowledge base (see 2.7.2). The aim of knowledge elicitation is to match closely the structure on the computer with the one adopted by the expert when solving problems. There are several potential difficulties associated with this process. Firstly, the human brain is far more complex than the most advanced software package. It is therefore difficult to formulate a simplified structure to explain the experts strategy in solving a problem. Secondly, there is the psychological reaction to expert systems by the experts themselves. As a result of the publicity given to some early expert systems, and the broader subject of artificial intelligence, some experts treat such systems as a threat to their position (see (Davies and Hakiel 1988) and (Hart 1986)).

2.8.2. Direct Methods

There are a group of methods which can be brought together under the title of 'Direct Methods'. These require the expert to explain how he/she uses his/her expertise to solve a problem. The most common methods are as follows:

2.8.2.1. Questionnaires

Questionnaires can be an efficient and convenient method of knowledge elicitation. They are generally of a
different format to those used in attitude surveys, for example. They normally take the form of a set of cards, describing either variables or relationships. An example of this principle is given in Olson & Rueter (1987). The information gathered on variables generally includes the following:

1. Types of permissible values (eg. Numeric)
2. Range of values
3. Can the value be uncertain
4. Is the value known or not, at the outset of reasoning

Those cards expressing relationships, tend to be more open ended in nature. The relationship can be asked for graphically and descriptively.

2.8.2.2. Interviews

The most widely used form of knowledge elicitation is the interview technique, the theory being that by participating in a loosely structured conversation with the relevant expert, he/she will pass on information regarding methods used in solving problems. This should include the objects involved, and the relationships between them. It should also reveal the processes which take place in solving a problem.

A guide to interviewing can be found in a paper by Davies & Hakiel (1988), where methods are discussed, and useful
guidelines detailed.

Unlike other methods, there are no laid down rules and regulations to follow, simply a few common sense guidelines. It is important for the session to be relaxed and not at all imposing for the expert. Any apprehensions must be alleviated by reading the personality of the individual, and steering the conversation accordingly. Common problems include the following.

The expert may feel that he/she does not actually know how they solve day to day problems, resulting in a fear of appearing less expert than they ought to be. Alternatively, they may feel that only a few steps are performed in their work, making it appear very easy. There may be fears that the expert’s job will become redundant if a computer can fulfil the same task.

The interviewer should start with fairly general questions, to get the thought processes going, and narrow them down as the opportunity arises. The key to success with this method is to win the confidence of the expert. Ensure that they realise that you value their help.

2.8.2.3. Observation of An Expert working

One of the most obvious ways to elicit knowledge on the processes used to solve a problem is to observe an
expert solving a given exercise. The decision to be made when using this method is how to record the results. There are two basic options. The one probably most commonly used is to observe, record on paper, and attempt to follow the logic used by the expert. This is made easier if the observer has a good understanding of the expertise involved. Videotape could be used to record events at the time, and later reviewed by both the knowledge engineer and the expert.

2.8.2.4. Protocol Analysis

Protocol analysis is simply a variation on observation methods, described in the previous section. Videotape is often used, and paper recordings made by the knowledge engineer. In addition, the expert is requested to talk through his/her thought processes, as he/she solves the problems. The type of details that are requested of the expert include declaring goals at each stage, what resources are being used, and so on. It should be noted that thinking out loud by the expert can interfere with his/her normal thought processes. It should only be used where it is envisaged that it would be quite natural for the expert to talk through the task. Olson & Rueter (1987) point out that in tasks such as composing music, a special language may be adopted, other than natural language. Talking out loud may interfere in this case.
2.8.2.5. Interruption Analysis

This method aims to avoid the drawbacks that can be encountered with protocol analysis. Rather than asking the expert to talk through his/her actions, the knowledge engineer makes his/her own notes, until a point is reached where the logic can no longer be followed. At this point, the observer interrupts the task, and asks the expert to explain why he/she has taken the noted steps, and what the thought processes were. This method is most commonly used when a first prototype of an expert system has been created, in order to test whether the computer system matches the problem solving strategy of the expert. It avoids the possible interference caused by talking through the whole problem, while still allowing a measure of the expert’s methodology at the time of operation.

2.8.3. Indirect Methods

In addition to the direct methods discussed in the preceding section, there are several methods which do not rely on explanations of problem solving methods obtained directly from the expert. It is not always possible, or reliable, to ask an expert to tell you how he/she solved a set problem. Sometimes, the nature of expertise is such that the experts themselves do not know how they reached the solution. In these cases, a selection of indirect methods are available.
Indirect methods tend to be more complex in nature, from an experimenter point of view, than the direct examples. They also make assumptions about the type of knowledge being elicited, and can therefore be misused. Where they have been adopted carefully, they have shown themselves to be psychologically valid. In most cases, they involve a greater level of mathematical knowledge to administer, and can be time consuming. They generally need to be supported by one or more of the direct methods to give a full solution.

2.8.3.1. Repertory Grid

One of the most widely used indirect methods is based on a repertory grid-centred approach (Kelly 1955). Originally intended for use in clinical psychology areas, it was later adapted for use in rule generation for expert systems. The method basically identifies several objects in the problem domain, and then extracts traits from the expert that distinguish between them. Objects are normally grouped into threes, and the expert is asked what it is that distinguishes two of these objects from the third one. The main dimensions used to compare objects are thus extracted. The expert is then asked, in tabular form, to rate all objects on the identified dimensions. Eventually, via a relatively complex process, rules are generated. These are based on objects that imply each other, displayed by the strength of the various dimensions connecting them. Computer software packages are available
to automate a large part of this complex process. For a full description of this method of knowledge elicitation, readers are referred to Boose (1988).

2.8.4. Machine Induction

All the methods of building a knowledge base discussed so far rely in differing degrees on the experts in the field concerned. The problems associated with gathering knowledge from experts have prompted some work to be directed towards reducing the role of the expert. A resulting method is 'machine induction'. There are many critics of the method who dispute whether it has anything to contribute to the problem of knowledge elicitation. However, to review the whole field it should be represented in this text.

In general, the aim in knowledge elicitation is to extract a set of rules from an expert, and then apply the rules to solve problems. The reasoning involved is from the general to the specific, we deduce statements which follow the rules. As long as the rules are followed, then the statement will be correct. This is known as a 'top-down' method. Induction works the other way around, and is therefore a 'bottom-up' method. If a set of examples are collected from an expert, then rules are induced which describe the examples. If the resulting rules have been correctly induced, then they will work for general cases,
and not just for the set of examples originally adopted. In order for the method to work, certain conditions need to exist. There needs to be a comprehensive selection of examples. A set of attributes need to be available to describe the examples, such as measurements, logical values (eg. true/false), descriptive categories (eg. small, large). There is also a need for an inductive algorithm, in the form of software, to induce rules from the examples. An algorithm which has been used in expert system shells and inductive tools is the Iterative Dichotomiser 3 (ID3) (Michie 1979).

Hart (1986) on machine induction, concludes that, in principal, the method is good, but it is emphasized that the quality of the rules is closely linked to the quality of the examples or 'training set'. Hart stipulates that the examples should be drawn up by the expert, in a form that is natural to him/her. The resulting rules should be tested on examples other than the ones used to induce them in the first place. Hart (1986) also states that experts find it easier to describe examples and attributes than describing their own decision mechanisms.

2.9. Examples of Expert System Applications

Discussions so far have considered good and bad practice for the implementation of knowledge based systems. By looking at a small selection of existing knowledge based system projects, we can form an impression of the extent
to which recent ideas on design methodology have so far been adopted.

Tables 2.1 - 2.3 contain categorized information gathered from papers presenting work completed, or in progress. In some cases, it cannot be concluded that modern socio-technical design ideas were not adopted, as published details often do not cover aspects other than technical development. Case studies rarely detail the extent of user participation.

Out of the thirteen examples studied, only one can be said to have definitely used a socio-technical design methodology, with a strong emphasis on the user and organizational factors. This was SSPA (The switching schedule production assistant by Eason et al (1987). Other projects appear to have recognised the need for user involvement during the design phase, but have perhaps not achieved it due to the lack of a good methodology. This cannot be stated beyond doubt, but evidence seems to point in this direction. Despite recent realization of the need to move away from the traditional technically centred design strategy, ten out of the thirteen examples still show signs of being oriented towards the technology rather than the user and/or organization.

Regarding knowledge acquisition, the simplest observation that can be made is that only one out of the thirteen
<table>
<thead>
<tr>
<th>NO.</th>
<th>REFERENCE</th>
<th>NAME OF SYSTEM AND PURPOSE</th>
<th>KNOWLEDGE ACQUISITION</th>
<th>DESIGN</th>
<th>USER INVOLVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gleeson &amp; West 1987</td>
<td>CLINTE - International tax (Coopers &amp; Lybrand)</td>
<td>Recorded conversations, analysed by knowledge engineers. Reference to text books</td>
<td>Technically centred design. Interface based on windows and icons. No shell used. One-off package.</td>
<td>Very little apparent. No information on user acceptance and method of introduction</td>
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<tr>
<td>2</td>
<td>Torsun 1986</td>
<td>PAYE - A tax expert system</td>
<td>Gathered from existing text, and advice from experts where required</td>
<td>Knowledge base written in PROLOG, with an interface to an INGRES relational data base, and COBOL data base files. Top-down design strategy. Technically centred design</td>
<td>None apparent. Interface design was technically based to link with INGRES etc.</td>
</tr>
<tr>
<td>3</td>
<td>Sorensen and Nordhus 1987</td>
<td>LOKE - A drill bit selection system</td>
<td>Knowledge engineers learning the subject. Interviews with drilling supervisors. Run through examples. Correction after prototyping</td>
<td>Technically centred design. Built using an expert system shell (M1) additional routines written in C.</td>
<td>None apparent. No interface guidelines seem to have been involved.</td>
</tr>
<tr>
<td>4</td>
<td>Brode et al 1987</td>
<td>IMS An intelligent maintenance system for a system X, BT exchange</td>
<td>Deep models derived in the main from documentation. Experts used to check first working system, and identify improvements.</td>
<td>Technically centred design, but with an appreciation of the organizational and Human factors considerations at a minimal level. System developed using the language 'common LISP' and designed to work under UNIX.</td>
<td>No direct user involvement in the design process. But MMI considers user perceptions of the existing system.</td>
</tr>
<tr>
<td>5</td>
<td>Reynolds et al 1987</td>
<td>DELIA Exploration for hydrocarbons (Oil and Gas)</td>
<td>Knowledge elicited from one particular expert. His cooperation allowed loosely structured interviews to be used. Running through examples. Rules were derived and tested, and amended in an iterative cycle.</td>
<td>Technically centred design, using more than one AI language, through the development environment POPLOG. The system runs under UNIX on a SUN workstation. Object oriented techniques were adopted. Menu and mouse driven interface</td>
<td>No end user involvement, however the system is only a prototype.</td>
</tr>
<tr>
<td>NO.</td>
<td>REFERENCE</td>
<td>NAME OF SYSTEM AND PURPOSE</td>
<td>KNOWLEDGE ACQUISITION</td>
<td>DESIGN</td>
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<tr>
<td>7</td>
<td>Skingle and Mulvey 1988</td>
<td>System for fault and condition monitoring on underground trains</td>
<td>Interviews with engineers, plus circuit diagrams from London Underground Ltd.</td>
<td>Technically centred design. System developed in C. Final package delivered on custom made hardware, to cope with adverse working conditions.</td>
<td>No mention of user involvement during design stage. Also testing on a train appeared to be mainly technical performance</td>
</tr>
<tr>
<td>8</td>
<td>Eccleson and Main 1988</td>
<td>A knowledge based system for manufacturing quality control.</td>
<td>Comprehensive approach. Seven methods used. Conversations, structured interviews, walk-throughs, teach-back, documented material, and prototyping.</td>
<td>Partly user-centred design. Close expert involvement through prototyping. System is written in PROLOG and run on an IBM PC. Interface appears to be user friendly with good help facilities and comprehensive error messages.</td>
<td>A large number of non-software personnel contributed to the design process. Not clear whether users were involved in testing the interface</td>
</tr>
<tr>
<td>9</td>
<td>Ellam and Maisey 1986</td>
<td>A knowledge based system to assist in medical image interpretation</td>
<td>Experts asked to work through 25 test cases. The experts were asked to suggest as many diagnoses as were thought appropriate, and to give the likelihood of each. They were also asked to explain their reasons.</td>
<td>Mainly technically centred, but with a study of the existing system helping to allow for organizational aspects to a limited extent.</td>
<td>Some user involvement in wording of questions asked by system. No mention of involvement in screen design etc.</td>
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<tr>
<td>NO.</td>
<td>REFERENCE</td>
<td>NAME OF SYSTEM AND PURPOSE</td>
<td>KNOWLEDGE ACQUISITION</td>
<td>DESIGN</td>
<td>USER INVOLVEMENT</td>
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<td>10</td>
<td>Eason et al 1987</td>
<td>SSPA - The switching schedule production assistant.</td>
<td>Two types of knowledge collected. Firstly, the rules for the knowledge base, also information on how the user completes the required task. Structured interviews, using worked examples</td>
<td>Socio-technical design. User participation on the design team, ensured user-centred design from the outset. Detailed study of organizational issues involved. Early prototype. Allocation of functions decided jointly with users. Expert system shell for prototype, then WIMP interface on an advanced workstation.</td>
<td>User at the centre of the design process. Represented on all panels. Feedback from users after first prototype ensured on target system to meet users total needs and job design.</td>
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<tr>
<td>11</td>
<td>Cahill and Carter 1987</td>
<td>OASIS - A knowledge based system for high speed process control</td>
<td>Sensors attached to the production machine. Data collected, and when stoppages occurred, the data recorded was related to the stoppage by an expert observer.</td>
<td>Technical and user centred design. Main system is written in C and runs on an industrial rack based PC/AT. Proving trials carried out at specific sites, with prototypes. Some organizational considerations allowed for in design.</td>
<td>Reasonable user involvement but quite late in design. Final system can be adapted to suit the individual user.</td>
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<tr>
<td>12</td>
<td>Gustafson and Bosworth 1989</td>
<td>CHESS: Health enhancement support system.</td>
<td>Panel of experts decided on the level of personal risk depending on the response to a set of questions.</td>
<td>Not Clear. Organizational issues appear to be considered, and the users appear to be catered for in the design, but only from an expert's opinion of what they require. The package is PC based.</td>
<td>User considerations are given a high priority, but user involvement in the design process is not apparent.</td>
</tr>
<tr>
<td>13</td>
<td>Taylor and Corlett (1987)</td>
<td>ALFIE - Auxiliary logistics for industrial engineers (A computer aid for Ergonomic design)</td>
<td>Expertise gained by the knowledge engineer, coupled with literature sources and experts themselves.</td>
<td>Mainly technically centred design. Main attention given to the layout of the knowledge base, with some work on knowledge acquisition. Good structure to knowledge, but poor interface.</td>
<td>Only consideration of user's needs appears to be based on the developers opinion. No apparent user consultation, in particular for the interface adopted.</td>
</tr>
</tbody>
</table>
examples made clear reference to a documented structured method of knowledge acquisition (No.8 Table 2.2). In that example, a total of seven methods were used. In all the other projects, ignoring the effectiveness or otherwise of the techniques adopted, the methods of knowledge acquisition were all flexible and relatively informal.

Interface design receives little attention in the published literature appertaining to these examples. Where it is referred to, the user does not seem to be considered, with the exception of No.10 (table 2.3) and possibly No.4. (table 2.1). It may in turn indicate that existing documented guidelines for conventional software user interface design are not being utilized to their full extent. Published literature appertaining to No.13 table 2.3 (Taylor and Corlett 1987) indicates that the developers were aware of the weaknesses in the interface design, and intended tackling this aspect of the system at a later date.

2.10. Chapter Summary

It has been shown, during the course of this chapter, that parallels can be drawn between the history of conventional software and the newer knowledge based system technology. If this is the case, then we can expect further progress to be made in the implementation of knowledge based systems into organizations. Areas of particular concern are knowledge elicitation and interface design. The
problem for interface design may be simply a need to encourage the application of documented standards for conventional software, although new guidelines may be required to suit the new technology. As the technical design of knowledge based or expert systems improves, together with better 'off the shelf' shells and development environments, more of the designer's time may be released to consider user and organizational issues. The examples of existing systems illustrated in tables 2.1 - 2.3 demonstrate two things. Firstly, they show the broad spectrum of applications suitable to knowledge based systems, across industry and commerce, and many more examples were available beyond these thirteen. Secondly, they illustrate only a slow uptake of user-centred and socio-technical design methodologies.

A survey carried out by O'Neill and Morris (1989), clearly identified an "Ignorance of user’s needs" amongst developers of expert systems. They found that non-expert users were often the last people to be considered during the development of expert systems. It was often the case that the man-machine interface was tagged on at the end of a project, almost as an afterthought. Berry and Broadbent (1987), in an earlier survey, found that in the areas of evaluation, interface design, and explanation facilities, the user’s needs were being neglected. However, some large organizations were beginning to appreciate the problem, and were redirecting their efforts accordingly.
There seems to be a general consensus that an iterative design procedure, adopting early prototyping, is possibly the best method of facilitating user involvement in the design process. This is supported by Candy and Edmonds (1988), who emphasize the need for user requirements analysis, prototyping and evaluation in a good design methodology. In a HM Treasury publication (HM Treasury 1985), the design process for expert systems is said to consist of four phases: feasibility study, the demonstration system, enhanced demonstration, and the production system. They clearly point out the need for user involvement in each prototype, and the importance of matching the interface to the needs of the end users.

A useful reference paper is one written some time ago by Nickerson (1981). A great deal of the points he makes about why people may not use potentially useful interactive software would seem to be common sense. Yet some nine years later, not all the factors mentioned are considered in the design of both conventional and expert system software. In conclusion, it would be useful to reiterate the comments users made under some of the categories Nickerson investigated:

**Functionality**

"The system is very impressive, but it doesn't offer me anything I really need"

"The system clearly was not designed with my job in mind"
Accessibility-availability

"I share a terminal with several other users, so often have to wait for it"

"The computer is often down when I want to use it."

Start-stop hassle

"Exiting from a work session is not much easier than getting started. It should be possible just to say 'goodbye' and leave"

System dynamics and response time

"sometimes when I am waiting for a response, I don't know whether the system is alive or dead. If I knew it was dead, I could go do something else."

"What's worse than waiting for a response is not knowing what the duration of the wait is going to be."

Training and user aids

"I don't have the time to learn how to use the system"

"Effective use of the system depends on knowing too many details."

Consistency and integration

"There is a need for standardization across systems. I don't like to have to remember that to delete the last character I typed I have to strike one control key if I am interacting with program A and a different one if I am interacting with program B."
User conceptualization of the system

"I don't understand what's going on within the system, and that makes me uncomfortable."

"I don't trust it. Maybe if I understood it better, I would."

All the preceding comments were recorded by Nickerson in 1981, yet many of them could still be applied to software today.

The literature reviewed in this chapter was considered carefully in the formulation of the design methodology for the project described in this thesis.

Chapters 3 - 9 document the project in detail, including evaluation results. Chapter 10 presents a discussion of the issues arising, and chapter 11 proposes guidelines for future knowledge based system projects. It is hoped that the reader will already have some insight into the subject area, drawn either from personal experience, or from the information presented in this chapter. It is envisaged that this will help in appreciating some of the issues presented in the remainder of this thesis.
CHAPTER 3
3. STUDY OF THE EXISTING APRE ENQUIRY HANDLING SYSTEM

3.1. Introduction

The Army Personnel Research Establishment (APRE) is the Human Factors establishment for the British Army and is concerned with the physiological, and psychological, aspects of the soldier. The Applied Physiology (AP) Division of APRE is particularly concerned with the physiological limitations of the soldier and the interactions between his/her protective clothing, equipment, the environment, and his/her performance. Figure 3.1 shows a simplified structure diagram of the organization.

APRE has as its customers sponsoring agencies within the Ministry of Defence (MoD). Over the past twenty years, the working pattern at APRE has changed. Initially the work was mainly experimental and a large number of field trials and surveys were performed to answer relatively long term questions. The current situation (1990) consists of a number of short term high priority tasks, which form part of development programmes involving other MoD establishments and industry. Over this period, the number of permanent staff in AP Division has diminished slightly, while at the same time the demand for work has increased. The requirement now is for expert advice to be provided on a day to day basis, in response to a short enquiry letter or simply a phone call, as shown in section 3.4.2.1.
Figure 3.1 - Simplified organizational structure of the APRE
The Applied Physiology (AP) Division has resident experts in physiology, occupational medicine, ergonomics and related disciplines, together with an extensive selection of experimental equipment. In addition to this, the APRE library has built up a large and unique collection of reports and publications.

3.2. Current Method of Enquiry Handling

An analysis of the way in which questions were answered indicated that the method sometimes involved a time consuming "treasure trail" process. This included searches through past reports and files, together with discussions with other relevant personnel. This is described fully in section 3.4.

3.3. Existing Computer Hardware/software

For some years prior to the commencement of the MAPS project, the APRE had developed a system of both hardware and software, and it was important to identify and document this before any decision was made on the mechanics of the new knowledge based system. Any new system would need to utilize existing software, where that software currently performed the task it was designed for in an efficient manner.

3.3.1. Hardware

The APRE, as an establishment, had a network of Digital
Equipment Corporation (DEC) VAX and MICROVAX mini computers: these were distributed amongst the different sections. The Applied Physiology (AP) Division, had at the time three mini computers, all produced by Digital Equipment Corporation. These were a PDP11, a VAX 11/751 and a MICROVAX II computer. In addition to these, it had several British Broadcasting Corporation (BBC) model B desk top micro computers.

3.3.2. Software

Software installed on the DEC VAX computers included very little other than the operating system (VMS), and the high level programming language FORTRAN 77. However, there was an in-house database system known as DBA (See section 3.4.3.1). This gave access to all reports, internal or otherwise, held in the establishment’s library. The system was installed on the VAX 11/750 in the AP Division. There was a selection of software for BBC micro computers, held by individual members of staff. For word processing, there were two options. VAX/VMS comes with a text processing program known as RUNOFF, this offers a 'batch type' system of producing formatted documents. Alternatively, some members of staff were familiar with word processing packages for the BBC micro computer, for example WORDSTAR. This offers on screen editing of documents, rather than the batch system offered by RUNOFF.
As a research establishment, APRE collects large volumes of experimental data. In order to make sense of this, and present it as a readable report, the members of staff need the facility to produce summary and test statistics. The only facility on the VAX network was SPSS (Statistical Package for the Social Sciences), which, despite being a very sophisticated software tool, does not offer the type of user interface suitable for naive computer users. There were several statistical packages available on the BBC, amongst these being; UNISTAT; MICROTAB; SUPERCALC; and INSTAT.

3.4. Performance of The Existing System

To ascertain the effectiveness of the existing system, it was necessary to study the process of enquiry handling and the use of software and hardware. To do this, interviews took place with a selection of key personnel, with a discussion on the type of resources that they used in answering day to day enquiries. These took place over a period of three weeks at the start of the project. The only recordings made of these sessions were brief notes for use by the experimenter. It was felt that this study would also help in assuring that a knowledge based system was the appropriate solution to the problem (see also section 4.1). The result of this investigation was the production of a flow diagram showing the various lines of communication involved in answering an enquiry. Additional minor routes may have existed, but the main structure was
Many interactions take place within senior management to determine optimum use of resources/staff to answer enquiry.
as illustrated in figure 3.2. Letters A - C represent the three main communication lines between different personnel and the resources. Numbers 1 - 8 represent the interfaces with each of the resources.

3.4.1. Types of Enquiries Received By The APRE

The MAPS knowledge based system was designed to cover as many as possible of the enquiries directed at the applied physiology (AP) division of the organization. The subject area covered by the aforementioned division was described in section 3.1. To give a broad overview of the type of enquiries received, the following brief descriptions are presented.

(1) In the area of physical fitness, enquiries may relate to assessment of an individual's physical state, perhaps compared with the results of surveys carried out to record the fitness of a population of soldiers. Other enquiries may relate to the description of a suitable training program. Enquiries may relate to endurance figures or recognised tests of endurance.

(2) In the area of clothing, information may be required on the properties of garments, including amongst other things, factors such as insulation values, protective qualities and effects on performance due to encumbrance. Protective
Clothing questions may relate to such factors as water and flame resistance. Thermal comfort may be important, or at extreme temperatures the protection of extremities such as hands and feet. Interest may be in the choice of sleeping bags for arctic conditions.

(3) In the area of anthropometry, requests may be made for statistics on body dimensions. These may be required for assessment of the suitability of either equipment or clothing. This may be dimensions such as arm and leg length or alternatively estimations of body fat.

(4) Questions on thermal stress may include human performance in either hot or cold conditions. Answers may take the form of compliance with recognised standards and guidelines on the subject. Advice may be given on the correct methods of measurement, in particular the recording of environmental conditions.

(5) Enquiries may arrive on the broad subject of manual materials handling. Typical problems could relate to the loading of vehicles with heavy containers, with the answer describing the allowable weight and the number of lifts that could take place during a working day.
The preceding examples are only a small subset of the possible enquiries likely to be received by APRE. As the example in the following section demonstrates, any one enquiry could easily cross the boundary between subject areas.

3.4.2. An example Route Through The Enquiry System

The subject of applied physiology covers a wide area of expertise, and in many cases a typical enquiry would cover several aspects of the domain knowledge. In order to give a clearer understanding of the organization, a simplified yet feasible hypothetical enquiry has been adopted. The APRE enquiry handling system was a flexible and adaptable network of staff and communication links, the emphasis being on teamwork. The following description of the route through an enquiry is intended to give an overview only, and does not document the many 'real life' reasons why particular members of senior management and staff may have chosen to communicate with each other. In particular, it does not take account of work load, training and other man management considerations. The example given draws on components of actual enquiries, and the route taken to solve the problem was derived via the process described in section 3.4. After formulating the following information, the hypothetical route through the organization was discussed with APRE staff members to check the feasibility of the final route described here.
3.4.2.1. The question

Summary of the contents of a hypothetical letter to APRE

"A worker at a steel mill has to carry out maintenance work on equipment in a hot environment. He is wearing metal splash protective clothing, and the environment is hot and humid (32 degC air, 70%RH). He is also required to carry equipment on his back of some 15kg. He normally works for one hour under these conditions, the tasks being only light manual duty (excluding carriage of load). Although this is not a military situation, it is possible that similar situations may arise during Army operations, where heat, protective clothing, and load carrying are involved. If so, could you advise on any heat stress and fitness problems that may be encountered."

3.4.2.2. The Method of Answering The Enquiry

[A] The enquiry may arrive at any point within senior management, or directly to a particular member of the scientific staff. Depending on the point of entry into the system, decisions will be made as to the best individual to proceed with the enquiry. This may or may not involve passing the enquiry to another member of staff. Assuming this decision has been made, he/she may progress as follows.

[B] For the purposes of this example, we will assume a thermal expert is now proceeding with the enquiry.
Firstly, he/she will want to know whether any previous studies have been carried out, either military or not, on similar working conditions. This information will be held by the library, recorded on the computerised database system, DBA (See section 3.4.3.1.). As discussions with staff have shown that most find it difficult to use DBA, he/she may well ask the library staff to retrieve the information. Secondly, he/she will probably require additional information about the environment from the person asking the question, and any additional details about clothing and type of work. He/she will need to decide on a figure for clothing insulation and metabolic rate.

[C] Depending on his/her experience, he/she may well need to consult with two other members of staff. One for calculation of the clothing insulation, and one for calculation of the metabolic rate. The clothing insulation may either be estimated from experience, or it may be calculated from estimate equations; probably using a pocket calculator for summation purposes.

[D] The second person to be consulted may be an expert in manual materials handling, who will use a selection of his/her own resources to estimate the metabolic rate. These resources could be a selection from past reports, tables of standard values, or mathematical prediction models. The prediction models may be in the form of a
computer program, or may be calculated with pen and paper.

He/she will then use all the collected data to run through a heat stress model of some description. At the simplest level, he/she may choose to determine whether the conditions are within the limits of a specific standard, for example WBGT (Wet Bulb Globe Temperature). At a more complex level, he/she may have the resources to run a computer program to simulate the body's response to the environment. This may be a program on a micro computer, or possibly on the network of mini computers.

Finally, he/she may draft a reply to the 'client', including any limits on the reliability of the answer given. He/she may well hand write the first draft, and pass this to a typist to copy type. He/she would include any relevant calculations carried out by the additional two members of staff he/she consulted during the process.

Many assumptions and generalities have been made in presenting this example, and other routes may well have been utilised in a real situation. The enquiry handling system appeared to be flexible in its operation, and would vary to accommodate a wide range of enquiries. The process can be traced along paths in figure 3.2, or more specifically in the flow diagram shown in figure 3.3.
3.4.3. Components of The Existing System

No numerical measures of performance were thought appropriate or useful in this particular situation. However, it was still of great importance to fully assess performance in a descriptive manner to identify weak points in the system. Also, areas in which the application of new technology/methods could offer an improvement.

A list of sources of information could be compiled, to describe the current facilities used in answering an enquiry, as follows, and illustrated in figure 3.2:
1. Past reports, accessed through DBA, or via card index/microfilm in the library.

2. Personal files, through office filing cabinets or shelves.

3. Consultation with other personnel.

4. Pocket calculator to process an equation.

5. Personal program run on a micro computer.

6. Personal program run on the VAX network of mini computers.

7. Results of past surveys/trials.

8. Shared software accessed through the VAX network of mini computers.

In addition to this list of resources, a list of categories of user could be identified as follows, and again illustrated in figure 3.2:

A. Library staff
B. Senior management
C. Scientific staff

A matrix of all the possible combinations of personnel and interface can be generated from the two preceding lists, as follows (Table 3.1), together with the anticipated future requirements/improvements.
If we take each resource in turn, and expand on the situation as it existed at the time.

3.4.3.1 The Library and DBA Database

Row 1 Table 3.1

The library staff were clearly well organised and highly efficient in their operations, and given the necessary reference numbers from the computer database, DBA, they could extract the required report. The area where there could have been a problem was the interface component of the computer software in DBA.

The DBA database was a computerised information retrieval
system installed on the establishments network of VAX mini computers, thus making it widely available to all members of staff via individual VDU terminals. It was written, in-house, by a contract computer programmer, using the computer programming language FORTRAN 77. Its database consists of two main areas. The largest of these contains a single page of reference information on every report, internal or external, held in the establishments library (see figure 3.6). Each page includes: Accession number; Security class; Origin; Title; Authors; Report number; Date; Format; Number of pages; Location; Page reference; and Keywords. At the time of writing, there were some 24000 pages of this form. The second area of the database contained only reports relevant to the Applied Physiology (AP) Division, and contained around 4500 records/pages. However, in this case there were two pages of information for each report held by the library. The first was as described for the main area of 24000 references (see figure 3.6), but attached to this page was a second page containing an abstract. The two areas of the database were called REPORTS and ABSTRACTS respectively.

From a functional point of view, DBA fulfilled its purpose easily, supplying a method of retrieving reports, after defining a search. It had for some years provided access to a large and unique collection of literature. It could clearly be identified as an important future component of any new knowledge based system. However, the
user interface would require further investigation. Informal discussions with the users suggested that there was difficulty in operating the software. Common problems included remembering the names of fields (sections of each record, for example Title, Author, keywords etc., shown in figure 3.6) to be searched, and instructing DBA to produce a hard copy of the reports. Three examples of the screen content and layout can be seen in figures 3.4 - 3.6.

Figure 3.4 shows the first page of DBA. The input line at the bottom of the page is similar during other stages of use, where the detailed list above is no longer available. Users may then find it difficult to choose between M/L/S/P/F/E, given the first letters only.

Figure 3.4 - First page of DBA (original interface)
Figure 3.5 - DBA Search Definition (original interface)

Figure 3.6 - Typical DBA Report Page (original interface)
Before DBA would print out any records to a dump file, the print listing format had to be defined. This involved selecting 'L', and pressing the return key several times until the user had reached the bottom of the screen. This was required simply to select the default setting. If the user had not performed this task, DBA would report that it was printing out files, but the dump file would be empty.

As a number of users approached the author, as someone with knowledge of the computer system, asking either how to print out DBA records, or alternatively asking where their output had gone, this did seem to be a problem.

A second possible cause of difficulty with printing out files was that although DBA claimed to be printing out, it was only writing records to a file called PRINT.DMP in the user's default directory. As the word 'printing' had been adopted, the user often assumed that output would go to a printer somewhere, and not to an unnamed file.

Figure 3.5 shows the DBA search definition screen. Day to day discussions with members of APRE applied physiology division staff revealed that only a minority of users could perform a search using this layout of information, the major problem being that there was no indication of the options that could be input, although this was available through an unnamed function key. The use of the word 'connector' meant very little to most people, the
required input being a logical connector (and/or/not). If someone got as far as defining a search correctly, there was no indication as to how to start it. Pressing return until the cursor reached the bottom of the screen would suffice, although pressing the enter key would start the search immediately.

Figure 3.6 shows a typical DBA report page. It would normally contain information on a report held in the library. It contains all the information needed by the library in order to retrieve the report in paper form.

In short, several potential obstacles existed to prevent easy use of the database system, and this would have to be tackled at a later date. DBA represented a powerful source of information, designed along ‘technically’ proficient software methods. The potential problems only applied to the human-computer interface adopted. This has been highlighted in column 1 of table 3.1. The only members of staff not having serious problems with the database were the library staff (A in table 3.1). Although the learning curve was particularly long for DBA, this was less of a problem for the library staff, as they tended to use it on a daily basis, as opposed to intermittently. This allowed them to learn the functions and keywords required.

At this stage in the MAPS project, no documented empirical evidence was collected to prove or otherwise the
aforementioned difficulties with the DBA database system. However, informally, indications seemed to point in this direction, and DBA would be assessed more formally during the evaluations conducted later in the life cycle of MAPS.

3.4.3.2. Personal Files

Row 2 Table 3.1

Each individual had his or her own method of storing personal files, and there were no reports of dissatisfaction with the current setup. However, this situation would be reviewed during the project.

3.4.3.3. Consultation With Other Personnel

Row 3 Table 3.1

Communication between different disciplines within the Applied Physiology Division did not appear to be a major problem. It was not feasible, within the time frame of the MAPS project, to collect data to quantify the quality of communication between disciplines. It could be said that there was no apparent lack of cooperation amongst staff to consult with their colleagues. However, there may have been possibilities for improvement in the tools available to encourage the use of knowledge from outside an individual's own area of expertise. At the time, if a particular enquiry involved both thermal stress and
physical fitness for example, then if the core of the problem was in the thermal area, the problem would be given to a thermal expert. In the course of answering the enquiry, the thermal expert would have to travel to another part of the building, and consult an expert in physical fitness. This is fine in cases where consultation is advantageous, but there are occasions when, for a particular enquiry, all that is needed on the physical fitness side is the processing of an equation. It would therefore be helpful to supply the facility for experts in other fields to have access to some knowledge outside their own area of expertise.

3.4.3.4 Processing of Equations With a Calculator

Row 4 Table 3.1

This could be identified as an area where potential improvements could be made. On several occasions during the investigation of the current system, personnel identified that they would use a pocket calculator to process a commonly required equation. The worse cases were where an equation had to be processed several times in order to reach a set of variables. If a computer program could be made available to personnel, then the solution could be reached more quickly, especially where several sets of variables need to be input to reach a decision.
3.4.3.5 Personal Programs Run On a Micro Computer

Row 5 Table 3.1

In a few cases, it was observed that some members of staff had their own short computer programs to solve equations. These were most commonly stored on floppy disks for use on BBC model B micro computers. This was perhaps better than the use of a pocket calculator in cases involving large amounts of data, but there did seem to be some drawbacks. The process of storing data on a library of floppy disks did involve a search time to find the correct disk. If the program concerned was useful in a variety of cases, it would not be readily available to all personnel. To achieve this using stand alone micro computers would potentially prove difficult using floppy disks. Apart from any other problems, it would have been a labour intensive task to ensure that all copies of the program were kept up to date in the light of any alterations.

3.4.3.6 Personal Programs On The VAX Network

Row 6 Table 3.1

Most of the points raised about programs on micro computers also applied to programs on the VAX minicomputer network. These would generally be stored in a particular user’s directory, and would potentially not be known about, or be accessible by, other members of staff.
It was also possible that they may not be updated in the light of new data.

Where many copies of similar programs are used by many individuals, it is potentially difficult to maintain the quality of such programs. That is, to ensure they are both error free and up to date. Assuming an update to a program is received by the establishment, it would be labour intensive and extremely difficult to ensure that all copies of that program are replaced or amended. If only one master copy is accessed, the task becomes easier.

3.4.3.7 Results of Past Surveys/Trials

Row 7 Table 3.1

The nature of The APRE’s work is such that a large body of information is in the form of survey/trials results. This may be presented as a report containing summary statistics, stored in the library, or in individual offices. The complete set of raw data was archived using a variety of storage methods, ranging from tables in a ring binder, punched cards, through to magnetic tape and floppy disks. This meant that if the reports on the data did not include the statistics a user may require, it may have been either very difficult and time consuming, or simply impossible, to extract new values from the original data.
3.4.3.8 Shared Software On The VAX Network

Row 8 Table 3.1

Very little shared software was available on the VAX network, apart from the DBA database system, a FORTRAN compiler, the RUNOFF word processor, and the SPSS statistical package. These did not appear to be used to their full capacity, possibly due to a combination of interface problems, lack of internal publicity, and very little user support.

3.5. Chapter summary

From the observations made, it could be concluded that, although the existing system could handle incoming enquiries as it stood, there was room for improvement in the tools available to make the task easier. A large body of knowledge could be identified at the APRE, some of which was already in a form facilitating easy retrieval of information. Other sources were, however, not matched to the user’s needs. These areas would therefore be the target of any new system.

Serious human-computer interface problems were noted with the existing library database, and to fully utilize its potential power this would have to be investigated. In general, there was under usage of the existing computer software/hardware as an aid in accessing information.
There was a call for improvements in the interface adopted by existing systems, and an integration with new software units to fill the gaps in the facilities available.
CHAPTER 4
4. DEFINITION OF THE ROLE TO BE PLAYED BY MAPS

4.1. Target Areas For Knowledge based system Technology

The study of the existing APRE system detailed in the preceding chapter, revealed that the resources available for rapid advice giving could be enhanced. Although the system of enquiry handling produced the desired results, in terms of solutions to problems, certain areas could be improved. Possible changes were in the methods used to access knowledge.

The sources of knowledge within the APRE were illustrated in figure 3.2 (numbered 1 - 8), and listed in section 3.4.3. In addition to this, three groups of users were identified in figure 3.2 (A - C), and again listed in section 3.4.3. A matrix was used to summarise the different interfaces (computer or otherwise) that existed (see table 3.1). It was possible to highlight areas where computer software could help improve the existing interface with knowledge.

The areas where it appeared the greatest improvements could be made were as follows:

[1] Past reports, accessed through the DBA database, or via card index/microfilm in the library.

(A1 to C1 in table 3.1.)
[2] The availability of shared software, accessed through the network of VAX mini computers, to present all types of knowledge.  
(A8 to C8 in table 3.1)

(B3 and C3 in table 3.1)

[4] Reduce the need for operations on pocket calculators, where computer programs would be less labour intensive, and facilitate better quality control.  
(B4 and C4 in table 3.1)

These were therefore the target areas for any new software. At the same time, it was possible to identify future requirements more specifically related to computer interface design. These were based on performance of any existing software, and the profile of the expected users (see section 4.3).

They could be summarised as follows:-

A. Understanding operating system commands  
B. Using the in-house data base system (DBA)  
C. Cross reference between different expert fields  
D. Accessibility of survey data  
E. Presenting results in a report form  
F. Availability of utilities, for example conversion of units.
4.1.1. Operating System Commands

When personnel attempted to use the existing hardware or software, one of the major problems was a difficulty in understanding the computer’s operating system. The most frequently observed problem was a lack of understanding of directory structures, and an inability to move around the computer’s file storage area.

4.1.2. The In-house Database System (DBA)

The database system, DBA (see section 3.4.3.1.), was primarily used by members of the library staff, quite often on behalf of another member of staff. As the system was available through a terminal in the majority of private offices, this suggested there may be a problem with usability. By the completion of the MAPS project, it was aimed to produce a new ‘front end’ to DBA. This would attempt to make the system more suitable for infrequent, computer naive, users.

4.1.3. Cross Reference Between Areas of Expertise

Some enquiries crossed the border between different areas of applied physiology (see example in section 3.4.2.1.), and sometimes involved time consuming consultations with other members of staff, in different offices within the establishment. For certain transactions, person to person contact is probably the best method of transferring knowledge. However, in many cases, all that is required is
access to the appropriate mathematical equation or raw data. This could be identified as a possible application of knowledge based system (KBS) technology, as such systems are often intended to distribute expert knowledge. The interface would be designed to allow easy movement between all the relevant areas of applied physiology, with guidance available for those users who were not expert in the field concerned.

4.1.4. Accessibility of Survey Data

Computers, and the field of information technology, are particularly well suited to dealing with very large volumes of raw data. The APRE Applied Physiology (AP) Division was a wealth of raw data, especially in areas such as anthropometry and physical fitness. MAPS would aim to have particular knowledge programs specifically designed to present such data in a clear and logical manner. There were many cases where the raw data was only available on magnetic tape or punch cards.

4.1.5. Presentation of User's Results

In line with the observations made in the previous chapter, and in 4.1.1. regarding the computer's operating system, it was anticipated from initial investigation that problems were, and would continue to be, encountered with the printing out of material gathered on the computer. A major step forward may have been, by the final
version of MAPS, to incorporate the printing out of files within the package. By acting as an intermediary between the user and the operating system, this would hopefully reduce the need to remember complex computer language commands.

4.1.6. Availability of Utilities

During the study of the existing system (chapter 3), the usefulness of a program to convert units was commented on by staff on more than one occasion. This would be incorporated in MAPS as early as possible. Other general utilities would be developed as the need became apparent.

4.2. Links with existing software

It was decided from the outset of the project, that MAPS should utilize existing software where appropriate, and where its facilities would still be required in the new system. This was particularly important in the case of the library database (DBA). Despite the problems identified with the interface design (see section 3.4.3.1.), it was still an efficient method of access to the many reports held by the library, and the data contained within it was both unique and extensive. Therefore, MAPS would need to make DBA available from within the system in its existing form, until such time as modifications could be made to the interface. As MAPS1 was intended as a limited demonstration system, designed to initialise early user
feedback, the link with DBA consisted of simply calling the database and presenting it to the user within MAPS. No attempt was made to improve its interface to make it more compatible with the rest of the system.

It was also noted that the design of MAPS should make it quick and easy to allow any new commercial software purchased and installed on the computer system to be available to the user while inside MAPS. This may have included such things as statistical or graph plotting packages.

MAPS1 was written in the computer's own operating system, namely DEC VMS. This allowed any new, or existing, commercial software to be included in the program by a one line command. For example, in the case of the DBA database system, all that was required was a single line in the MAPS program saying 'run DBA'.

4.3. Characteristics of The User Population

The Applied Physiology (AP) Division of APRE comprised around 25 applied physiology experts. As a team they possessed expertise in all of the relevant areas of physiology. The level of help and physiological guidance given by MAPS could be pitched much higher than it would be if the users were drawn from the general public.
In terms of the understanding of computers, the range of abilities was wide. One or two members of staff were regular users of the VAX network, with a good knowledge of the system, although they could not be described as programmers. They understood the DBA database and the word processing package (Runoff). At the other extreme, a few people rarely used the computers at APRE, and had little understanding of the basic concepts, such as directories and files.

4.4. Definition of The Role For MAPS

The position the new knowledge based system, MAPS, would take in the overall function of the computer facilities and information systems at APRE, can be shown as in figure 4.1. This was the model suggested to the users, and corresponded closely to the actual technical situation. Utilities apart, most of the units in the diagram existed prior to MAPS: there were two basic differences with the introduction of MAPS.

Firstly, prior to MAPS (see figure 3.2), most of the knowledge existed on a paper basis only, with access either through the library, or on personal book shelves. Where knowledge was of a mathematical nature, this was all too often worked through on pocket calculators, which, although having their place in many systems, do not lend themselves well to the handling of large amounts of data.
The second difference was that with the introduction of MAPS, many of the existing facilities would be available through one system (figure 4.1., items 1, 3, 4, 7 and 8). This would allow the interface to be standardised across all of them, creating a greater level of consistency. Additionally, it would help ensure easier access to the data via terminals in the majority of offices in the building.

Items 2 and 3, (personal files and consultation with other staff, figure 4.1), would continue to play an important role alongside MAPS. Consultation with other staff should take place both with the aid of MAPS, and in person as before.

Items 5 and 6, (own programs run on a micro computer, and also on mini computers, respectively, figure 4.1), would still exist, but hopefully in greatly reduced numbers, MAPS making similar programs available to everybody, and (again) with a more consistent interface design.

In conclusion, MAPS would become a component of a new enquiry handling system, preserving the best aspects of the old one. This can be seen by comparing figure 4.1 and figure 3.2.
Figure 4.1 - MAPS in The New Enquiry System

RESOURCES

1. LIBRARY AND DBA DATABASE
2. PERSONAL FILES
3. CONSULTATION WITH OTHER STAFF
4. POCKET CALCULATOR (available on screen)
5. OWN PROGRAMS ON MICRO COMPUTER
6. OWN PROGRAMS ON MINI COMPUTER
7. PAST SURVEYS AND TRIALS RESULTS
8. SHARED SOFTWARE ON MINI COMPUTER

STILL REQUIRED ALONGSIDE MAPS
MINIMAL REQUIREMENT

LIBRARY STAFF
SCIENTIFIC STAFF

PERSONNEL

ENQUIRY

SOLUTION

Directors
Assistant Directors
Section Heads

Many interactions take place within senior management to determine optimum use of resources/staff to answer enquiry.
4.5. MAPS and The Typical Enquiry

The Applied Physiology (AP) Division of The APRE concentrates on the physiological well being of the soldier. It receives a wide range of enquiries.

A hypothetical enquiry was illustrated in chapter 3 (see section 3.4.2.1.) during the study of the existing enquiry handling system. For convenience, this is presented again in the following section.

4.5.1. The Question (as section 3.4.2.1.)

Summary of the contents of a hypothetical letter to APRE

"A worker at a steel mill has to carry out maintenance work on equipment in a hot environment. He is wearing metal splash protective clothing, and the environment is hot and humid (32 degC air, 70%RH). He is also required to carry equipment on his back of some 15kg. He normally works for one hour under these conditions, the tasks being only light manual duty (excluding carriage of load). Although this is not a military situation, it is hoped that similar situations may arise during Army operations, where heat, protective clothing, and load carrying are involved. If so, could you advise on any heat stress and fitness problems that may be encountered."
4.5.2. Answering The Enquiry (With the aid of MAPS)

In section 3.4.2.2., the path through the existing enquiry system was documented for the preceding hypothetical enquiry. The stages were labelled A - F. In the following section, the text in bold and underlined represents the new paths that may be possible using the MAPS system.

[A] As previously, the enquiry may arrive at any point within senior management, or directly to a particular member of the scientific staff. With the availability of MAPS, more information will be readily available at all staff levels, therefore increasing the percentage of enquiries that may be answered at the point of entry into the organization. Assuming, as previously, that the decision has been made to direct the enquiry to a particular expert with appropriate experience, the process may proceed as follows.

[B] For the purpose of this example, we will assume a thermal expert is now proceeding with the enquiry. He/she may obtain additional information about the environment from the client. As before, he/she will want to know whether any previous studies have been carried out, either military or not, on similar working conditions. This information will be held by the library, recorded on the computerised database system, DBA. At this point he/she may log into the MAPS knowledge based system, and using the new interface to DBA, recover the required
past papers, if they exist.

[C] Remaining inside MAPS, he/she will select clothing from the main menu, and obtain an estimate of the clothing insulation, by entering information about the items being worn.

[D] Still within MAPS, he/she may select Manual Materials Handling from the main menu. By selecting a specific mathematical model for estimating the metabolic rate of load carriage, he/she may arrive at a suitable figure.

[E] Still within MAPS, he/she may use the collected data on clothing value, metabolic rate, and the environment, to run a computer program. This will select an appropriate model of thermal stress and run it for the given data, given the option of graphical output if required.

[F] Finally, he/she may draft a reply to the 'client', including any limits on the reliability of the answer given (limits obtained from MAPS). As before, he/she may well hand write the letter, but, the results of the thermal model, in both textual and graphical form, can be included, and forwarded to the typist as enclosures for the letter.

The stages A to F shown above, can be compared with those in section 3.4.2.2. for the existing enquiry handling system. As stated before (section 3.4.2.2.), many
assumptions and generalities have been made, and many other routes may be utilised in a real situation. In practice the organization would be adaptable and flexible, responding to each enquiry in a suitable manner. It may also still be necessary for the thermal expert to consult either, or both, of the clothing and materials handling experts. What it was hoped MAPS would achieve, is the option of a short cut, if feasible, in a particular enquiry.

In section 3.4.2.2., the enquiry was represented by a flow chart (figure 3.3). This flow chart can be adapted to show a possible route using MAPS (figure 4.2)

![Flow Diagram](image)

**Figure 4.2 - Flow Diagram (Example Enquiry using MAPS)**
4.6 Expected Frequency of Use

The nature of the proposed MAPS system is such that the knowledge base would continue to grow for many years. It may never be considered complete, as there will always be gaps to fill in its store of knowledge programs. This means that it would be used to answer some of the incoming enquiries, but not all of them. Also, any one expert would predominantly deal with enquiries relating to his own area of expertise. It could be anticipated that users would be relatively infrequent. It was also felt to be prudent to consider users as discretionary, as the majority of the information required to answer an enquiry would be able to be found outside MAPS.

4.7. Chapter Summary

It has been suggested in the content of this chapter that a significant contribution could potentially be made by some form of knowledge based system. This would be used to aid in the drawing together of expert information. In order to best match the system to the needs of both the users and the establishment overall, a list of target areas was proposed, and then each item described in some detail (see section 4.1). It was then important to have a clear profile of the user to help in designing the interface.

The expected type of enquiry was described, but it should
be noted that flexibility was the key in this area. If users were to subsequently find MAPS more useful in, for example, preparing reports or processing new survey data, this would have to be taken into consideration when, or if, this situation arose.
5. DEMONSTRATION SYSTEM (MAPS1)

5.1 Introduction

It had been agreed to call the the final knowledge based system MAPS (Modular Applied Physiology System): the demonstration system was therefore called MAPS1. It was made available approximately six months after the commencement of the project. MAPS1, and its role within the overall project was outlined in section 1.4.4.

5.2. Aim

There were two parts to the aim for the demonstration system (MAPS1). Firstly, to supply a source of early user feedback, before any commitment had been made in either design criteria or hardware/software purchase. This would hopefully allow a more objective decision to be made in the light of response by users of the package. It had been explained to the users that MAPS1 was simply a first impression of what was required, and that their response was needed to move forward towards the first prototype.

Secondly, it supplied a means of introducing the project to the users. Prior to the introduction of MAPS1, few members of the organization had been in contact with a knowledge based system. It allowed the developer of the software to be integrated into the organization, and to have a clear purpose in the eyes of the other staff members.
5.3. Method

5.3.1. Technical Details

At the outset of the project, a survey was carried out to document the tools available for developing expert or knowledge based systems, as well as current research and development techniques. The information collected is incorporated in chapter 2. The outcome of this investigation helped in the choice of system architecture for the first demonstration system, MAPS1.

MAPS1 was written using just two conventional software tools already available at The APRE, these being the computer’s own operating system (Digital Equipment Corporation (DEC) VMS), and the high level programming language FORTRAN 77 (DEC implementation).

The main shell consisted of a series of VMS command procedures, in a shallow nested structure. These in turn called a set of FORTRAN executable programs which made up the majority of the knowledge base. A diagram of the basic technical structure can be seen in figure 5.1.

There were twelve disk subdirectories (storage areas), containing the programs and data. Nine of these were devoted to the nine areas of applied physiology (see section 6.2). The first command procedure to run when a user requested MAPS, was a short routine to locate the

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specific areas of the disk drive used to store the various components of MAPS. This ensured that any changes made to the computer system, necessitating a move to a different disk location, could easily be achieved by altering this first command procedure. Descriptions of each command procedure in MAPS1 can be found in appendix A.

Figure 5.1 - Technical structure of MAPS1 (see appendix A for technical specification)
5.3.2. Screen Layout and Interface Design

At this stage of the project, it was important to avoid becoming committed to one particular interface design methodology. It was therefore decided to adopt a simple menu selection system, using text files and the computer's own operating system (see appendix A for details). The Smith and Mosier (1984) guidelines suggest menu selection as suitable for untrained users. There was no investment in commercial software or hardware at this point in time, so had the user evaluation identified that an alternative structure be adopted, the decision could be made without bias. The design could be user driven almost from the outset.

The knowledge domain was split into nine areas of applied physiology (figure 5.4). The headings were chosen to match those already in use in the manual enquiry system. Figures 5.2 through 5.12 show a simple MAPS1 enquiry and the screens involved. The user's response is indicated in parentheses at the foot of each screen.

In this example, the area of interest on the main menu is Anthropometry (figure 5.4). The user is not going directly to a specific item of software (figure 5.5), the direct route would only be taken if the knowledge program was already known. In figure 5.6, MAPS1 narrows down the area of interest to 'Fatness/lean body mass'. The following page (figure 5.7) ascertains that an estimation is
required. An estimate is required on an individual set of data, as opposed to a large group of subjects (figure 5.8). At this stage MAPS1 offers a range of knowledge programs appropriate to this situation. The user then declares that he/she is interested in body surface area (figure 5.9). MAPS1 now calls up the FORTRAN knowledge program to aid in solving the problem, offering the option to run the program or quit and return to the MAPS1 screen. After every run through the program, the begin and quit page would be returned to. To simplify the case, it is assumed a run has been performed, so Q to Quit is selected (figure 5.10). Finally the user is returned to the main menu (figure 5.11), where the choice is made to exit the system by typing 'E'.

Figure 5.2 - Initial Welcome Screen

(Response = Return)
PLEASE NOTE: For most programs in the MAPS1 system the 'LOCK' key should be in the on position. Please check this now.

Do you require instructions on how to use the system?

PLEASE ANSWER Y OR N:

Figure 5.3 - Instructions option

(Response = N)

* = AVAILABLE

WHAT IS YOUR AREA OF INTEREST ?

LEVEL 1

* 1. Physical fitness
   2. Clothing
* 3. Anthropometry
* 4. Thermal stress & water requirements
  5. Development & troop trials
* 6. Physical Stress & Performance
* 7. Noise & Vibration
  8. Personal Protection
* 9. Army Occ. Health Research Unit

*10. General literature (DBA)
*11. Conversion of units

PLEASE ENTER CODE NUMBER (1-10)
OR TYPE 'E' TO EXIT FROM SYSTEM:

Figure 5.4 - Main Menu

(Response = 3)
DO YOU REQUIRE ACCESS TO A SPECIFIC ITEM OF ANTHROPOMETRY SOFTWARE?

PLEASE ANSWER 'Y' OR 'N': [ ]

Figure 5.5 - Specific Software Option
(Response = N)

* = AVAILABLE

WHAT IS YOUR AREA OF INTEREST?

* 1. Population measures
   2. Effects of clothing
   3. Dynamic anthropometry
   4. Photogrammetry
   * 5. Fatness/lean body mass

A. New anthropometry enquiry

Type "M" to return to main menu
Type "E" to exit from system

PLEASE ENTER CODE NUMBER:

Figure 5.6 - Area of Interest
(Response = 5)
Figure 5.7 - Estimate or Literature
(Response = 2)

Figure 5.8 - Estimation Needs
(Response = 1)
Figure 5.9 - Choice Of Estimation

(Response = 1)

Figure 5.10 - Knowledge Program Front Page

(Response = Q)
Figure 5.11 - Main Menu

(Response = E)

Figure 5.12 - Closing Screen

THANK YOU FOR USING THIS SYSTEM

If there is anything you would like to see changed, improved or added, please send a message through 'mail' to

WADSWORTH

Or contact me in the computer porta cabin
5.3.3. User Documentation

Two documents were produced and circulated to users of the system. The first (Appendix B), contained brief instructions on how to utilize the system. The second document listed the current knowledge content of MAPS1.

The list of current knowledge was periodically updated and recirculated.

5.3.4. Presentation to Users

MAPS1 was introduced to the potential user population in groups of around six or seven. The presentation included the circulation of user documentation (see section 5.3.3.), a 'live' demonstration of how MAPS1 worked, and a question and answer session.

Users were made aware of the nature and structure of the research programme, and approximately what they could expect to see at various stages.

The response was such that there was a rapid uptake in the use of MAPS1. Additional knowledge was also forthcoming, to be included in the system where possible and appropriate.

5.3.5. Monitoring Usage

In line with the aim of collecting early user feedback,
MAPS1 incorporated an automatic report mechanism. This allowed monitoring of the software at all times, without the presence of an observer. Every time MAPS1 was entered, a file was appended with information regarding the session. This included: when and where the login had taken place; every key press made; whether any errors took

Figure 5.13 - Example of the file produced by the automatic report mechanism in MAPS1, 2 and 3

place; and the duration of the session. In addition, a mail message was sent to the developer’s terminal on entry and exit of MAPS1.

The sum total of all this information was the ability to respond quickly to day to day problems and enhancements to the software. This further encouraged feedback from the users, as the quick response time was recognised.
In particular cases, the mail message allowed the developer to approach the user who had been having problems, the same day, if not within minutes, of the situation occurring.

It was hoped that summation data collected from the report file could be used to monitor long term trends in frequency of use of the system. An example of the report file format can be seen in figure 5.13.

5.4. Assessment of MAPS1

5.4.1. Aim

The aim of the assessment was to obtain feedback from the users on the design of MAPS1. There was a limitation on the amount of time that individual experts could justify spending on work associated with the development of MAPS. For this reason, it was decided to better utilize the time involved for subjects in the assessment. The assessment would therefore act as a tutorial in addition to an evaluation, helping to encourage use of the system.

5.4.2. Method

5.4.2.1. Subjects

There were a total of twenty subjects. These were all APRE staff, the majority of them being from the Applied Physiology (AP) Division. They were all either existing,
or potential, MAPS1 users. Each one was an expert in at least one of the areas of Applied Physiology used in MAPS1, with the exception of one or two administrative staff members. Their range of knowledge of how to use computers was from totally naive to proficient. They were all aware of the MAPS project and its aims.

5.4.2.2. The Exercises

A series of exercises was devised for completion using MAPS1. There were seven in total, and these were graded by the amount of guidance given to complete the task. In the first instance, the subject simply had to follow a set of MAPS1 commands to arrive at the solution. Towards the end of the exercises only the problem was presented, and the subject had to arrive at the solution using MAPS1. On completion of each exercise the subject had to assess the task on two adjective scales, these being EASY-DIFFICULT, and FAST-SLOW. By using graded tasks of this type, the evaluation took the form of a tutorial in addition to an assessment of MAPS1. A copy of the exercises, as presented to the users, can be seen in appendix C. They can be seen in summary form in table 5.1.

5.4.2.3. The Questionnaire

After completion of the exercises, the subject was asked to complete a questionnaire. This comprised several adjective scales, together with an opportunity to add
comments. The adjective scales were similar to those adopted by Osgood et al (1957) in his method of semantic differentials. An example of the questionnaire can be seen in appendix D, and summarised in table 5.2

5.4.2.4. Experimental Protocol

1. On arrival, subjects were asked if they minded a voice recorder being used during the experiment. If there was no objection, a tape drive was started.

2. Subjects were given a sheet of text explaining the purpose of the experiment, together with instructions on how to complete the adjective scales to be presented later.

3. They were then given five minutes to try MAPS1 in any way they wanted.

4. They were then asked to complete the series of exercises, presented on a typed sheet. They were told guidance would be available, if they could not proceed.

5. After each exercise, they were asked to complete two adjective scales, presented at the end of each exercise on the printed sheet.

6. On completing all the exercises, the subject was asked to fill in the questionnaire, comprising both adjective scales and space for comments.
<table>
<thead>
<tr>
<th>Exerc.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>For a clothed subject in a heat stress situation, run the Gagge and Nishi prediction model for the given set of environmental and subject variables. Print out the results.</td>
<td>2</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>Full instructions were included. Printing out the results required use of the computer's 'print' command.</td>
</tr>
<tr>
<td>B</td>
<td>Find all the available literature on dehydration in the heat. Note record numbers for future reference.</td>
<td>4</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>This required use of the DBA database system, but with full instructions.</td>
</tr>
<tr>
<td>C</td>
<td>Find the estimation of metabolic rate according to Pandolf et al, for a man walking up an incline with a load.</td>
<td>6</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>Only guidance given was to indicate which branch of the main menu contained the solution.</td>
</tr>
<tr>
<td>D</td>
<td>Given a set of skinfold measurements, find the best estimate of percentage body fat.</td>
<td>8</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given, but all required data listed in logical form.</td>
</tr>
<tr>
<td>E</td>
<td>(I) What is the range of and average, sitting height of Guardsmen in the British Army. (II) What is the correlation between sitting height and shoulder height for Gurkhas in the UK.</td>
<td>10</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Given the measurements of noise levels of a military weapon, determine whether it is within safe limits to avoid damage to hearing.</td>
<td>12</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given. Data found in description of the problem.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>Given a situation where a mechanic is required to work in a hot environment, and the environmental measures are given. Determine the length of time he can work in these conditions, without risk of heat stress.</td>
<td>14</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given. Data found in description of the problem.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>Quest.</td>
<td>Description</td>
<td>Scale</td>
<td>Adjectives</td>
<td>Scores</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
<td>----------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS1 in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS1, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>required to use the system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Uncrowded - Crowded</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options</td>
<td>17</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>18</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS1</td>
<td>22</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>as a method of retrieving individual programs</td>
<td>23</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>When working outside your own area of interest, how would you describe the</td>
<td>26</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>guidance given</td>
<td>27</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
<td>Helpful - unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>29</td>
<td>Too much - Too little</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS1 on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Useful - Useless</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>34</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>Crowded - uncrowded</td>
<td>7 - 1</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2. - MAPS1 Summary Questionnaire Details
(See appendix D for full details)
5.4.2.5. Experimental Conditions

Each user session took place in a normal office environment. This included general background noise, such as printers, telephones and general conversation amongst colleagues. The experimenter (the author) made observations throughout the session, noting where confusion or hesitation was evident. The only restriction was that the subject was not interrupted to complete any secondary tasks, for example answering the phone. The conditions were therefore as close to the normal working environment as possible.

5.4.3. Results

5.4.3.1 Exercise Scale Results

The mean response to the scales presented after the exercises, can be seen in table 5.3 and figure 5.14. Two scales were presented after each exercise, these being EASY - DIFFICULT and FAST - SLOW.

It can be noted that the responses are towards the top end of the scale in each case, thus reducing the definition of the information obtained. Ideally, this would suggest that all the tasks were generally found to be both EASY and FAST to complete. It must, however, be noted that the questions were tailored to match the capabilities of MAPS1, and not simply a set of random problems. Also, the first exercises supplied all the relevant keystrokes to
Table 5.3. - MAPS1 Exercise Results
(higher values imply better performance)
(see table 5.1 for exercise details)

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>5.80</td>
<td>3.00</td>
<td>7.00</td>
<td>1.21</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5.65</td>
<td>3.00</td>
<td>7.00</td>
<td>1.28</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>5.74</td>
<td>2.00</td>
<td>7.00</td>
<td>1.29</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5.45</td>
<td>2.00</td>
<td>7.00</td>
<td>1.24</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>5.65</td>
<td>4.00</td>
<td>7.00</td>
<td>0.73</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>5.75</td>
<td>4.00</td>
<td>7.00</td>
<td>0.94</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>8</td>
<td>6.30</td>
<td>5.00</td>
<td>7.00</td>
<td>0.71</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>6.35</td>
<td>5.00</td>
<td>7.00</td>
<td>0.57</td>
<td>20</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>5.84</td>
<td>4.00</td>
<td>7.00</td>
<td>0.93</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>6.00</td>
<td>4.00</td>
<td>7.00</td>
<td>1.03</td>
<td>19</td>
</tr>
<tr>
<td>F</td>
<td>12</td>
<td>6.00</td>
<td>4.00</td>
<td>7.00</td>
<td>0.84</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>6.30</td>
<td>5.00</td>
<td>7.00</td>
<td>0.71</td>
<td>20</td>
</tr>
<tr>
<td>G</td>
<td>14</td>
<td>5.58</td>
<td>4.00</td>
<td>7.00</td>
<td>0.94</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>5.84</td>
<td>5.00</td>
<td>7.00</td>
<td>0.67</td>
<td>19</td>
</tr>
</tbody>
</table>

Figure 5.14 - MAPS1 Evaluation
Exercise Responses Scales 2 - 15
(higher values imply better performance)
(see table 5.1 for exercise details)

145
complete the task, and should therefore be found easy to complete.

With the exception of exercise A, all subjects were able to complete the tasks, but again, it must be noted that in some cases guidance was given by the experimenter. Consequently, it would be meaningless to look at the rate of completion of a task as an indicator of the performance of MAPS1.

Exercise A was the only task where users were requested to print out the results. All subjects completed the first part of the exercise, but very few could successfully print out the results without intervention by the experimenter. The implications of this are discussed in section 5.4.4.4.

5.4.3.2. Questionnaire Scale Results

Table 5.4 and Figures 5.15 to 5.17 show the results from the questionnaire scales.

The results of the assessment suggested that the majority of the subjects found the system easy to use, and appropriate to the situation (see figure 5.17, question 13, 'Overall how would you rate MAPS1'). However, as with the exercise scale responses, these results should be viewed in the light of the choice of exercises, and the level of guidance given (see section 5.4.4., Discussion).
<table>
<thead>
<tr>
<th>QUESTION NO.</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3.25</td>
<td>1.00</td>
<td>6.00</td>
<td>1.44</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.25</td>
<td>1.00</td>
<td>6.00</td>
<td>1.34</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4.75</td>
<td>1.00</td>
<td>7.00</td>
<td>1.81</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4.60</td>
<td>1.00</td>
<td>7.00</td>
<td>1.80</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>1.75</td>
<td>1.00</td>
<td>4.00</td>
<td>1.09</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>5.85</td>
<td>4.00</td>
<td>7.00</td>
<td>0.85</td>
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<td>8</td>
<td>5.55</td>
<td>3.00</td>
<td>7.00</td>
<td>1.24</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>2.40</td>
<td>1.00</td>
<td>5.00</td>
<td>1.16</td>
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</tr>
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<td>6</td>
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<td>1.00</td>
<td>7.00</td>
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<td>20</td>
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<td>11</td>
<td>1.50</td>
<td>1.00</td>
<td>2.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
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<td>12</td>
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<td>4.00</td>
<td>7.00</td>
<td>0.79</td>
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</tr>
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<td>5.80</td>
<td>4.00</td>
<td>7.00</td>
<td>0.87</td>
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<tr>
<td></td>
<td>14</td>
<td>5.60</td>
<td>3.00</td>
<td>7.00</td>
<td>1.20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>6.00</td>
<td>4.00</td>
<td>7.00</td>
<td>0.84</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>5.95</td>
<td>3.00</td>
<td>7.00</td>
<td>1.02</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>5.42</td>
<td>3.00</td>
<td>7.00</td>
<td>1.39</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>5.50</td>
<td>3.00</td>
<td>7.00</td>
<td>1.28</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>5.70</td>
<td>3.00</td>
<td>7.00</td>
<td>1.19</td>
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<td>3.00</td>
<td>7.00</td>
<td>1.06</td>
<td>20</td>
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<tr>
<td></td>
<td>21</td>
<td>5.80</td>
<td>3.00</td>
<td>7.00</td>
<td>1.03</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>6.17</td>
<td>5.00</td>
<td>7.00</td>
<td>0.76</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>6.24</td>
<td>5.00</td>
<td>7.00</td>
<td>0.84</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>6.28</td>
<td>4.00</td>
<td>7.00</td>
<td>0.80</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>6.29</td>
<td>5.00</td>
<td>7.00</td>
<td>0.75</td>
<td>17</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>6.00</td>
<td>3.00</td>
<td>7.00</td>
<td>0.97</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>5.95</td>
<td>3.00</td>
<td>7.00</td>
<td>1.02</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>6.20</td>
<td>2.00</td>
<td>7.00</td>
<td>1.12</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>3.90</td>
<td>2.00</td>
<td>6.00</td>
<td>0.83</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>1.75</td>
<td>1.00</td>
<td>2.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>31</td>
<td>6.00</td>
<td>4.00</td>
<td>7.00</td>
<td>0.71</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>6.05</td>
<td>5.00</td>
<td>7.00</td>
<td>0.67</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>6.35</td>
<td>5.00</td>
<td>7.00</td>
<td>0.57</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>6.30</td>
<td>5.00</td>
<td>7.00</td>
<td>0.56</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>6.10</td>
<td>5.00</td>
<td>7.00</td>
<td>0.70</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>5.95</td>
<td>4.00</td>
<td>7.00</td>
<td>0.74</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>6.35</td>
<td>6.00</td>
<td>7.00</td>
<td>0.48</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>5.70</td>
<td>3.00</td>
<td>7.00</td>
<td>1.05</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 5.4. - MAPS1 Questionnaire Scale Results
(see table 5.2 for questions)
### MAPS1 Evaluation Questionnaire Responses

**Table:**

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS1 in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS1, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
</table>

**Figure 5.15 - MAPS1 Evaluation Questionnaire Results Scales 2 - 11**

148
### MAPS1 Evaluation Questionnaire Responses

![Bar chart showing evaluation questionnaire responses.](image)

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12</td>
<td>Good - Bad, Clear - Unclear, Uncrowded - Crowded, Informative - Uninformative, Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options</td>
<td>17</td>
<td>Good - Bad, Informative - Uninformative, Helpful - Unhelpful, Appropriate - Inappropriate, Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS1 as a method of retrieving individual programs</td>
<td>22</td>
<td>Good - Bad, Appropriate - Inappropriate, Helpful - Unhelpful, Fast - Slow</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

**Figure 5.16 - MAPS1 Evaluation Questionnaire Results Scales 12 - 25**

149
<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale No.</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>When working outside your own area of interest, how would you describe the guidance given</td>
<td>26</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29</td>
<td>Too much - Too little</td>
<td>7 - 1</td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Y = 1, N = 2</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS1 on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Useful - Useless</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>Crowded - Uncrowded</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

Figure 5.17 - MAPS1 Evaluation Questionnaire Results Scales 26 - 38
5.4.3.3. Additional Comments By Subjects

In addition to the scale responses described in the preceding section, subjects were given space to add their own comments. In the main, this was to clarify their reason for the value response to the adjective scale. The results are presented in tables 5.5a and 5.5b, reproduced exactly as they were recorded by the subjects on the questionnaire. In general, it was noted by the experimenter that, in most cases, the option to make a comment was utilized to justify a low score on the scale response, judged by the subject not to be favourable towards MAPS1. Where scale responses were favourable, often no additional comment was included.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>Requires 2 to 3 attempts before fully understanding systems</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Easier with PMW (experimenter) behind me.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Mostly with operating system, rather than MAPS.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Not like DBA.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>General hesitancy as I wished to use it as a filing system, and I was unsure of how to apply DATS parameters.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Manual would help, to elaborate on commands and choices. Once the user overcomes his/her general hesitancy, it is a very easy system to use.</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>To ensure system is not inappropriately used.</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Did not know if I had gone down the right branch.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Needs an instruction system, Q vs E etc.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Only on the format of results from exercise G.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>I forgot the instructions.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Some purposeful drift, retaining sense of position.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>On last exercise I missed the answer and had no knowledge of how to return.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Moving in and out of the system, very quickly overcome.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>General unfamiliarity with use of DBA parameters.</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>Double space where possible, use more of available screen area.</td>
</tr>
</tbody>
</table>

Table 5.5a - Comments By Subjects (MAPS1)  
(see table 5.2 for questions)
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>Need to understand the names.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Good for me, as I tend to think in terms of research areas.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>The topic of clothing is very varied and future information may crowd the option.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Correspond loosely with APA project numbers and therefore quite helpful for those familiar with these.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>I feel that any combination of label choice would be open to criticism.</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>But only one program in my direct area of interest, other programs in the same field are possible.</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>There’s no substitute for knowing something about the subject, impossible to make the world idiot proof.</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Yes, when in anthropometry and DBA.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Yes, when a person is fully in with the system it may seem slow, but to a new person it was very fast.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Yes, only when using DBA.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Yes, when loading data base, but if it states waiting that’s ok.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Yes, literature search.</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>Speed of info display.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Can always try again without causing problems.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Logical arrangement of info. Speed, being able to search for any AP info.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Fairly quick and easy access to a range of complex material not often used and which would otherwise require extensive searching through own literature files.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>So simple to use.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Knowing that the data (if installed) is available in a fast and easily accessible form.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Considerably easier than expected.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>User friendly, don’t need to memorize the manual.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Easy access to specific areas of interest, with rapid return to access other areas of possible interest or use, MAPS is easy to use and understand.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Enjoyed this as a game.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Relative simplicity of system.</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>Confusion over topics.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Having to remember the order for returning to MAPS or quitting from a FORTRAN program.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>For an ignorant user, knowing what stage I was, the implication of y/n to <em>specific software</em> question.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Logging into VAX and operating system outside MAPS. Use of detailed parameters not always definable easily.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>No indication of relative usefulness of different models, nor indication of when a model is extrapolated beyond its design limits.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Learning when to quit, return to menu or return to subject.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Predictions can be made using data which lie outside of the range for which equations were intended with no warning or indication given.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Incompleteness of DBA filing system, is there a list of options, keynames and values defined.</td>
</tr>
</tbody>
</table>

Table 5.5b - Comments By Subjects (MAPS1)  
(see table 5.2 for questions)
5.4.4. Discussion

Several key areas could be identified as requiring further improvement or expansion (see following sections for discussion). These can be listed as follows:-

A. Movement within the knowledge tree
B. Availability of utilities
C. Ambiguous wording of questions
D. Printing out of results files
E. Location indicator
F. DBA interface

5.4.4.1. Movement Within The Tree Structure

Although some movement within the tree structure was available in MAPS1, this was seen by most users as inadequate. After making a mistake on a particular menu, the situation could not be corrected without returning to a point much higher in the knowledge base.

This was suggested by comments made on the questionnaire. In particular in response to question 15, comments [2], [3], and [6] (table 5.5b).

5.4.4.2. Availability of Utilities

The only 'utility' available was a program to convert units, and this could only be entered from the main menu.
Users had normally ventured a long way into the knowledge tree, when they found they required units conversion. In addition, it was felt by a significant number of users that other aids to report generation and general day to day tasks should be in the system. Possibilities included a statistics package and a graphics package.

There was no direct evidence of the need for easy access to utilities during the evaluation. However, the experimenter received informal feedback during the period MAPS1 was available on the computer, which made it appear worth pursuing further.

5.4.4.3. Ambiguous Wording of Questions

Although MAPS1 had been intended to avoid the use of computer jargon and misleading sentences, examples of these could be found. The question shown in figure 5.5,

'Do you require access to a specific item of ..... software ?'

invariably caused long periods of hesitation. When answering YES or NO, many people responded with 'yes' when they actually required guidance to the software. One comment was recorded by a subject specifically referring to this sentence (see table 5.5b, Question 15 comment [3]).
5.4.4.4. Printing Out of Results Files

The printing out of results files was the only part of MAPS1 that required the use of the operating system itself, at a very minimal level. Although this went slightly against the MAPS philosophy, it would have required more development work and a delay in releasing this early demonstration system. It was hoped that the knowledge required to print out files would not cause a severe problem.

In fact, the large majority of the subjects in the evaluation found it impossible to perform this task. The users most familiar with the computer system managed to remember the PRINT command, but then were unable to identify which printer within the establishment the output had gone to.

Only one comment was made on the questionnaire that may confirm this problem. That being to question 4, comment [3] (see table 5.5a).

5.4.4.5. Location Indicator

With reference to figures 5.4 to 5.9, the text in the top right hand corner of the screen was intended as an indication of the position within the knowledge tree. This corresponds with the levels shown in section 3.1 of the user guide (see appendix B).
There was no evidence from visual observations made during the evaluation that these indications of location were being adopted. Scale 11 (see figure 5.15, question 7) asked whether users felt lost at any stage. The responses were coded as yes=1 and no=2. As can be seen from figure 5.15, the mean response was between 1 and 2, therefore indicating a possible problem (Actual mean score of 1.5, see table 5.4).

No evidence of the value or otherwise of the level indicator can be found in the comments made after question 7 (see table 5.5a).

5.4.4.6. DBA Interface

Exercise B (see table 5.1) required use of the DBA database system to retrieve records on dehydration in the heat. Although all the instructions for every key press were given on the exercise sheet, the scale ratings were amongst the lowest, as can be seen in figure 5.14. scales 4 and 5. The actual mean scores were 5.74 and 5.45 respectively (see table 5.3). The comments made on the questionnaire, and to the experimenter, confirmed that substantial problems had occurred with the DBA interface. In particular see the following responses by users in table 5.5a and table 5.5b :-

Question 4  comment [4]

Question 7  comment [8]
In particular, there were clear difficulties in knowing the keywords required during search definitions (see figure 3.5).

5.5. Chapter Summary

As an early form of user feedback, MAPS1 worked effectively through the automatic report mechanism, day to day contact with the users, and the formal evaluation. As a knowledge based system it had many weaknesses, some of which were anticipated before its release, others which came as a surprise. It did, however, show that there was a role for a system of this general type in APRE, and that such a system may well improve the efficiency of enquiry handling. Much more work was needed in both the interface design, and expansion of the knowledge base.

The approach taken for the evaluation of MAPS1 clearly had restrictions in the objective data obtained, and subjective data could only be used on a general basis. However, the reason for using the evaluation jointly as a tutorial still stood. With practical constraints on both the availability of subjects, and the time individuals
could allocate to participating, the user sessions needed to be utilized fully. These conditions would still exist at the time of the evaluation of MAPS2. It was anticipated that the final evaluation of MAPS3 would be amended in order to become more objective. In particular, the user sessions would be conducted by an independent observer, and not the developer of the software. Consequently, in the meantime only small amendments were anticipated in the evaluation protocol for MAPS2.

To summarize, although MAPS1 was only designed as a demonstration system and the evaluation was simple, it could be concluded that MAPS1 was a working system. Some improvements were identified, but generally it looked as though the MAPS idea had potential.

As identified earlier, the knowledge for MAPS1 was included on simple criteria, and no formal method of expanding the knowledge base had been proposed. There was a need for a structured approach for future prototypes. This issue is addressed in the following chapter.
6.0. CONSTRUCTION OF THE MAPS KNOWLEDGE BASE

6.1. Stages In The Process

Figure 6.1 represents the stages involved in moving from the initial identification of the boundaries of the knowledge base, through production of a working knowledge program, or 'unit', to future expansion.

Figure 6.1 - Stages In The Knowledge Base Development
6.2. Dividing The Subject Area

When the author first started work on site at The Army Personnel Research Establishment (APRE), one of the first tasks was to study the existing system of enquiry handling. This was discussed at some length in chapter 3. During this phase, it was also necessary to identify the boundaries of the knowledge to be covered by MAPS, and how this could be split up into logical areas. This would then form the main menu of the knowledge based system.

As part of the existing organizational structure at APRE, there existed a break down of the Applied Physiology field into more specific areas of the subject. This was in use for cataloguing projects and internal reports. It was therefore logical to adopt this, as the resident experts were already familiar with the headings involved. The final list was as below.

1. Physical Fitness
2. Clothing
3. Anthropometry
4. Thermal Stress & Water Requirements
5. Manual Materials Handling
6. Noise
7. Vibration
8. Personal Protection
9. Army Occ. Health Research Unit (AOHRU)
These were the final headings used in MAPS3, and only differed slightly from those used in the demonstration system, MAPS1, and later in MAPS2. Clearly, item 9 in the list is the odd one out, as it is not an actual subject area. In fact, it defines a group of experts within APRE. It could be assumed that personnel would have an idea of the responsibilities of personnel under this item number (predominantly occupational health).

It should be noted that the list was tested during user evaluations of all three versions of MAPS, and any slight alterations were in response to information gathered.

6.3. Knowledge For The Demonstration System (MAPS1)

As MAPS1 was intended as an early demonstration system, very little time could be allocated to development of the knowledge base. For this reason, the criteria used to decide on the first knowledge units to be written and included differed from that adopted in later versions of MAPS. They were selected on the basis of their usefulness to particular members of the potential user population. This would help encourage use of the system, while the knowledge base was still relatively small. Knowledge elicitation was very modest, and unstructured. In many cases, knowledge units were developed simply because an expert approached the knowledge engineer (the author), and suggested a useful program. It had been pointed out at informal meetings that suggestions would be welcome. No
standard interface for each knowledge unit was formulated, except for a standard front page, indicating to users that they were entering a knowledge program/unit. This can be seen in figure 5.10.

6.4. Knowledge Elicitation For MAPS2 Onwards

6.4.1. Introduction

It was necessary to approach the development of the final knowledge base in a more formal, logical manner. The first task was to select a method of knowledge elicitation. The variations available were described in chapter 2 (section 2.8.). Given the nature of the knowledge domain, it was decided to adopt aspects of three of the methods discussed in section 2.8.2. These were:

(A) Interviews
(B) Observation of an Expert Working
(C) Protocol Analysis

It was decided that none of the indirect methods available were appropriate to MAPS, including repertory grid techniques (see section 2.8.3.). The main reason for this was the nature of the knowledge involved. It could be seen from the knowledge forthcoming for inclusion in MAPS1 that the main task facing the knowledge engineer was in determining the range of facilities required within a particular subject area, rather than generating sets of
rules to describe the knowledge. Many of the sources of knowledge were available prior to the MAPS knowledge based system in various forms, either computerised or on paper. In most cases they comprised mathematical equations, and were not particularly rule based.

Indirect methods aim to arrive at a set of rules to explain the knowledge, and have little to offer in arriving at a description of the facilities required to solve a given problem. The MAPS knowledge based system was essentially a computerised version of some of the components of the existing manual method of enquiry handling, or more correctly a component of the overall new enquiry handling system.

Two or three items on the main menu were tackled for MAPS2, and a further two or three for MAPS3. The appropriate expert was identified, and a meeting arranged.

6.4.2. The Knowledge Engineer

A term often used in knowledge based systems projects is that of the 'knowledge engineer'. In general this refers to the individual with the responsibility for transferring the knowledge of the expert into a form suitable for computer representation.

In the early stages of the project, the knowledge engineer was the developer of the MAPS software (the
author). Later in the project life cycle, the opportunity was taken to employ a team member with expertise in some of the nine areas of physiology included in MAPS. Therefore, in later stages of development of the knowledge base, the knowledge engineer was better equipped to communicate directly in the experts own 'language'. This also meant that the knowledge engineer in some cases was the source of knowledge, to complement that acquired from the experts at APRE. This involved sources from outside APRE, for example other experts (eg. from the Human Sciences department of Loughborough University), and standard text and papers.

6.4.3. Identifying The Experts

The first task was to identify the appropriate expert for each area of Applied Physiology. Although the main criterion was that they should possess expertise in the knowledge domain, it was also important to look at their personality. This would help determine the likelihood that they would cooperate in the exercise, and to some extent dictate the exact form the meeting would take. Special attention was given to the level of computer knowledge they possessed, as well as the gap between the knowledge of the expert and that of the knowledge engineer.

6.4.4. Formal Sessions With The Expert

Firstly, the expert was asked whether any example
enquiries could be identified. If this was feasible, he/she was asked to discuss, or talk through, the resources used in answering the problem. The sessions were informal, and as such the method of observation could be varied throughout. Where appropriate, the expert talked through his/her tactics, but was allowed to interrupt this whenever he/she thought of useful material to be included in the knowledge. In effect, the expert was allowed to control the interview, and self select the knowledge elicitation method used, from one problem to the next.

6.4.5. Knowledge Tree Diagrams

At a later stage in the project, to help accelerate the input of new knowledge to the system, approximate knowledge trees were drawn up for most of the areas in the main menu. These were produced as a result of an earlier formal session with the expert, as described in the preceding section, 6.4.4. Alternatively, where no session had yet taken place, they were based on the level of expert knowledge held by the knowledge engineer and knowledge elicited from other sources. They were circulated to the current/potential users of MAPS, for their comments, corrections, or additions. The diagrams can be seen in figures 6.2 - 6.8. Personal protection and The Army Occupational Health Research Unit (AOHRU), were not covered at this stage of the project. Small changes took place in the structures shown, up to the completion of the final MAPS system.
Figure 6.2 - Tree Diagram For Physical Fitness

- Surveys
  - Muscle Strength
    - isometric
    - isokinetic
    - Literature
  - Muscular Endurance
    - Wingate
    - Bruce
    - Lakomy
    - Thorstonson
    - Margaria
    - isokinetic
    - Literature
  - Aerobic Fitness
    - VO2 Max
    - Indirect tests
    - NATO
    - Astrand Nomogram
    - BFT
    - Literature
  - Performance Enhancement
    - Carbohydrate loading
    - Literature
- Assessment
- Training
  - Muscle Strength
  - Muscular Endurance
  - Aerobic Fitness
Figure 6.3 - Tree Diagram for Clothing

- Thermal Comfort
  - Heat balance equation
  - Insulation/ permeability
  - Physiological responses
- Physical Properties
  - Fibre Types
  - Insulation values
- Sleeping Systems
- Extremities
  - Protection
  - Thermoregulation
  - Ergonomics
  - Pathology
- Performance Effects
  - Respirators
  - Incumbrance
- Protective Clothing
  - NBC
  - Immersion suits
  - Auxiliary Eqpt
  - Body armour
  - Water resistance
  - Flame resistance
  - Ballistic protection
  - Chemical resistance
  - Insect resistance
Figure 6.4 - Tree Diagram For Anthropometry

Anthropometry

Body surface area estimation
- Skinfolds
  - Calf, arm and wrist
  - Circumferences and height
  - Natick data

Survey results
- British Army survey
- US-AMRL survey 1967
- Survey of ski teams

Data handling
- User supplied data file
- V/P raw data for body fat programs
- Analysis of the above

Literature
Figure 6.5 - Tree Diagram for Thermal Stress and Water Requirements
Figure 6.6 - Tree Diagram For Manual Materials Handling

Manual Materials Handling

Industrial health & safety guidelines
- Niosh
- Force limits
- HSE 82
- CEC 85
- Psychophysical 78
- Def Standard 85
- Team lifting
- Literature

Metabolic rate estimation for load carriage
- Body load
  - Givoni/Goldman 71
  - Garg 78
  - Mahanty 83
  - Literature
- Arm load
  - Morksey/Liou 84
  - Randie 84
  - Randie 86
  - Stretcher Bearing
  - Literature

Maximum Capabilities
- Single lifts human strength
  - MLC
  - Max strength
  - PSD
  - Dynamics
  - Isoresistive
- Repetitive lifting
  - Legg & Pateman 83
  - Pateman & Clark 85
  - US Data 87
  - Lifting specific objects (e.g., military handling)
  - Literature
Figure 6.7 - Tree Diagram For Noise

- Principles
  - Physical principles
  - Application to Ergonomics
- Continuous noise
  - Communication
  - Hearing loss
  - Non-Auditory health effects
  - Vehicle noise
    (internal & external)
- Impulsive noise
- Performance effects
  - Auditory effects
  - Non-Auditory health effects
  - Def Stan 00-27
- Measurement analysis
Figure 6.8 - Tree Diagram for Vibration
6.5. Producing Working Knowledge Programs

6.5.1. Introduction

It was intended that the knowledge base for MAPS would continue to grow over many years, as well as being updated in the light of new research. Some of the items on the main menu were not developed beyond producing the tree structure, shown in figures 6.2 - 6.8. A small selection of knowledge programs useful to key members of staff were included. However, it was possible to fully develop some of the other main menu items. This involved a procedure to move from the aforementioned tree diagrams, to a computerised knowledge base. The following sections explain the methods used to bridge this gap.

6.5.2. The Paper System

After completion of the knowledge elicitation stage, described in section 6.4., an extensive paper based report was produced. This outlined what methods and techniques were available to solve any given problem. Included were items such as relevant British and military standards, together with any equations, with full instructions on how to apply them. In addition, any mathematical models for estimating solutions to a problem were described, and application methods detailed. Sources of literature and raw data were documented. The report was in such a format that it contained all the information a computer programmer would require to write working programs.
6.5.3. The Standard Knowledge Program Interface

To shorten the time required to code a program, debug it and install it into MAPS, two standard interfaces were designed (one for text and one for equations). Subroutines were written in FORTRAN77, which could be used to duplicate knowledge programs for different equations and textual information. These are described fully in chapter 8 section 8.

6.5.4. Quality Control

It was vital that users could be confident that any item of knowledge, or processing of an equation, was correct and up to date. To this end, data sheets were produced for each knowledge unit. This gave details of the source of any information or equations, and where possible, test data.

6.5.5. Keeping the User Informed

It was important to promote any new knowledge programs, as soon as they were added to the system. This was achieved in two ways. Firstly, a list of all the knowledge programs was constantly updated, and periodically circulated to users. Secondly, the 'new news' facility in MAPS (see 8.5.4) carried information on the latest additions to the knowledge base. This would be presented as the first page of MAPS3, if the system detected that the news had not yet been displayed to that particular user.
6.5.6. The Computerised Development Environment

To help speed up the process of adding an executable knowledge program to the main system, adding/deleting registered users, and typing in new news items, a development environment was written. This was not intended to be used by non-programmers, and as such was not as user friendly and robust as MAPS itself. It was a tool for the developer of MAPS, in this case the author. It could potentially have been used to maintain the system in the absence of the original developer. Additional facilities made it a convenient method of editing and debugging MAPS, as well as updating copies of MAPS on other computers. An example of the screen layout can be seen in figure 6.9.

![MAPS3 Development Environment Example Screen](image)

Figure 6.9 - MAPS3 Development Environment Example Screen
6.6. Chapter Summary

The MAPS system covered a wide area of Applied Physiology, and as such would grow in its knowledge content for several years. It was with this in mind that methods for the expansion of the aforementioned knowledge base were created, and discussed in this chapter. Important components of this included:

(A) A flexible method of knowledge elicitation
(B) A set of subroutines allowing quick coding of new programs, and maintenance of a standard interface design.
(C) A mechanism to keep users informed of newly added knowledge.
(D) A development environment to allow maintenance of both the knowledge base, and the system itself.

Some of these components were only developed during the latter stages of the project, but knowledge elicitation, and keeping users informed of the knowledge added, were important to some degree from the launch of the first demonstration system, MAPS1. They were refined with the introduction of each new version of the package.

Most of what is described in this chapter, was introduced at the same time as MAPS3, described later in chapter 8.
7. THE FIRST PROTOTYPE (MAPS2)

7.1. Introduction

The first full prototype was named MAPS2. It was made available to users approximately 18 months after the commencement of the project. It followed on logically from the demonstration system (MAPS1), but was fundamentally different in a number of ways. As minimal resources had been used to develop MAPS1, it was not necessary to keep with the basic framework, and new ideas could be incorporated where appropriate.

After a full review of the information forthcoming in the evaluation of MAPS1, many changes were made to ensure that the design more closely matched the needs of the user, and the organization. These will be described in some detail later in this chapter.

The automatic report mechanism used in MAPS1 was continued in the new system, supplying a good form of feedback on a daily basis. Many weaknesses in the system were identified by examination of the results file generated (see figure 5.13).

7.2. Aim

MAPS2 was intended as an implementation of improvements suggested by the users, either directly, or via the evaluation of MAPS1. It made available a larger range of
knowledge programs, thus making MAPS2 a practical system for a larger group of the user population.

7.3. Method

7.3.1. Technical Details

7.3.1.1. Reappraisal of MAPS1 Methodology

As described in chapter 5, MAPS1 was written in the computer’s operating system, with the majority of the knowledge base produced using FORTRAN 77. This served the purpose very well, and after further investigation of tools available, still appeared to be the best approach. The structure of nested command procedures, (one main procedure, in turn calling a command procedure for each of the subject areas), offered a convenient breakdown of the coding. The incorporation of utilities such as the literature database, and the units conversion program, would need further development work in MAPS2.

7.3.1.2. MAPS2 Technical Details

The adoption of DEC/VMS command procedures and FORTRAN 77 remained essentially unchanged. The structure of each of the individual subject command procedures was improved to move towards a more modular approach, with less repeated sections of coding. Handling of errors, both computer and user, was further improved to increase reliability of the system when in use.
Figure 7.1 - Technical structure of MAPS2

Command Procedure to Locate Maps on Disk

Master Command Procedure Including Main Menu

Functions Command Procedure

Item 1
Command Procedure

Item 2
Command Procedure

Item 3
Command Procedure

Fortran Knowledge Programs
Although the technical structure was similar to that described for MAPS1, and illustrated in figure 5.1, some additions were made. These were centred around the calling of utilities. This now required its own command procedure. The revised technical structure can be seen in figure 7.1.

7.3.2. Improvements over MAPS1

7.3.2.1. Movement Within The Tree Structure

Movement within the knowledge tree of MAPS1 was very limited. In most cases, if the wrong answer had been entered, the user would have to return to the main menu, which could be two or more levels above the present position. MAPS2 therefore included a function key to go back a single page at a time, with an alternative key to return to the main menu. The function keys can be seen at the bottom of each MAPS2 screen, as in figure 7.3.

7.3.2.2. Availability of Utilities

Whenever functions such as units conversion were required by the user, a separate command procedure was called, with its own main menu of available facilities. This allowed access to programs such as units conversion, from considerably more points within the MAPS system. This therefore avoided the need to return to the main menu, as previously. The need for this change was apparent from the
evaluation of MAPS1, where many users requested easier access to such functions of the system.

7.3.2.3. Ambiguous Wording of Questions

Although every care had been taken to limit the use of computer jargon or misleading terms, occurrences did come to light during the evaluation of MAPS1. One example was the use of the phrase 'type return to continue'. This could, on occasions, result in an attempt to type out the word 'RETURN', as opposed to pressing the return key. This was found in the DBA database system, and changes were negotiated with the program developer.

7.3.2.4. Printing Out Results Files

During a consultation with MAPS1, the only time a user was required to understand the computer's operating system, at an elementary level, was in the printing out of results files. The evaluation showed that in almost every case, when an exercise involved the printing out of the results, the task could not be completed satisfactorily. In an attempt to solve this problem, MAPS2 allowed files to be printed out without leaving the menu driven MAPS package. This was possible by pressing the PF3 function key to enter the utilities menu, where, through simple menu selections, a file could be named and sent to the printer. This avoided any use of the VMS operating system.
7.3.2.5. Location Indicator

As discussed in chapter 5 (5.4.4.5), there was little evidence of the location indicator in MAPS1 being in use during a consultation. It was therefore proposed to improve on this system in MAPS2. This can be seen at the top of the screen in the examples (figures 7.3 to 7.11).

7.3.2.6. DBA Interface

Despite the observation of severe problems with the user interface of the library database (DBA), it was not possible to improve on the situation in MAPS2. Alterations in DBA needed to be undertaken by the developers of the software, and this could not be arranged at the time. The situation would be closely monitored, and in the long term a solution would be implemented.

7.3.2.7 Additional Utilities

As discussed earlier, MAPS2 aimed to improve the availability of utilities, but also to increase the range of such facilities. Several additions were made in this area, including the following:-

1. On screen calculator
2. Label printing
3. Improved units conversion
4. Spell checker
5. News and revisions
The on screen calculator presented a graphics image on the computer screen, of a conventional pocket scientific calculator, and used the number pad keys for input. It behaved in exactly the same way as a conventional pocket calculator, including second functions and a memory.

The label printing program allowed users to produce sticky address labels on the systems laser printer, in addition to storing such addresses.

The units conversion program was rewritten to be easier to use and more simply expanded. Whenever a user selected a conversion that could not be found by the program, a report was written to a file for later manual addition to the data base by the program developer (the author).

A spell checker program took any named text file and produced an output file consisting of a list of words it was unable to find in its data base.

A news and revisions facility gave access to information regarding additional knowledge programs, added to MAPS2 since the user last entered the system. The front page shown in figure 7.2 indicated (by a flashing function key) whether any new news existed which had not yet been read by that particular person.
7.3.3. Screen layout and Interface Design

7.3.3.1. A Typical Enquiry With Guidance

MAPS1 used a very basic screen layout and interface design in order to avoid a bias towards any particular methodology. With the introduction of MAPS2, it was time to review the approach and adopt greater resources. Modifications were made in the light of user feedback obtained from MAPS1, with further ideas from published guidelines such as those by Smith and Mosier (1984).

The new screen layout could be split into four areas, from top to bottom: a location area; a large menu area; a function key area; and, at the bottom of the screen, an input area. These can clearly be seen in figure 7.3. This screen layout would help maintain consistency, with each area of the screen being used for the same purpose throughout the system. This way users would know where to expect a request for input, where menus would be presented, where functions could be selected, and where the location is displayed.

Figures 7.2 to 7.12 show a typical enquiry, with the user’s response indicated below each figure. Briefly, the user first selects PF1 for a knowledge enquiry, the main menu is then displayed. The area of interest is chosen, and then the option required, in this case guidance (figure 7.4.). MAPS2 then starts to narrow the subject
area down to identify the particular area of interest. Firstly, metabolic rate is selected (figure 7.5); then estimation of metabolic rate, and finally body load carriage (figure 7.7). MAPS2 now presents a short list of suitable knowledge units/programs, given the information supplied by the user. On this occasion there are three possible models of metabolic rate estimate for body load carriage (Figure 7.8). At this stage, the system allows the experience of the user to be utilized to select the preferred model; although they would all be appropriate.

MAPS2 offers the chosen knowledge unit with a distinctive front page, indicating to the user that MAPS2 has located the appropriate software, and has made it available. The user can run the unit by typing 'B', or quit and return to the MAPS2 page by typing 'Q' (figure 7.9).

7.3.3.2. The Short Cut to Knowledge

Assuming that the user has pressed PF2 and returned to the main menu, he/she could again choose Manual Materials Handling, item 5, but this time knowing exactly what he/she requires, option 1 is selected (see figure 7.10). MAPS2 then takes the experienced user directly to a list of available knowledge programs on that broad subject (figure 7.11). By selecting item 8, the same metabolic rate prediction model can be run. Pressing PF4 will exit MAPS2 with a final reminder about results files written during the session (see figure 7.12).
Figure 7.2 - Initial welcome screen

(Response = PF1)

Figure 7.3 - Main menu

(Response = 5)
Figure 7.4 - Main menu
(Response = 2)

Figure 7.5 - Materials handling interest
(Response = 2)
Figure 7.6 - Metabolic facility

(Response = 2)

Figure 7.7 - Metabolic interest

(Response = 1)
Figure 7.8 - Body load programs

(Response = 1)

Figure 7.9 - Knowledge program front page

(Response = Q)
Figure 7.10 - Main menu

(Response = 5 & 1)

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>OPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Fitness</td>
<td>DIRECT to list of programs</td>
</tr>
<tr>
<td>Clothing</td>
<td>GUIDANCE to programs</td>
</tr>
<tr>
<td>Anthropometry</td>
<td>Literature</td>
</tr>
<tr>
<td>Thermal Stress &amp; Water requirements</td>
<td></td>
</tr>
<tr>
<td>Manual Materials Handling</td>
<td></td>
</tr>
<tr>
<td>Noise &amp; Vibration</td>
<td></td>
</tr>
<tr>
<td>Personal Protection</td>
<td></td>
</tr>
<tr>
<td>Army Occ Health Research Unit</td>
<td></td>
</tr>
<tr>
<td>General Literature (DBA)</td>
<td></td>
</tr>
</tbody>
</table>

PF1: PREVIOUS   PF3: UTILITIES (HELP, EXPLAIN, UNITS) F6: TO RESTART MAPS (AT ANYTIME)
PF2: MAIN MENU   PF4: EXIT FROM MAPS2

PLEASE ENTER SUBJECT CODE (1-9): 5
PLEASE ENTER OPTION CODE (1-3): 1

Figure 7.11 - Manual materials handling programs

(Response = PF4)

<table>
<thead>
<tr>
<th>MANUAL MATERIALS HANDLING</th>
<th>PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niosh Guidelines 81</td>
<td>I. Randle 1988</td>
</tr>
<tr>
<td>Force Limits 80</td>
<td>Stretcher bearing</td>
</tr>
<tr>
<td>HSE Draft 82</td>
<td>MLC</td>
</tr>
<tr>
<td>CEC Draft 85</td>
<td>Maximum strength</td>
</tr>
<tr>
<td>Psychophysical Tables</td>
<td>Legg &amp; Pateman</td>
</tr>
<tr>
<td>Def. Standard 1985</td>
<td>Pateman &amp; Clark</td>
</tr>
<tr>
<td>Team lifting</td>
<td>US Data</td>
</tr>
<tr>
<td>Giv. &amp; Gold. (body)</td>
<td>Lifting objects</td>
</tr>
<tr>
<td>Garg</td>
<td>Met. Est. Comparison</td>
</tr>
<tr>
<td>Mahanty</td>
<td>Giv. &amp; Gold. (arm)</td>
</tr>
<tr>
<td>Morrisay &amp; Liou</td>
<td></td>
</tr>
<tr>
<td>I. Randle 1984</td>
<td></td>
</tr>
</tbody>
</table>

PF1: PREVIOUS   PF3: UTILITIES (HELP, EXPLAIN, UNITS) F6: TO RESTART MAPS (AT ANYTIME)
PF2: MAIN MENU   PF4: EXIT FROM MAPS2

PLEASE ENTER CODE NUMBER: 8
7.4. Assessment of MAPS2

7.4.1. Aim

The aim of the assessment was to obtain feedback from the users on the design of MAPS2. As with the MAPS1 evaluation, it would simultaneously act as a tutorial. This would be at the expense of objective results, but would better utilize the time with the subjects. The evaluation was intended to collect data on the weaknesses of MAPS2, and not particularly to prove its qualities.

7.4.2. Method

7.4.2.1. Subjects

There were a total of twenty subjects. These were all APRE
staff, the majority of them being from the Applied Physiology (AP) Division. Where possible, the same subjects were used for the MAPS2 evaluation as were used for the MAPS1 evaluation. Each one was an expert in at least one of the areas of Applied Physiology used in MAPS1, with the exception of one or two administrative staff members. Their range of knowledge of how to use computers was from almost naive to proficient. They were all aware of the MAPS project and its aims.

7.4.2.2. The Exercises

The exercises were similar to those used for the MAPS1 evaluation. There were six in total, exercise G was omitted to shorten the length of each subject session. These were graded by the degree of guidance given to complete the task. On completion of each exercise, the subject had to assess the task on two adjective scales, these being EASY - DIFFICULT, and FAST - SLOW. By using graded tasks of this type, the evaluation took the form of a tutorial in addition to an assessment of MAPS2. A copy of the exercises, as presented to the users, can be seen in appendix C (shown as for MAPS1). They can be seen in summary in table 7.1.

7.4.2.3. The questionnaire

After completion of the exercises, each subject was asked to complete a questionnaire. This comprised...
scales together with an opportunity to make comments. The adjective scales were similar to those adopted by Osgood et al (1957) in his method of semantic differentials. An example of a similar questionnaire (that for MAPS1) can be seen in appendix D, and summarised in table 7.2.

7.4.2.4. Experimental Protocol

1. On arrival, subjects were asked if they minded a voice recorder being used during the experiment. If there was no objection, a tape drive was started.

2. Subjects were given a sheet of text explaining the purpose of the experiment, together with instructions on how to complete the adjective scales to be presented later.

3. They were then given five minutes to try MAPS2 in any way they wanted.

4. They were then asked to complete the series of exercises, presented on a typed sheet. They were told guidance would be available, if they could not proceed.

5. After each exercise, they were asked to complete two adjective scales, presented at the end of each exercise on the printed sheet.

6. On completing all the exercises, the subject was asked to fill in the questionnaire, comprising of both adjective scales and space for comments.
<table>
<thead>
<tr>
<th>Exerc.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>For a clothed subject in a heat stress situation, run the Gagge and Nishi prediction model for the given set of environmental and subject variables. Print out the results.</td>
<td>2</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>Full instructions were included. Printing out the results required use of the computers 'print' command</td>
</tr>
<tr>
<td>B</td>
<td>Find all the available literature on dehydration in the heat. Note record numbers for future reference.</td>
<td>4</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>This required use of the DBA database system, but with full instructions</td>
</tr>
<tr>
<td>C</td>
<td>Find the estimation of metabolic rate according to Pandoif et al, for a man walking up an incline with a load.</td>
<td>6</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>Only guidance given was to indicate which branch of the main menu contained the solution</td>
</tr>
<tr>
<td>D</td>
<td>Given a set of skinfold measurements, find the best estimate of percentage body fat.</td>
<td>8</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given, but all required data listed in logical form</td>
</tr>
<tr>
<td>E</td>
<td>(I) What is the range and average, sitting height of Guardsmen in the British Army. (II) What is the correlation between sitting Height and shoulder height for Gurkhas in the UK.</td>
<td>10</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given</td>
</tr>
<tr>
<td>F</td>
<td>Given the measurements of noise levels of a military weapon, determine whether it is within safe limits to avoid damage to hearing.</td>
<td>12</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given. Data found in description of the problem</td>
</tr>
<tr>
<td>G</td>
<td>Omitted for MAPS2 evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quest.</td>
<td>Description</td>
<td>Scale</td>
<td>Adjectives</td>
<td>Scores</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
<td>-----------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
<td></td>
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<td>On average, how often have you used MAPS2 in the past</td>
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<td>Categories of usage frequency</td>
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<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
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<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge</td>
<td>9</td>
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<td>7 - 1</td>
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<td>required to use the system</td>
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<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
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<td>7 - 1</td>
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<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
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<td>8</td>
<td>How would you describe the layout of the screen</td>
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<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
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<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Uncrowded - Crowded</td>
<td>7 - 1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>15</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>16</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
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<tr>
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<td>How would you describe the choice of labels/names for the menu options</td>
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<td>Good - Bad</td>
<td>7 - 1</td>
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<tr>
<td></td>
<td>(eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>18</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>19</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>20</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS2</td>
<td>22</td>
<td>Good - Bad</td>
<td>7 - 1</td>
<td></td>
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<tr>
<td></td>
<td>as a method of retrieving individual programs</td>
<td>23</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
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<td>24</td>
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<td>7 - 1</td>
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<td></td>
<td>25</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
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<td>11</td>
<td>When working outside your own area of interest, how would you describe the</td>
<td>26</td>
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<td>7 - 1</td>
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<tr>
<td></td>
<td>guidance given</td>
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<td>Clear - Unclear</td>
<td>7 - 1</td>
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<td></td>
<td></td>
<td>28</td>
<td>Helpful - unhelpful</td>
<td>7 - 1</td>
<td></td>
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<td></td>
<td></td>
<td>29</td>
<td>Too much - Too little</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
<td></td>
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<tr>
<td>13</td>
<td>Overall, how would you rate MAPS2 on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Useful - Useless</td>
<td>7 - 1</td>
<td></td>
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<td></td>
<td></td>
<td>34</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
<td></td>
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<td></td>
<td></td>
<td>35</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>36</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>Crowded - Uncrowded</td>
<td>7 - 1</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.2. - MAPS2 Summary Questionnaire Details
(See appendix D for full details)
7.4.2.5. Experimental Conditions

Each user session took place in a normal working environment. This included general background noise, such as printers, telephones and general conversation amongst colleagues. The experimenter (the author) made observations throughout the session, noting where confusion or hesitation was evident. The only restriction was that the subject was not interrupted to complete any secondary tasks, for example answering the phone. The conditions were therefore as close to the normal working environment as possible.

7.4.3. Results

7.4.3.1. Exercise Scale Results

The mean response to the scales presented after the exercises, can be seen in table 7.3, and figure 7.13. Two scales were presented after each exercise, these being EASY - DIFFICULT and FAST - SLOW.

The mean scores for the adjective scales were, as with MAPS1, favourable, with one or two small exceptions. Problems were still observed in using the DBA data base system, and this can be seen in relatively low mean scores on the two scales completed after attempting the exercise (scales 4 and 5 figure 7.13).
### Table 7.3 - MAPS2 Exercise Scale Results
(higher values imply better performance)
(see table 7.1 for exercise details)

<table>
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<tr>
<th>EXERCISE</th>
<th>SCALE NO</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
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<td>7.00</td>
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</table>

### Figure 7.13 - MAPS2 Evaluation
Exercise Responses Scales 2 - 13
(higher values imply better performance)
Objective data would be of little use, as help was given in completing the exercises where progress had stopped. All the subjects therefore completed the tasks in reasonable time. The greatest level of help was given for the exercise involving the use of DBA (exercise B table 7.1).

7.4.3.2. Questionnaire Scale Results

The results of the questionnaire are presented in table 7.4 and figures 7.14 to 7.16. This table and the figures only represent the responses to the adjective scales described in the method. In addition to this, much information was collected in the form of additional comments (see section 7.4.3.3.), and the tape recording made at the time. The latter collected verbal comments not recorded later in the questionnaire. It was also possible for the experimenter, being the developer of the software, to make notes on problems encountered by the subject.

It was felt by the author that the information collected from the scales must not be taken in isolation. Responses were made towards the top end of each scale, thus reducing the level of information obtainable.

It must also be noted that no attempt was made to conclude that MAPS2 had any particular qualities over and above other software packages, the emphasis was instead on areas needing attention.
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<th>QUESTION NO.</th>
<th>SCALE NO.</th>
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<th>MIN</th>
<th>MAX</th>
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Table 7.4 - MAPS2 Questionnaire Scale Results
(see table 7.2 for questions)
Figure 7.14 - MAPS2 Evaluation Questionnaire Results Scales 2 – 11
Figure 7.15 - MAPS2 Evaluation Questionnaire Results Scales 12 - 25
### Quest. Description

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<th>Scale</th>
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<th>Scores</th>
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<td></td>
<td></td>
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<td>Too much - Too little</td>
<td>7 - 1</td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y = 1, N = 2</td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS2 on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>38</td>
<td>Crowded - uncrowded</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

**Figure 7.16 - MAPS2 Evaluation Questionnaire Results Scales 26 - 38**
7.4.3.3. Additional Comments By Subjects

In addition to the scale responses described in the preceding section, subjects were given space to add their own comments. In the main, this was to clarify their reason for the value response to the adjective scale. The results are presented in tables 7.5a - 7.5c, exactly as they were recorded by the subjects on the questionnaire. In general, it was noted by the experimenter, as with the MAPS1 evaluation, that in most cases the option to make a comment was utilized to justify a low score on the scale response, judged by the subject not to be favourable towards MAPS2. Where scale responses were favourable, often no additional comment was include. This observation was welcome, as it was in line with the primary aim of highlighting weaknesses, as opposed to qualities.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>Overall, an excellent system.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Only a few minor hiccups that could easily be resolved on the next run through.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Lack of personal understanding of language, delayed attempts to progress, familiarity with system encourages one to use it more.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>If anything, it's too easy to become an expert, a little learning.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Slight confusion concerning options initially.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>I crashed it !!!</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>The first exercise appeared slow mainly due to the data to be input, but also due to unfamiliarity with the system.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Overall a good menu driven system, almost but not quite fool proof.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>No computer knowledge required, but familiarity with keyboard helpful.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Once you know your password, very easy.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Very little real computer knowledge required.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Idiot proof.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>It's difficult to judge how people not familiar with keyboard use would learn, but no reason why lack of knowledge would inhibit use.</td>
</tr>
</tbody>
</table>

Table 7.5a - Comments by subjects (MAPS2)  
(see table 7.2 for questions)
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>Low because the questions contained all the data required in the correct units and there was no extra mis-leading data.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Low to use system, but high to be sure you know what the answer actually means.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>High, if to be used correctly and effectively, dangerous if to be used by non physiologists without guidance. Operators would not need much knowledge at all.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>I felt I could use the system quickly and have a reasonable AP knowledge, someone with less knowledge could use it, but might take longer.</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Stats/physiology knowledge limited.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Practice required.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Problems were with anthropometric programs not MAPS. Never completely lost, just a few wrong turns.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Not really knowing what literature did.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Yes, had pressed the wrong button, which froze keyboard.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Confusion over dual use of PF2 key.</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>The time delay between pressing 'PF' key sometimes seems long enough to doubt whether you pressed it.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>PF keys should be underneath each other.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Unclear and uninformative because of confusion about what option keys did.</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Army Occ. on main menu (a bit confusing).</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Since I, and I suppose most people who will be using MAPS know what area of work they should be looking in, I found it very simple.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Perhaps some cross-reference in some areas.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>There is a problem through the nature of the subject itself.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Don't know what item 8 does, not a problem with the program layout, simply knowledge of APRE.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Some fairly technical, so only understood by physiologists.</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Although in my own area I have other ways of getting the results.</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>The problem is in the nature of the subject, there isn't always a clear distinction in principle between physiological topics.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Unclear on what options did.</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Yes, main menu.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Yes, start of MAPS, but mainly search is slow in DBA.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Yes, on searching for keys in literature, and pressing function keys.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Yes, DBA.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Yes, PF2 key.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Yes, there is a short delay for instance in going back to the main menu, takes a little getting use to.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>At the start.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>When searching the DBA.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Initial setup between entry to MAPS and first screen.</td>
</tr>
</tbody>
</table>

Table 7.5b - Comments by subjects (MAPS2)  
(see table 7.2 for questions)
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 contd.</td>
<td>10</td>
<td>On logging in, and during literature search.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Loading data, and on first entering MAPS.</td>
</tr>
<tr>
<td>14 best aspects</td>
<td>1</td>
<td>Very quick for estimation of values/predictions (i.e. speeds up access to these programs).</td>
</tr>
<tr>
<td>of MAPS2</td>
<td>2</td>
<td>Quick and easy, very little computer experience needed.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Anthropometry very useful.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Time saving.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Clear and helpful presentation.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Clear to move from stage to stage, helpful in its layout, i.e. programs for stats etc.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Way it guides through information required.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Gave enough information to give relatively fast decisions on which areas were required. Therefore no problems in getting stuck in a particular routine etc.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Clear, informative, comprehensive and easy to use.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Easy and useful.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>I enjoyed using this because it gave access very quickly to material I would otherwise have had to root around to find. It was quicker than relying on printed reports and probably more accurate.</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Speed apart from initial setup. Ability to be able to return to stored data on files.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Quite useable, sign posts to tell you where you are.</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Enormous detail retrievable</td>
</tr>
<tr>
<td>15 worst aspects</td>
<td>1</td>
<td>DBA.</td>
</tr>
<tr>
<td>of MAPS2</td>
<td>2</td>
<td>Problem is in the nature of the concept, really there should be no such animal as the instant expert. Getting a few answers out of the system makes one feel as if one knows ALL the answers.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Could be easier to use DBA.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Should have a blue screen.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Could take a long time, when completely full of data.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>In some cases, the programs themselves (e.g. survey data), printing out files of results, a bit cumbersome.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Confusion about literature option on title page.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>When looking for information, I was put off by the term 'program' and tempted to look at literature.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Slight uncertainty about which keys to use, esp. return/enter, and time to search data base.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Possible confusion over F keys and PF keys and numeric keys. Enter vs Type return.</td>
</tr>
</tbody>
</table>

Table 7.5c - Comments by subjects (MAPS2)  
(see table 7.2 for questions)
7.4.4. Discussion

From examination of both the scale responses, and the additional comments recorded on the questionnaire, together with day to day feedback from the users during the period that MAPS2 was available, the following observations could be made. These were by no means conclusive, but they could be used to help guide efforts in the development of MAPS3.

Much of the information was derived from the period during which the system was available, through contact with the users, and information from the automatic recording mechanism (see section 5.3.5). The use of the formal evaluation as a tutorial, although potentially reducing the quality of the results, was only one component in examining weaknesses in the system.

7.4.4.1. Printing Out of Results Files

From a study of the verbal comments made, after exercise A (see table 7.1. for exercise), although more people were able to successfully print out the results file, it was generally felt that too many key strokes were needed to complete the task. It also seemed tedious to have to remember the name of the output file, and type it in to access it. See table 7.5c question 15 comment [6].

In MAPS2, if you required a print out of the results, you
selected PF3 from any of the main screens. A separate utilities menu would then be displayed, including other facilities such as the on-screen calculator and units conversion. The user would then select an item entitled 'Access to results files', at which point the screen would display a list of all the results files stored in that user's MAPS subdirectory. The user would then be asked if access was needed to a file: if the response was yes, the name of the file would have to be typed in. Another menu would then offer several options for manipulating the named file, one of which sends the file to the default laser printer for that particular computer.

At the time of development of MAPS2, the above mechanism was a first attempt to match the system to the user's needs, when printing out files. The majority of people could now produce an output file, as opposed to the performance on MAPS1, where most people did not know how to use the operating system to print files. What was not realised at the time was that the task most often required was simply a printout of the results file associated with the most recently run knowledge program. Therefore this should be possible with a single key press, and without the need to type in the file name.

7.4.4.2. Location Indicator

The location indicator still appeared, from observations, not to be utilized in order to orientate through the
system. However, some improvement did seem evident through analysis of scale 11 (see table 7.2, question 7). This asked the subject whether or not they felt lost at any stage during the session. The coding used to arrive at the mean score was yes=1 and no=2. By reference to figure 7.18 (section 7.5, MAPS1 and 2 comparison), it can be seen that the value increased from MAPS1 to 2. Although this change may not be statistically significant, it does give some hope. It was felt that the problem may be lack of information regarding previous pages. As can be seen in figure 7.3, the user is only told what the last page was, whereas they may be better oriented if they could see the full route back to the main menu. Only one comment was made on the questionnaire referring to the location indicator (see table 7.5c question 14 comment [13].

7.4.4.3. Availability of Utilities

Utilities were now more abundant and easier to access than in MAPS1. However, similar verbal comments were made regarding the key strokes needed to call them up, as were made for the printing out of results files. Users first had to press PF3, they would then be presented with a separate utilities menu, from which a selection could be made. No specific comments were made regarding the availability of utilities on the questionnaire. Most of the comments were made informally during normal working days between evaluations, directly to the author.
7.5 Comparison of MAPS1 and MAPS2 Evaluations

7.5.1. Aim

The aim of comparing the evaluations of MAPS1 and MAPS2, was to highlight any change in the performance of the software. However, as already discussed, any comparison would have to be treated with extreme caution, and the emphasis should be placed on any decrements rather than improvements.

7.5.2. Results

Figures 7.17 to 7.20 show a comparison of the scale results obtained at the time of the MAPS1 evaluation and then later for MAPS2.

Figure 7.17 - MAPS1 & 2 Evaluation Comparison Exercise Responses Scales 2 - 15
<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2, 3</td>
<td>Good - Bad, Extensive - Limited</td>
<td>7 - 1, 7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4, 5</td>
<td>Good - Bad, Extensive - Limited</td>
<td>7 - 1, 7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS2 in the past</td>
<td>6</td>
<td>Categories of usage frequency, A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS2, how would you describe the learning process</td>
<td>7, 8</td>
<td>Easy - Difficult, Fast - Slow</td>
<td>7 - 1, 7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
</table>

Figure 7.18 - MAPS1 & 2 Evaluation Comparison Questionnaire Scales 2 - 11
### MAPS1 & 2 Evaluations

**Questionnaire Responses**

![Bar chart showing questionnaire responses comparing MAPS1 and MAPS2](chart.png)

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12 - 25</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Uncrowded - Crowded</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options (eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>17 - 25</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS as a method of retrieving individual programs</td>
<td>22 - 25</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

*Figure 7.19 - MAPS1 & 2 Evaluation Comparison Questionnaire Scales 12 - 25*
MAPS1 & 2 Evaluations
Questionnaire Responses

Figure 7.20 - MAPS1 & 2 Evaluation Comparison
Questionnaire Scales 26 - 38
7.5.3. Discussion of Comparison Results

It was intended that a comparison of the results obtained would give some guidance as to the areas requiring further attention. As can be seen from the figures, very little difference was recorded between the values for MAPS1 and MAPS2. The data from the scales was therefore treated with caution, and not used as sole evidence of design progress, or otherwise. It was possible that a change in the subjects' level of expectation had taken place in the period between the two evaluations. A method of measuring this change would be incorporated in the evaluation of MAPS3. It can be observed that in most cases, an increase in value had occurred in the MAPS2 evaluation. Therefore, if a shift in expectation could be shown at a later date, the results may well have been significant.

7.6 Chapter Summary

As with MAPS1, the evaluation predominantly aimed to show weaknesses as opposed to specific qualities of the system. In this respect the exercise was successful, as specific areas of MAPS2 were identified as requiring improvement or extension. The three most significant of these were; the link with the DBA data base; the printing out of results files; and the availability of utilities. Several other areas required further work on the technical side of the system, to improve durability and the ease with which extra knowledge could be added.
CHAPTER 8
8. THE FINAL PROTOTYPE (MAPS3)

8.1. Introduction

MAPS3 represented what was to be the finished system, only to be altered where the final evaluation may indicate. It was more closely related to the interface design and structure of MAPS2, than MAPS2 was to its predecessor. However, in technical terms there were many changes in the final program coding of MAPS3.

It was decided to develop a standard interface design for the knowledge units within MAPS, and this is described in some detail later in this chapter (section 8.8).

8.2. Aim

The aim of MAPS3 was to produce a final knowledge based system for use by The Applied Physiology (AP) Division of The Army Personnel Research Establishment (APRE). It would contain some useful knowledge in all areas on the main menu, and more extensive knowledge in two or three areas. It would implement all the lessons learned during the development of MAPS1 and MAPS2. It would be durable in operation, thus minimising the need for maintenance, and reducing the risk of the system breaking down during operation. By developing a standard knowledge program interface, it would hopefully be easier to expand the knowledge base when new material became available.
8.3. Method

The method used to develop and implement MAPS3 is described in the following sections. As described in chapter 1, the basic design philosophy was one of iterative prototyping. It was intended that MAPS3 would be the last version in this iterative process: however, if it should prove necessary during the evaluation (see chapter 9), another version could be contemplated. Minor changes could be made without the introduction of a new version (eg. MAPS4).

8.4. Technical Details

8.4.1. Reappraisal of MAPS2 Methodology

No change was made in the tools used to write MAPS3, although a small expert system shell was purchased. It was intended that this shell be used in the development of individual knowledge units, where the nature of the knowledge dictated. The shell would be used as a small unit within MAPS, as opposed to being adopted to build the larger main system. The shell selected was ESP ADVISOR, by Expert Systems International. At the time of writing, it had not been used, as a suitable application had not arisen within the knowledge base.

8.4.2. MAPS3 Technical Details

The simplified technical structure is shown in figure
8.1, and is described in greater detail in appendix H. Substantial changes were made in the detailed program coding of MAPS3, which were not apparent to the user. It was further separated into modules, to make later development and expansion easier. The modular structure also resulted in a more robust system.
Major improvements were made in the method of producing each MAPS3 screen, through the use of scrolling regions to create the effect of windows. The details are discussed in section 8.6.

Another change in technical design made MAPS3 more portable between different VAX computers within the establishment, thus making the task of updating duplicate copies of the system used on other machines, quicker and easier. This formed part of the development environment described in chapter 6 (section 6.5.6).

8.5. Improvements Over MAPS2

8.5.1. Printing Out of Results Files

It was observed during the MAPS2 evaluation that the printing out of results files, although improved in MAPS2, still needed further attention. It could be seen from these observations, and analysis of the usage record, that in the majority of cases all the user required was a print out of the results produced by the knowledge unit he/she had just left. This should therefore be available through the press of a single key.

As MAPS2 had a separate utilities menu, redesign of the basic structure was required. This was achieved through a new MAPS screen design, which is discussed in some detail later in this chapter. An example is shown in figure 8.3.
The action required to print out a file now involved simply pressing the PF3 function key, at any of the MAPS screens and at any point after completing a run of a knowledge program. An additional feature in MAPS3 was the choice of printer. In MAPS2 the output would go to the default system printer for the computer the user was logged into. In MAPS3, the user could choose from a menu of printers, and select the default required in future. This new choice of printer would be maintained even after that particular user had left MAPS and entered the system again on another occasion.

8.5.2. Location Indicator

The location indicator was still used fairly infrequently in MAPS2, despite improvements made over the earlier MAPS1 system. Two options were open, either to assume from the evidence that a location indicator was not required, or to attempt to supply a better source of location information in MAPS3. It was decided to supply a revised location indicator. This can be seen at the top of any of the MAPS3 screens (see figure 8.3). It occupied one line of the screen, and showed each of the previous menus, back to the main menu. It therefore supplied more information than the previous versions, and gave a better picture of the position within the knowledge tree. A user could now see the route that had been taken in single steps down to the final solution page. It was now clear what effect the previous page key (PF1) would initiate.
8.5.3. Availability of Utilities

Comments made in the evaluation of MAPS2 suggested that too many key strokes were required to call up commonly used functions or utilities. A reduction was achieved in MAPS3, as with the utility for printing out results files, by designing a new screen layout. In this screen, all the utilities were displayed on the bottom four lines, and were available through the pressing of a single function key.

8.5.4. Latest News Facility

The mechanism for the presentation of latest news on knowledge programs added or improved was updated with the introduction of MAPS3. Previously, news had been available by pressing a function key on the initial welcome screen of MAPS2 (see figure 7.2). Records of usage showed that very few people pressed this key to obtain news. In the new system, if 'new' news existed and had not been read by a particular user, the new news text would appear on the screen before the main menu was presented, on first entering the system. Thereafter, the information could be reviewed by pressing function key F11 from any MAPS3 screen.

8.5.5. New Interface to DBA Database

In the evaluations of both MAPS1 and MAPS2, it was found that the large majority of subjects had problems using the
DBA database interface. It was noted at the time of the MAPS2 introduction that no improvements had been possible due to alterations required in the DBA software. These needed to be completed by the developer of the DBA system. A meeting took place with the individual concerned, and alterations were arranged to separate the interface from the main 'engine' of the program. This permitted the MAPS3 developer (the author) to incorporate a new interface, which would collect the data on literature searches from the user. This could then be presented to DBA as a file containing commands, which would then be fed to the original DBA interface.

Users would be able to see the information they had supplied through the MAPS3 interface being input to the old DBA screen layouts (see figures 3.4 - 3.6) on their behalf.

Two options were offered in the new interface when requesting a literature search. After selecting one of the nine areas of Applied Physiology, if the user selected option three for literature (see figure 8.3), they could either input their own search definition, or MAPS3 could supply a suitable search definition for them.

8.5.5.1. Automatic Definition of Search Criteria

If MAPS3 was told to define the search, the first thing
the users would see would be the automatic operation of the old DBA interface, followed by the first record matching the criteria of the search. They could then print this out by pressing 'P', or proceed to the next record by pressing 'N'. All records selected for printing would be sent to the printer on leaving the search.

8.5.5.2. User Input of Search Definition

If a user required to input his/her own search definition, a new screen layout would appear. This would allow the input of various keywords, authors, origins, and titles. This took the form of a matrix, with each element connected with a logical term (and/or/not). An example can be seen in figure 8.2.

![Figure 8.2 - New MAPS3 Interface to DBA Database](image-url)
8.6. The New MAPS3 Screen Layout

8.6.1. Introduction

The concept behind the MAPS3 screen layout was to produce a screen which would be clear and uncluttered, yet at the same time contain all the required information and functions, without the need for hidden menus. It was anticipated that this would help in making the system easy to use and reduce the need for reference to manuals, particularly in the case of infrequent users.

8.6.2. Description of Screen Layout

The screen was split into four windows (see figure 8.3). Looking from top to bottom these were :-

A. Location indicator window (top line)
B. Menu presentation area (Main central area)
C. Input window (1 line)
D. Function key window (4 lines)

The location indicator displayed all the previous windows, with the current window highlighted. The menu presentation area made up the largest part of the screen, and contained the current menu selection choice. The input window appeared directly below the menu options, and also contained any MAPS error messages if and when they occurred. The functions window used the bottom four lines of the screen. The four main function keys appeared highlighted just below the input line, these being PF1 -
PF4. The remaining functions were arranged below these four, and were not highlighted.

8.6.3 Feedback to The User

Feedback after pressing a key had been enhanced in MAPS3. Whenever a selection was made from a menu, the choice was immediately highlighted on the menu list itself. This can be seen in figure 8.4., where Manual Materials Handling (item 5) has just been selected. If a function key had been pressed, a message appeared at the right hand end of the input window to confirm this. An example of a function key press can be seen in figure 8.11 where PF4 has been selected. A flashing 'WORKING' message appeared in the input box whenever MAPS3 was processing information, therefore avoiding periods when nothing appeared to be happening.

8.7. A Typical Enquiry

Figures 8.3 - 8.12 show a typical MAPS3 enquiry, with the users response indicated below each figure. In this example the user is interested in Manual Materials Handling, and requires guidance to the programs (figure 8.4). They go on to identify that they are interested in Metabolic rate, they require an estimate, and the load is carried close to the body (figures 8.5 - 8.7). MAPS3 then offers the choice of three models appropriate to this situation of load carriage. The user selects the Givoni and
Goldman model, item 1 on the menu (figure 8.8). MAPS3 then presents the front page of that knowledge program (figure 8.9). If we assume the knowledge program has been run and MAPS3 has returned again to the front page, the user may now select Q to quit, and will be returned to the MAPS3 screen in figure 8.10. By pressing the PF3 function key, a paper copy of the results can be obtained. A message then appears, to say that the output is being printed out on the predefined printer. Lastly, the user selects PF4 to leave the system (figure 8.11). This is confirmed in the input box, and a flashing 'WORKING' sign shows that MAPS3 is in the process of exiting. As the system finishes, a final message reminds the user of any results files written during the preceding session (figure 8.12).

![Main Menu]

Figure 8.3 - Main menu

(Response = 5)
Figure 8.4 - Main menu

(Response = 2)

Figure 8.5 - Materials handling interest

(Response = 2)
Figure 8.6 - Estimate or References

(Response = 2)

Figure 8.7 - Type of Load

(Response = 1)
Figure 8.8 - Choice of Model
(Response = 1)

Figure 8.9 - Knowledge Program Front Page
(Response = Q (AFTER USING PROGRAM))
Figure 8.10 - Body Load Programs

(Response = PF3)

Figure 8.11 - Body Load Programs

(Response = PF4)
8.8. The Knowledge Program Interface

8.8.1. Introduction

For MAPS1 and MAPS2, little development work was devoted to producing a standard interface design for the individual knowledge programs. This was primarily due to a constraint on man power, making the development of a good interface for the main shell of the system of greater importance at the early stages of the project. It is also true that the early prototypes contained only a relatively small amount of knowledge programs, whereas, with the main shell interface refined to the point of being complete, more man power was now being devoted to expanding the knowledge base. It was therefore time to devise a
structured method for producing knowledge programs. This knowledge program interface was completed under the supervision of the author. A description of the development can be found in Wadsworth et al (1990).

8.8.2. Method

Initially, three methods were considered for the interface design, the first being a simple textual display comprising questions and user responses in a simple format, the screen being cleared after each question. The second was to adopt windows stacked on top of each other, with the option to return to the previous window to correct input. The third method, and the one chosen, was to use a set of 'tiled' (ie. not overlapping) windows. All the windows would be fully visible throughout any run of the program. The three methods were shown on an informal basis to a group of potential users, and their responses noted. This was not documented, and is an example of the way in which users were involved in the design process on a regular day to day basis. It appeared, from this initial study, that the tiled layout showed the greatest promise. With reference to Shneiderman (1989), when used in a hypertext type interface, the tiled layout was favoured. Further support for the tiled arrangement of windows can be found in Bly and Rosenberg (1986), who identified that tiled windows could be better than their stacked counterparts for naive infrequent users. They also suggested that much of the advantage offered by a stacked
arrangement was only gained after a learning period. As it was hoped that MAPS would require very little learning, the tiled arrangement appeared to be the best option.

The tiled window interface was developed using FORTRAN, plus a screen management system available through the VAX/VMS implementation of the language. It was decided to make the program modular, in a similar manner to the remainder of MAPS3, in order to allow quick adaptation of the coding to each of the knowledge programs in MAPS. An example of the equation processing interface can be seen in figure 8.17. In addition to the layout chosen for processing equations, a second was selected for the presentation of simple textual information.

8.8.2.1. The Textual Information Interface

The textual information interface can be seen in figure 8.15. The central area of the screen was reserved for the text of the knowledge. A window at the foot of the screen displayed the keys available to move around in the text. In this example the previous key, normally displayed in the bottom left hand corner, does not appear, as this is the first page of text. At the top right hand corner of the screen was an indication of the page number, in this case 'page 1 of 3'.

The final layout of the screen for presenting textual
information was arrived at after close consultation with the users via a short evaluation of two alternative arrangements. The final layout was a combination of the best aspects of the two tested. The differences included boxing in the function key descriptions at the foot of the screen, and the positioning of the page count.

### 8.8.2.2. The Tiled Window Interface

The interface for the processing of equations can be seen in figure 8.17. and consisted of four tiled windows. These were:

1. An instructions window
2. An input/results window
3. A messages window
4. A data window

Each window was clearly labelled. The INSTRUCTIONS window displayed information regarding the input the program was expecting. The INPUT window allowed the user to enter his/her response. The MESSAGES window, at the foot of the screen, displayed any error messages or additional information relevant to the method of input of data. The DATA window, on the right hand side of the screen, displayed a list of the data values entered, as the run of the program progressed. Finally, the INPUT window appeared in reverse video as a results window, when the data input was complete.
8.8.2.3. A Typical Knowledge Program Run

Figures 8.13 - 8.27 show a typical run of a knowledge program. Figure 8.13 shows the knowledge program front page, if the user selects 'B', the program will progress as shown. Firstly offering background information, then continuing to ask for the required parameters: gradient, walking speed, and so on. Each time a value is accepted, it is recorded in the data box.

After all the data has been entered, the user is given the option to alter any of the values, as shown. Finally the answer is given and the program returns to the familiar front page (figure 8.27).

![Figure 8.13 - Knowledge Program Front Page](image)

(Response = B)
Do you require information on the background of this program and how it runs.

YES       NO

USE CURSOR ARROWS TO PICK OPTION THEN HIT [RETURN]

Figure 8.14 - Background Information Option
(Response = RETURN)

MODEL FOR METABOLIC RATE PREDICTION OF BODY LOAD CARRIAGE

The following model was derived by Givoni and Goldman.
Details of the study can be found in:

Journal of Applied Physiology, 30, pg 429-433 1971

The report is entitled: "Predicting metabolic energy cost".

Figure 8.15 - Background Text Presentation
(Response = Space bar)
Do you wish to keep a copy of the background information. This will be stored in GI.GO.MPS

**NO COPY**  **SAVE COPY**

*USE CURSOR ARROWS TO PICK OPTION THEN HIT [RETURN]*

Figure 8.16 - Hard Copy of Information

(Response = RETURN)

---

Enter the treadmill gradient as a percentage between 0% and 25%

**INPUT**

Gradient > 10

**MESSAGES**

Figure 8.17 - Input of Gradient

(Response = 10)
Figure 8.18 - Input of Walking Speed
(Response = .9)

Figure 8.19 - Input of Load Weight
(Response = 15)
Figure 8.20 - Input of Body Weight

(Response = 70)

Figure 8.21 - Input of Terrain Factor

(Response = Move cursor to TREADMILL)
Figure 8.22 - Option to Alter Input Values

(Response = Move cursor to YES)

Figure 8.23 - Selection of Data to Alter

(Response = Move cursor to Load)
Figure 8.24 - Input of Altered Value

(Response = 10)

Figure 8.25 - Option to Alter Input Values

(Response = RETURN)
Using the values shown opposite the metabolic rate is 466.38 Watts.

Figure 8.26 - Presentation of Results
(Response = RETURN)

MODEL FOR METABOLIC RATE PREDICTION OF BODY LOAD CARRIAGE DEVELOPED BY GIVONI B AND GOLDMAN RF 1971

PROGRAMMER: J. TOWLE (SEPT 87)
REVISED : ANDY HILL (AUG 89)

B Begin
Q Quit

Results will be copied into a file called GIGO.MPS

Figure 8.27 - Knowledge Program Front Page
(Response = Q)

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8.9. Introduction to The Users

MAPS3 was launched via a seminar to all members of The Applied Physiology Division staff. This utilized a large overhead screen to demonstrate typical runs of the system. Differences and improvements over MAPS2 were highlighted, and how these would affect use of the package. All personnel who had been on the list of legal users for MAPS2 were automatically given immediate access to MAPS3 following the seminar. This differed from the earlier introduction of MAPS2, where personnel were only given access to the new version after coming for an individual demonstration.

MAPS3 replaced MAPS2, and access to MAPS2 was no longer permitted. Previously, a short period existed when both the new and old versions were available (MAPS1 and 2). Records of usage showed that virtually no logins occurred to the old system. MAPS2 and 3 were also closely related in their screen layout and general structure. This hopefully did not deter users who had become proficient with MAPS2.

8.10. User Documentation

It was decided not to produce a user manual for MAPS3, as the philosophy behind the system was that reference to a manual should not be required. However, a list of the current contents of the knowledge base was maintained and
constantly updated.

8.11. Chapter Summary

MAPS3 had brought together the experience gained in the development of MAPS1 and MAPS2. It had moved the interface design to a satisfactory conclusion, leaving the emphasis on the expansion of the knowledge base, the latter being made easier by the standard knowledge program interface described in section 8.8. However, if any weaknesses were identified in the final MAPS3 evaluation, they could be addressed before completing the project. The MAPS system was now highly modularised in its structure, and very robust, needing no day to day system programming support.

It was now necessary to assess the performance of MAPS3 on a formal level, again with the prime objective of highlighting areas needing further work. The following chapter describes the formal evaluation of MAPS3, and compares the results with the earlier evaluations of MAPS1 and MAPS2. The results would hopefully help identify further research required on the broad subject of the implementation of knowledge based systems into organizations.
9. THE FINAL MAPS EVALUATION

9.1. Introduction

After completion of the MAPS2 evaluation, a comparison was made with the scale responses obtained in the previous MAPS1 evaluation (see section 7.5). There was a conflict between the trend in the scale responses between the two occasions, and those from the additional comments. It may have been possible that a shift in expectation had occurred. Changes were needed in the design of the final evaluation to measure any shift. It was therefore decided to reevaluate MAPS1 at the same time as MAPS3.

Previously, the evaluations had been intended to serve a dual purpose, firstly as an evaluation, and secondly as a tutorial. Graded tasks were used, with a gradual reduction in the guidance given to complete them. To make the results of the final evaluation more objective, several changes were made in the methodology. In particular, the graded tasks were replaced with the problems alone, without guidance, and an independent observer was used in place of the author as experimenter.

9.2. Aim

The aim of the final evaluation was to highlight any areas of the software that required further changes, and to ensure the system fulfilled the aims of the overall project, declared in section 1.3.
9.3. Method

The way in which the method varied from the earlier evaluations of MAPS1 and MAPS2 can be seen in the summary of the experimental protocol presented in section 9.3.5. The following sections describe the subjects, the exercises used, and the questionnaires.

9.3.1. Subjects

As in previous evaluations, there were a total of twenty subjects. These were all APRE staff, the majority of them being from the Applied Physiology (AP) Division. Where possible, the subjects were those who had taken part in the earlier evaluations. Each one was an expert in at least one of the areas of applied physiology used in MAPS3, with the exception of one or two administrative staff. Although improving, their range of knowledge of how to use computers still ranged from almost naive to proficient.

9.3.2. The Exercises

They were asked to complete three hypothetical problems using both MAPS1 and MAPS3, the order of presentation of MAPS1 and 3 being split equally between the subjects to minimize any order effect. The three questions can be seen in table 9.1 and appendix E. The codes for the scale responses matched the ones used for both MAPS1 and MAPS2, as the three questions were a subset of the original six
used for MAPS1. Although it could not be claimed that the three exercises used fully tested the capabilities of MAPS3, they were chosen in the light of the time available to conduct each session and to allow a comparison with the original MAPS1 evaluation.

9.3.3. The questionnaires

On completion of all three tasks for either MAPS3 or MAPS1, a questionnaire was filled in, incorporating both scale responses and space for comments. Finally, when both MAPS3 and MAPS1 evaluations were finished, a third questionnaire was completed. This asked for a comparison between the two systems.

All three questionnaires were similar, with the wording altered where appropriate, and some questions omitted. The general form was as summarised in table 9.2. They can be seen as given to the subjects in appendices D, F, and G.

9.3.3.1. The Five Sets of Questionnaire Data

MAPS1 A The original evaluation of MAPS1 described in section 5.4. Exercise sheet is shown in appendix C (also table 5.1), and the questionnaire in appendix D (also table 5.2).
The new evaluation of MAPS1, conducted at the time of the MAPS3 evaluation. Exercise sheet shown in appendix E (summarised in table 9.1), and questionnaire shown in appendix F (summarised in table 9.2).

Scale responses for MAPS1 when presented as a comparison with MAPS3 on the questionnaire shown in appendix G (summarised in table 9.2).

The evaluation of MAPS3. Exercise sheet shown in appendix E (summarised in table 9.1), and the questionnaire similar to the one shown in appendix D (summarised in table 9.2).

Scale responses for MAPS3 when presented on a comparison questionnaire with MAPS1 shown in appendix G (summarised in table 9.2).

9.3.4. Experimental Conditions

As with previous evaluations, the experimental conditions were maintained as close to reality as feasible. Each user session took place in a normal office environment, with distractions such as printers, telephones and general conversation. This time, no help was given by the experimenter, as the sessions were not used as tutorials. No secondary tasks were completed such as answering the phone, or dealing with enquiries from other colleagues.
<table>
<thead>
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<th>Exerc.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Score</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Omitted for MAPS3 evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Find all the available literature on dehydration in the heat. Note record numbers for future reference.</td>
<td>4</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>This required use of the DBA database system, but with full instructions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Find the estimation of metabolic rate according to Pandolf et al, for a man walking up an incline with a load.</td>
<td>6</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>Only guidance given was to indicate which branch of the main menu contained the solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Given a set of skinfold measurements, find the best estimate of percentage body fat.</td>
<td>8</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
<td>No guidance given, but all required data listed in logical form</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
<td></td>
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<td>Omitted for MAPS3 evaluation</td>
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| F      | " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " " &b...
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<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
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<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
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<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
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<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
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<td>3</td>
<td>On average, how often have you used MAPS3 in the past</td>
<td>6</td>
<td>Categories of usage frequency</td>
<td>7 - 1</td>
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<td>On first using MAPS3, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
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<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
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<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
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<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
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<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12</td>
<td>Good - Bad</td>
<td>7 - 1</td>
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<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options (eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>17</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS3 as a method of retrieving individual programs</td>
<td>22</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>11</td>
<td>When working outside your own area of interest, how would you describe the guidance given</td>
<td>26</td>
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</tr>
<tr>
<td></td>
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<td>27</td>
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<td></td>
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<td>28</td>
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<td>7 - 1</td>
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<tr>
<td></td>
<td></td>
<td>29</td>
<td>Too much - Too little</td>
<td>7 - 1</td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS3 on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Useful - Useless</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>Crowded - uncrowded</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

Table 9.2. - Final Evaluation, questionnaire details  
(See also appendix D, F, and G)
9.3.5. Summary of Experimental Protocol

As already discussed, the order of presentation of MAPS1 and MAPS3 was changed for half the subjects. What follows is a brief description of the events in one experimental session.

1. Subject reads an introductory sheet to the evaluation, and instructions on responding to adjective scales.

2. He/she is presented with a sheet containing three problems, and is asked to solve them using the MAPS1 system. After completing each problem, two adjective scales are filled in.

3. A questionnaire on MAPS1 is completed by the subject.

4. The subject is presented with the same three problems again, and is asked to solve them using MAPS3.

5. A questionnaire on MAPS3 is completed by the subject.

6. Finally, the subject is asked to complete a questionnaire comparing the two systems.

The experimenter made notes throughout the session on observations of problems encountered in completing the
exercises. The sessions were conducted in a normal office environment, with the usual visual and auditory distractions.

9.4. Results of MAPS3 Evaluation

9.4.1. Exercise Scale Results

The results of the adjective scales for MAPS3, presented after each exercise, are shown in table 9.3, and graphically in figure 9.1. On their own, the scale responses did not supply much information. However, when coupled with comments made by subjects after responding to the adjective scales (see 9.4.3.), some observations can be made. These are discussed briefly in section 9.4.4.

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>4</td>
<td>6.00</td>
<td>4.00</td>
<td>7.00</td>
<td>0.77</td>
<td>20</td>
</tr>
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<td>3.85</td>
<td>1.00</td>
<td>7.00</td>
<td>1.77</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>5.85</td>
<td>3.00</td>
<td>7.00</td>
<td>1.01</td>
<td>20</td>
</tr>
<tr>
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<td>7.00</td>
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<td>20</td>
</tr>
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<td>D</td>
<td>8</td>
<td>5.95</td>
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<td>7.00</td>
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<td>20</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>5.75</td>
<td>3.00</td>
<td>7.00</td>
<td>1.22</td>
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</tr>
</tbody>
</table>

Table 9.3 - MAPS3 Exercise Scale Results

(higher values imply better performance)
(see table 9.1 for exercise details)
Exercise | Description                                                                                                                                                                                                                                                                                                                                                     | Scale |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Omitted for MAPS3 evaluation</td>
<td>2 3</td>
</tr>
<tr>
<td>B</td>
<td>Find all the available literature on dehydration in the heat. Note record numbers.</td>
<td>4 5</td>
</tr>
<tr>
<td>C</td>
<td>Find the estimation of metabolic rate according to Pandolf et al, for a man walking up an incline with a load.</td>
<td>6 7</td>
</tr>
<tr>
<td>D</td>
<td>Given a set of skinfold measurements, find the best estimate of percentage body fat</td>
<td>8 9</td>
</tr>
<tr>
<td>E</td>
<td>Omitted for MAPS3 evaluation</td>
<td>10 11</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>12 13</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>14 15</td>
</tr>
</tbody>
</table>

Figure 9.1 - MAPS3 Evaluation Exercise Responses Scales 4 - 9
(higher values imply better performance)
9.4.2. Questionnaire Scale Results (MAPS3)

Table 9.4 and figures 9.2 - 9.4 represent the responses to the adjective scales completed on the questionnaire. Their significance is discussed later in section 9.4.4.

<table>
<thead>
<tr>
<th>QUESTION NO.</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
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Table 9.4 - MAPS3 Questionnaire Scale Results
<table>
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<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2, 3</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4, 5</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS3 in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS3, how would you describe the learning process</td>
<td>7, 8</td>
<td>Easy - Difficult, Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
</table>

Figure 9.2 - MAPS3 Evaluation Questionnaire Results Scales 2 - 11
### Figure 9.3 - MAPS3 Evaluation Questionnaire Results Scales 12 - 25

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25</td>
<td>Good - Bad, Clear - Unclear, Uncrowded - Crowded, Informative - Uninformative, Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options (eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>17, 18, 19, 20, 21</td>
<td>Good - Bad, Informative - Uninformative, Helpful - Unhelpful, Appropriate - Inappropriate, Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS3 as a method of retrieving individual programs</td>
<td>22, 23, 24, 25</td>
<td>Good - Bad, Appropriate - Inappropriate, Helpful - Unhelpful, Fast - Slow</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>
### MAPS3 Evaluation Questionnaire Responses

![Bar chart showing responses to MAPS3 evaluation questions.](image)

### Questionnaire Responses

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>When working outside your own area of interest, how would you describe the guidance given</td>
<td>26, 27, 28, 29</td>
<td>Good - Bad, Clear - Unclear, Helpful - Unhelpful, Too much - Too little</td>
<td>7 - 1, 7 - 1, 7 - 1, 7 - 1</td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS3 on the following scales.</td>
<td>31, 32, 33, 34, 35, 36, 37, 38</td>
<td>Easy - Difficult, Fast - Slow, Useful - Useless, Appropriate - Inappropriate, Logical - Illogical, Clear - Unclear, Helpful - Unhelpful, Crowded - uncrowded</td>
<td>7 - 1, 7 - 1, 7 - 1, 7 - 1, 7 - 1, 7 - 1, 7 - 1, 7 - 1</td>
</tr>
</tbody>
</table>

**Figure 9.4 - MAPS3 Evaluation Questionnaire Results Scales 26 - 38**
9.4.3. Additional Comments By Subjects (MAPS3)

Space was provided after each adjective scale on the questionnaire, for additional comments. These are presented exactly as recorded by the subjects at the time, in tables 9.5a -9.5c.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>Not difficult, really just requires practice.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Having grown through MAPS1 &amp; 2, I found 3 a natural progression, so really no problem.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Menu layouts slightly confusing at first.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Some prior knowledge (physiology) required.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>I found it initially more difficult to use than MAPS1, however after several usages, I can see it being more user friendly.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Colour needed.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Could be more user friendly.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Main menu layout is a little confusing (use of function keys is unclear).</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Computer software side is good but there is little guidance on technical (eg. physiology) considerations.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Straight forward and relatively easy. There are a few problem areas but they are easily overcome.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Only login knowledge required to make a start.</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>Titles not very easy to understand</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>May use body fat programs if you have skin fold measures - slight ambiguity.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Some descriptions are ambiguous, eg. the measurement of % body fat by the Durnin method is just described as skinfold thickness in the menu.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>As for MAPS1 - are all equations in metabolic rate estimation appropriate - are variables within range for which models developed.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>For metabolic rate task, was difficult to find relevant topic option.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>One can get answers with very little knowledge - but are they the right answers, only an expert would know</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Yes, using the new search facility the problems with using the F17 key to input keywords. Generally though the user can hack around in the system knowing that if lost you can soon find yourself.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Yes, in wrong menu, didn’t use info on top line.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>No, temporarily misplaced maybe, but lost! No way!</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Yes, menu was not very clear, hence I found it difficult to find the metabolic rate estimation program.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Yes, it’s after a bit of a guess as to which was right option.</td>
</tr>
</tbody>
</table>

Table 9.5a - Comments By Subjects (MAPS3)
(See table 9.2 for questions)
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1</td>
<td>Wording could be better, more appropriate.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>But it's very slow to get going.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>On a larger screen an info panel the same size would give a feeling of greater space.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Gwoni and Goldman very good now.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>A huge improvement over MAPS1.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>DBA very much better.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Computer side is good but need more on technical (eg. physiology) considerations.</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Assuming previous physiological knowledge.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Could be improved. A stranger to the system could have difficulties.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Knowledge of where your query may be found is useful, ie. under which topic it may appear.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>But the name by itself is not enough.</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Information still limited.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>I have no area of interest.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Can be very slow if a particular equation is being repeated, since pressing return will not bring back the previous answer to a particular question, and default answers can't be set up.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Often I found there is no literature available.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>However, in my own area of interest I generally have access to my own programs which are faster and easier since I am familiar with them.</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>In DBA, the command keys to be used seemed to be scattered around the keyboard a bit.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>This is a partnership between the computer expert and the technical expert (in this case physiology) the latter is not pulling his weight.</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Yes, getting into the system and the programs.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Yes, start up and data base.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Yes, switch on, and moving into literature search.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Yes, initial log in to MAPS. Performing front end to DBA.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Yes, when choosing options and changing to different levels of the menu.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Yes, can't recall - but time lag reasonable in view of what is being done.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Yes, on start up.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Yes, searching DBA.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>After quitting the programs to return to main menu.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Yes, in DBA, after pressing ‘do’ key long delay before anything at all happens - user might think wrong key has been used. Also delay before full main menu reappears after doing something.</td>
</tr>
</tbody>
</table>

Table 9.5b - Comments By Subjects (MAPS3)  
(See table 9.2 for questions)
Table 9.5c - Comments By Subjects (MAPS3)
(See table 9.2 for questions)

9.4.4. Discussion of MAPS3 Evaluation

With reference to figure 9.1, showing the responses to the two scales presented after each exercise: The two responses made for the first exercise (4 & 5), requiring the subject to retrieve information from the DBA database, indicated the performance of the new MAPS3 interface with the database. The first adjective scale, (scale number 4) was EASY - DIFFICULT, the second scale (scale number 5) was FAST - SLOW. Scale 4 had the highest recorded value of all the exercise scales for MAPS3, whereas scale 5 was the lowest. It would therefore appear that users found the new DBA interface easy to use, but that possibly the time taken for the actual search was still slow.

The comments made on the questionnaire appear to point at a speed of response problem. With reference to question 12 comments [2], [3], [4], [8], and [10] (see table 9.5b) all
label DBA as slow to respond. However, when referring to the new interface to DBA, both positive and negative comments can be found in similar numbers. On the negative side, there appears to be some confusion over the the use of function keys (question 7 comment [1], and question 11 comment [1], table 9.5a & 9.5b respectively). This will need to be investigated in future developments of MAPS.

Many of the comments regarding speed of response may be answered by the installation of a new computer, which at the time of writing was expected within two months. In the opinion of the systems manager, the new computer would allow MAPS to operate considerably quicker. A reevaluation of MAPS after the installation would have been interesting.

One particular comment caused concern, that being question 10 comment [5] (see table 9.5b), where a user felt that his/her own computer programs were faster than MAPS3. Although it was always clear that MAPS3 was only one component of the overall enquiry handling system (see figure 4.1), such comments could have indicated a source of information that would have been better included within MAPS3.

Very little comment can be made on the scale responses when considered in isolation; this would be better achieved when compared with the other evaluations in later
sections. It can be seen that there is a slight dip in the results of scale 32 figure 9.4. This was a FAST - SLOW scale referring to MAPS3 overall, further evidence that speed would need attention in the future.

9.5. Comparison of All Evaluations

9.5.1. Aim

To extract more information from the overall MAPS project, it may be useful to compare the results of all evaluations conducted to date. Firstly a comparison of the original evaluations of all three systems (MAPS1, MAPS2 and MAPS3) conducted on separate occasions during the iterative development process. Secondly, a look at all the evaluations conducted on MAPS1, at the beginning and end of the project. Finally, a direct comparison between the results for MAPS1 and for MAPS3.

9.5.2. Comparison of Individual MAPS1, 2 & 3 Evaluations

9.5.2.1. Results

Figures 9.5 - 9.8 draw together the results of each of the three evaluations, conducted on separate occasions. Those for MAPS1 and 2 were recorded earlier in the project, and were presented in chapters 5 and 7 respectively. Those for MAPS3 were recorded during the final evaluation, with the questionnaire presented after use of MAPS3, results were shown in section 9.4.
MAPS1, 2 & 3 Evaluations

Exercise Responses

Figure 9.5 - MAPS1, 2 & 3 Evaluation Comparison
Exercise Responses Scales 2 - 15

(higher values imply better performance)
MAPS1, 2 & 3 Evaluations

Questionnaire Responses

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td>required to use the system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
</table>

Figure 9.6 - MAPS1, 2 & 3 Evaluation Comparison Questionnaire Scales 2 - 11
Figure 9.7 - MAPS1, 2 & 3 Evaluation Comparison
Questionnaire Scales 12 - 25
MAPS1, 2 & 3 Evaluations

Questionnaire Responses

Figure 9.8 - MAPS1, 2 & 3 Evaluation Comparison
Questionnaire Scales 26 - 38
9.5.2.2. Discussion (Individual MAPS1, 2 & 3 Evaluations)

Taken at face value, the comparison of the three separate evaluations suggests that MAPS3 did not perform as well as either MAPS1 or 2. However, the additional comments, and tape recordings of the sessions, indicated that users preferred MAPS3 to the earlier versions.

It was observed, in a comparison made between the MAPS1 and 2 evaluations in chapter 7 section 7.5, that very little change occurred in responses to scales between the two trials. It was suggested then that a shift in expectation may have occurred in the time between the evaluations. The comparison of all three evaluations appears to further support this theory.

It was therefore necessary to look in greater depth at this effect in order to attempt to cancel it out, hence the reassessment of MAPS1 during the MAPS3 evaluation.

9.5.3. Comparison of All MAPS1 Evaluations

9.5.3.1. Introduction

There were three sets of data collected for MAPS1, these being: The original evaluation, MAPS1 A; The reevaluation (MAPS1 B), with the separate questionnaire after completion of the exercises (table 9.6, and table 9.7); and the comparison questionnaire (MAPS1 C), after using both MAPS1 and 3 (table 9.8).
9.5.3.2. Aim

The way in which users' opinion of MAPS1 had altered during the duration of the project, particularly in the light of the introduction of MAPS3, could be better illustrated by looking at the two occasions when users were asked to complete exercises, and the three occasions when a questionnaire was completed. It was anticipated that the clearest comparison would be between the very first evaluation of MAPS1, and the occasion when users were asked to make a direct comparison between the old and new versions.

9.5.3.3. Exercise Scale Results (All MAPS1 Evaluations)

The data collected for the two scales presented after each exercise, is shown in table 9.6 and figure 9.9. (data for MAPS1 A is also shown in table 5.3).

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>3.55</td>
<td>1.00</td>
<td>7.00</td>
<td>1.86</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.05</td>
<td>1.00</td>
<td>6.00</td>
<td>1.60</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>4.85</td>
<td>1.00</td>
<td>7.00</td>
<td>1.71</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>4.65</td>
<td>1.00</td>
<td>7.00</td>
<td>1.59</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>8</td>
<td>5.40</td>
<td>3.00</td>
<td>7.00</td>
<td>0.92</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>5.00</td>
<td>3.00</td>
<td>6.00</td>
<td>1.14</td>
<td>20</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>11</td>
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<tr>
<td>F</td>
<td>12</td>
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</tr>
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<td></td>
<td>15</td>
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<td>-</td>
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<td>-</td>
</tr>
</tbody>
</table>

Table 9.6 - MAPS1 B Exercise Scale Results
(higher values imply better performance)
(see table 9.1 for exercise details)
Figure 9.9 - MAPS1 Evaluation Comparison
Exercise Responses scales 2 - 15

(higher values imply better performance)

Continuous line for presentation purposes
but no linear link is inferred

271
9.5.3.4. Questionnaire Scale Results (All MAPS1 Evaluations)

The results of the scales presented on the questionnaire are shown in table 9.7 (MAPS1 B) and table 9.8 (MAPS1 C), and figures 9.10 - 9.12. (For MAPS1 A see table 5.4).

<table>
<thead>
<tr>
<th>QUESTION NO.</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>-</td>
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<td>-</td>
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</tr>
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<td>6</td>
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<td>2.00</td>
<td>6.00</td>
<td>1.30</td>
<td>20</td>
</tr>
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Table 9.7 - MAPS1 B Questionnaire Scale Results
<table>
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<tr>
<th>QUESTION NO.</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
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<td>6.00</td>
<td>1.35</td>
<td>20</td>
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</table>

Table 9.8 - MAPS1 C Questionnaire Scale Results
MAPS1 Evaluations, A, B & C

Questionnaire Responses

Continuous line for presentation purposes but no linear link is inferred

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS1 in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS1, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
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Figure 9.10 - MAPS1 Evaluations Comparison Questionnaire Scales 2 - 11
MAPS1 Evaluations A, B & C

Questionnaire Responses

Continuous line for presentation purposes but no linear link is inferred

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<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>How would you describe the layout of the screen</td>
<td>12</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Uncrowded - Crowded</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td>9</td>
<td>How would you describe the choice of labels/names for the menu options</td>
<td>17</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td>(eg. Clothing, Anthropometry, Physical Fitness etc.)</td>
<td>18</td>
<td>Informative - Uninformative</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td>10</td>
<td>When working in your own area of interest, how would you describe MAPS1</td>
<td>22</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td>as a method of retrieving individual programs</td>
<td>23</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
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Figure 9.11 - MAPS1 Evaluations Comparison Questionnaire Scales 12 - 25
Figure 9.12 - MAPS1 Evaluations Comparison
Questionnaire Scales 26 - 38
### 9.5.3.5. Additional Comments By Subjects (MAPS1 B)

In addition to the adjective scale results for the separate reevaluation of MAPS1 (MAPS1 B) listed in tables 9.6 and 9.7, subjects commented on their reasons for responding to the aforementioned scales. The results are presented in tables 9.9a and 9.9b.

<table>
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<tr>
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<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>Inadequate instructions on menus (without having to need help pages).</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>User interface could be a little clearer, but that may just be me.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Speed improved with practice, but generally a slowish process.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Remembering command slightly difficult.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>First time I had encountered a KBS.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Only previous use was on last evaluation (no physiological knowledge was a disadvantage).</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Having now seen better system (MAPS3), it seems primitive.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>DBA options have to be known or the fact that PF1 = help.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>What was needed was a willingness not to be afraid of computers.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Still relatively simple.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Familiarity with the keyboard is an advantage.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>For someone who hadn't used a computer before some practice may be necessary.</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>I had none so I have to infer what some of the files related to.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>A moderate level of knowledge was needed to know where and what to look for.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Some ambiguity in areas eg. body fat question.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>However, high level would be required if the example data require interpretation or, as for example in the load carriage question where predictions are made from several equations - which ones are appropriate to the scenario described.</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>Yes, wasn't sure on the REPORTS task and needed more instructions on DBA.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Yes, me being too quick and not knowing quite what I was looking for.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Yes, I couldn't remember the procedures for library data base search.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Yes, typing wrong command takes you out of the system and didn't know how to get back in.</td>
</tr>
<tr>
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<td>5</td>
<td>Yes, relative lack of on-screen direction.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Yes, DBA.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Yes, lacking in experience of the use of system.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>A bit disoriented.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Yes, how to break out of DBA to re-enter with correct search pattern.</td>
</tr>
<tr>
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<td>10</td>
<td>Yes, I don't know how to use DBA - no obvious simple instructions.</td>
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</tbody>
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Table 9.9a – Comments By Subjects (MAPS1 B)  
(see table 9.2 for questions)
<table>
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<th>Comment Number</th>
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</thead>
<tbody>
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<td>7</td>
<td>11</td>
<td>Yes, system seized up.</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Yes, screen did not show enough info.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Yes, not having used it before and not having been shown how.</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Yes, on exiting programs I expected to go back to main menu, instead I went to previous screen.</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Yes, DBA options for keywords etc. in the search definition.</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Yes, lack of information, particularly in the DBA search.</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>DBA biggest problem (esp. commands menu/list).</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Again it seemed good when new but is dated.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Not always immediately clear where to go eg. <em>do you require specific software</em> and in problem 3, how to get back to main MAPS menu.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>There's not much to choose between MAPS1 and MAPS3 (except for reports/abstracts) where DBA is user vicious.</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Access of info is good if doing a 'one off' but if repeated calculations are required MAPS1 would be a slow process.</td>
</tr>
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<td></td>
<td>2</td>
<td>Nothing here.</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Wording not appropriate.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>DBA was the greatest problem.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>All within area of interest.</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Yes, only DBA (in search) but this is understandable.</td>
</tr>
<tr>
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<td>2</td>
<td>Yes, during the DBA search.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Yes, getting back to main menu.</td>
</tr>
<tr>
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<td>4</td>
<td>Yes, accessing data base.</td>
</tr>
<tr>
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<td>5</td>
<td>Yes, start up.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Yes, DBA search.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Yes, in start up and waiting for search.</td>
</tr>
<tr>
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<td>8</td>
<td>Yes, problem occurred when entering wrong data, and unable to exit without apparently crashing the system.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Yes, only in finding the data asked for ie. reports.</td>
</tr>
<tr>
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<td>10</td>
<td>Yes, searching for literature.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Yes, particularly on DBA.</td>
</tr>
<tr>
<td>other comments</td>
<td>1</td>
<td>Surprised how primitive</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Very little help given in DBA</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>MAPS1 and MAPS3 are not dissimilar.</td>
</tr>
</tbody>
</table>

Table 9.9b - Comments By Subjects (MAPS1 B)
(see table 9.2 for questions)

9.5.3.6. Discussion (All MAPS1 Evaluations)

It is apparent from these results that the original user opinion of MAPS1 was significantly higher than when
reassessed much later in the project. It can also be noted that very little change in opinion occurred between the individual questionnaire (MAPS1 B), and the comparison questionnaire (MAPS1 C). This would appear to further reinforce the 'new' attitude towards MAPS1, in the light of the availability of MAPS3.

How users judged the level of computer knowledge required to use the system, can be seen in the response to scale 9 in figure 9.10. On the more recent reevaluation of MAPS1, users considered that more knowledge of the computer was required. This was hopefully due to the lower requirement for computer knowledge achieved with MAPS3.

The response to scale 10 (figure 9.10), referring to the level of applied physiology knowledge required, remained virtually unchanged on all three occasions that MAPS1 was evaluated. This is probably a function of the fact that the knowledge structure and content throughout MAPS1, 2 and 3 had remained essentially the same, with expansion in appropriate areas. Therefore the requirement to understand the subject should not have altered substantially.

The response to scale 30 (Did the system appear to be slow to react at any time), changed slightly between the early and late evaluation of MAPS1, shown in figure 9.12. It appeared as though the users judged the system to be slower, in the light of the later MAPS3 version.
With reference to figure 9.9, all the exercises were judged more difficult than they had been originally found. The largest differences were recorded for scales 4 and 5, which related to the use of the DBA database system (Exercise B, table 9.1). It seemed as though the introduction of a new DBA interface in MAPS3 had altered the user's expectation of the database. This theory was further supported by looking at the comparison between the individual evaluations of MAPS1, 2 and 3 in figure 9.5. Although in the majority of cases, when individual evaluations were compared, the response for MAPS3 was lower than that for MAPS1 and 2, in the case of scale 4, it was in fact higher. This was without reference to the reevaluation of MAPS1.

The comments made after each question during the more recent reevaluation of MAPS1, presented in tables 9.9a and 9.9b, clearly show greater dissatisfaction with MAPS1 than when it was originally evaluated (see section 5.4.3.3, tables 5.5a and 5.5b). Of particular note was the number of negative comments relating to DBA, these appeared after nearly every question asked.

9.5.4. Direct Comparison Between MAPS3 and MAPS1

9.5.4.1. Introduction

The results of the repeat evaluations of MAPS1 (section 9.5.3.), suggested that a better comparison could be made
by discounting the original evaluation of MAPS1 (MAPS1 A). This could be justified on the grounds that when the users were first shown MAPS1 they had not seen any comparable system before, and given the inclusion of useful knowledge previously not easily available, it was perhaps not surprising that they were impressed. This was one reason why no conclusions were drawn to suggest that MAPS1 was particularly good, merely that weaknesses existed.

A direct comparison between the first and last versions of MAPS was perhaps the best indication of progress. Users could judge for themselves the improvements that may, or may not, have been made during the four plus years of the project.

9.5.4.2. Aim (MAPS3 and MAPS1 Comparison)

The aim was to highlight areas of MAPS3 that represented progress, areas that had possibly offered little over MAPS1, and most importantly, areas that should be addressed in the future.

9.5.4.3. Exercise Scale Results (MAPS3 and 1 Comparison)

The results obtained for the two scales presented after the exercises are illustrated in figure 9.13. The figure shows the responses after the final evaluation of MAPS3, and after the reevaluation of MAPS1 conducted at the same time (MAPS1 B).
Figure 9.13 - MAPS3 & MAPS1 Comparison
Exercise Responses Scales 4 - 9
(higher values imply better performance)
9.5.4.4. Questionnaire Scale Results (MAPS3 & 1 Comparison)

Table 9.10 shows the results of the comparison questionnaire for MAPS3 (MAPS3 C), those for MAPS1 C are shown in table 9.8 and for MAPS3 in table 9.4. All the questionnaire results are presented in figures 9.14 - 9.16.

<table>
<thead>
<tr>
<th>QUESTION NO.</th>
<th>SCALE NO.</th>
<th>MEAN</th>
<th>MIN</th>
<th>MAX</th>
<th>SD</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>4</td>
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<td>18</td>
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<td>7.00</td>
<td>0.60</td>
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<td>7.00</td>
<td>0.85</td>
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<td></td>
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<td>4.00</td>
<td>7.00</td>
<td>0.65</td>
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<td>40</td>
<td>4.85</td>
<td>2.00</td>
<td>6.00</td>
<td>1.26</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 9.10 - MAPS3 C Questionnaire Scale Results (see table 9.2 for question details)
MAPS3 & MAPS1 Comparison

Questionnaire Responses

Continuous line for presentation purposes but no linear link is inferred.

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How would you describe your knowledge of computers, and how they work</td>
<td>2</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>2</td>
<td>How would you describe your knowledge of Applied Physiology</td>
<td>4</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Extensive - Limited</td>
<td>7 - 1</td>
</tr>
<tr>
<td>3</td>
<td>On average, how often have you used MAPS in the past</td>
<td>6</td>
<td>Categories of usage frequency. A - F</td>
<td>7 - 1</td>
</tr>
<tr>
<td>4</td>
<td>On first using MAPS, how would you describe the learning process</td>
<td>7</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td>5</td>
<td>In your opinion, how would you describe the level of computer knowledge required to use the system</td>
<td>9</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>6</td>
<td>What level of applied physiology knowledge was required</td>
<td>10</td>
<td>High - Low</td>
<td>7 - 1</td>
</tr>
<tr>
<td>7</td>
<td>At any time during the session, did you feel you were lost</td>
<td>11</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
</tbody>
</table>

Figure 9.14 - MAPS3 & MAPS1 Comparison
Questionnaire Scales 2 - 11
Figure 9.15 - MAPS3 & MAPS1 Comparison
Questionnaire Scales 12 - 25
### MAPS3 & MAPS1 Comparison

**Questionnaire Responses**

![Graph showing questionnaire responses for MAPS3 and MAPS1](image)

Continuous line for presentation purposes but no linear link is inferred.

<table>
<thead>
<tr>
<th>Quest.</th>
<th>Description</th>
<th>Scale</th>
<th>Adjectives</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>When working outside your own area of interest, how would you describe the guidance given</td>
<td>26</td>
<td>Good - Bad</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29</td>
<td>Too much - Too little</td>
<td>7 - 1</td>
</tr>
<tr>
<td>12</td>
<td>Did the system appear slow to react at any stage</td>
<td>30</td>
<td>(Y or N)</td>
<td>Y=1, N=2</td>
</tr>
<tr>
<td>13</td>
<td>Overall, how would you rate MAPS on the following scales.</td>
<td>31</td>
<td>Easy - Difficult</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
<td>Fast - Slow</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Useful - Useless</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34</td>
<td>Appropriate - Inappropriate</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
<td>Logical - Illogical</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>Clear - Unclear</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>Helpful - Unhelpful</td>
<td>7 - 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38</td>
<td>Crowded - Uncrowded</td>
<td>7 - 1</td>
</tr>
</tbody>
</table>

Figure 9.16 - MAPS3 & MAPS1 Comparison Questionnaire Scales 26 - 38

286
9.5.4.5. Additional Comments By Subjects  
(MAPS3 and MAPS1 Comparison)

Additional comments made in the space provided after each question, are presented exactly as recorded by the subjects, in table 9.11.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Comment Number</th>
<th>Comment as written by subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1</td>
<td>Practice made MAPS3 easier after using MAPS1.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>You learn from the first run how to go through the second time.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Graphical format of MAPS3 is much easier to become familiar with.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>But only if you have used MAPS1 before.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>MAPS1 required greater DBA knowledge.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>As long as you know where the keyboard is you're OK!!</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>I found MAPS1 easier to use although I accept that MAPS3 is sophisticated.</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>Depends if you want an answer or the right answer.</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>Unfortunately it's slower to get going (MAPS3).</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>I'm still waiting.</td>
</tr>
<tr>
<td>other comments</td>
<td>1</td>
<td>Need more knowledge of computer systems for MAPS1 and less assistance available. Needed quite a bit of help with MAPS1.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>The &quot;main menu&quot; at the base of the screen for MAPS3 is a definite asset compared to MAPS1. The search definition is easier to comprehend in MAPS3 than in MAPS1.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Thought DBA much better on MAPS3.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>I am told MAPS3 is more helpful if one goes astray - which I didn't.</td>
</tr>
</tbody>
</table>

Table 9.11 - Comments By Subjects (MAPS3 and MAPS1 comparison)  
(see table 9.2 for questions)

9.5.4.6. Discussion (MAPS3 and MAPS1 Comparison)

The results suggested that a subjective improvement had been achieved between MAPS1 and MAPS3. The learning process had become easier (scales 7 & 8, figure 9.14). The degree of computer knowledge required was judged to be less for MAPS3 (scale 9 figure 9.14). As in previous
comparisons, and as expected, the level of applied physiology knowledge required remained about the same (scale 10 figure 9.14).

The scales covering the layout of the screen (scales 12 - 16 figure 9.15), showed the greatest improvement when judged on a simple good - bad scale (scale 12). The smallest improvement was on the CROWDED - UNCROWDED scale (scale 14). This could be cause for some concern, but considering the additional complexity of MAPS3 over MAPS1, and the requirement to have all facilities available on a single screen, this is probably understandable. The remainder of the scales all indicated an improvement for MAPS3, with the smallest increase for scale 32. This can be seen as a dip in the line shown in figure 9.16. It relates to the FAST - SLOW scale, in the overall assessment of the two systems. This is a fair reflection of both MAPS3 and 1 alike, as they are written in the computer’s operating system, and are available through a time sharing system. The advantages of using the aforementioned resources outweigh the trade off in speed. The absolute scale value is relatively high over the range 1 - 7, a value of 4.85 (see table 9.10, row 32).

With reference to figure 9.13, showing the responses to the scales presented after each exercise, an improvement was shown for every exercise. The largest improvement being for exercise B (using DBA database). Scale 4 (EASY -
DIFFICULT) showed an increase from 3.55 to 6.00, whereas a much smaller increase was recorded for scale 5 (FAST - SLOW). This was to be expected, as the software retrieving the literature from the database had not changed between the two systems. Therefore, although it may have been easier to input the search definition, the time taken for the search itself to be completed remained unchanged.

The comments made on the comparison questionnaire nearly all pointed to a preference for MAPS3. The small number of negative points related to speed (table 9.11, question 8 comment [1]), or to the yet incomplete knowledge base (table 9.11, question 10 comment [1]). One user found MAPS1 easier to use than MAPS3 (table 9.11, question 5 comment [4]). Discussions with the user appeared to suggest an apprehension due to the amount of information displayed on the MAPS3 screen layout. If the task had required more exploration of the facilities offered by MAPS3, this comment may not have appeared. No other users made reference to problems with the screen layout, but future work should reflect all views made by all users.


Figure 9.17 details MAPS usage represented as logins per month, from January 1987 to October 1990. The data was collected via the automatic report mechanism.

At the outset of the project it was not feasible to set a
level for target usage, as there were too many unknown factors. The project was originally conceived as a feasibility study by The APRE management, and the system was extended in scope as the work progressed. The rate of change of usage is therefore of greater interest.

Although information on the duration of each session was collected by the Automatic Report Mechanism (ARM), this is not presented here, as too many factors other than completing enquiries affected the duration. It could be observed that in some cases users would enter MAPS to answer an enquiry and then remain in MAPS for the rest of the working day, although not actively using it.

When compiling the values in figure 9.17, all possible care was taken to only record usage of MAPS for 'serious purposes'. If the duration of the session was less than 2 minutes, it was excluded from the count on the grounds that once the time to enter and exit MAPS had been removed, very little time remained to extract information from the knowledge base. On checking the key presses for some of the aforementioned 'short' sessions, in most cases the user had simply reached the main menu and then pressed PF4 to exit. The author could only assume that it had been realised that the required information or facility was not available in MAPS. All usage by the author, or anybody connected with the author, was removed before compilation of the figures.
MAPS Usage 1987 - 1990

Logins Per Month

- MAPS1 EVALUATION
- MAPS2 EVALUATED
- MAPS3 INTRODUCED
- FINAL EVALUATION
9.6.1. Factors Affecting Usage

MAPS, as outlined earlier, was designed primarily as an aid to handling day to day enquiries. These may either originate from other branches of the British Army, or alternatively from external organizations. The nature of such enquiries is that their distribution may be spasmodic. A second factor to consider in the handling of external enquiries is that the knowledge content of the latest version of MAPS3 was not complete. Consequently, some enquiries may not have been answerable through the MAPS system, and experienced users would have been aware of this before logging in.

The scope of MAPS was extended after completion of the early versions. It was broadened to act as a tool in report generation and further experimental work. As experimental work is generally on a relatively large scale, these are concentrated within a certain span of weeks in the year. This may have resulted in either an increase in MAPS usage over that period, or a significant decrease, depending on whether the experimental work was taking place within the establishment, or on-site.

9.6.2. Landmarks in The Development Cycle

Despite the aforementioned factors, an upward trend can be seen in figure 9.17. It was possible to match some of the peaks and troughs with various events in the life cycle of
the MAPS project, for example the introduction of each version of the system, and in turn, the separate evaluations. These have been superimposed on the bar chart in figure 9.17. It must be noted that the number of logins did not include those required for the evaluation sessions.

The MAPS1 evaluation clearly caused an increase in interest in the system. This was the anticipated effect, as it was designed as a tutorial in addition to an evaluation. In the months following the evaluation, usage gradually fell back to a lower level.

With the introduction of MAPS2, an increase in use occurred again. This may have been an effect of the method of introduction, which took the form of a seminar and demonstration. Additionally, users were required to attend an individual demonstration of the system, before being allowed access. As before, some levelling off occurred later on, although on this occasion a higher average was achieved.

The evaluation of MAPS2 resulted in a very marked increase in usage. The method of evaluation was similar to that for MAPS1, and again additionally formed a tutorial. The increase in usage was sustained for around three months.

The introduction of MAPS3 caused a clear peak in usage figures. The method of introduction varied from MAPS2 in
that no requirement was made to attend an individual demonstration, before being registered on the user list. This appeared to result in a more rapid usage increase than previously. It did, however, fall back again after about a month.

The final evaluation did not appear to result in an increase in usage. As already detailed, many factors could influence the number of logins apart from the evaluation. However an interesting observation can be made, this being that the final evaluation differed in one major way from the previous evaluations: it did not act as a tutorial. Not enough evidence has been presented here to prove the value of dual evaluations and tutorials, but it would be worth further investigation.

9.7. Chapter Summary

The results of the different evaluations, at each stage of the MAPS project, have shown some weaknesses in the software evaluation methodologies adopted. Factors affecting the results possibly include shifts in expectation by the users as new versions of the software were introduced. These will be discussed in chapter 10.

Figure 9.17 shows a healthy increase in usage over a four year period. It was hoped that this was partially a result of good software design, introduction methods, and user participation.
10. DISCUSSION

10.1. Introduction

The aim of this project, and thesis, was stated in chapter 1 (section 1.3). In brief, there were two components to the aim.

**Part 1**, to design, develop, implement, and evaluate a knowledge based system in applied physiology for the Army Personnel Research Establishment (APRE).

**Part 2**, to produce guidelines on the introduction of this type of software into an organization.

Achievement of the first part of this aim has been described in chapters 2 - 9, with a final evaluation presented in chapter 9. The second part, that of guidelines, has yet to be addressed.

It is the purpose of this discussion chapter to firstly identify key issues arising from the MAPS project, and, with hindsight, comment on their applicability in this situation.

10.2. Human Computer Interaction Guidelines

At the outset of this current project, it was clear that a large volume of written work had been produced on the subject of human computer interaction or HCI. There is a
handful of general text on the subject, together with many papers tackling specific areas. Interface design associated with knowledge based systems was reviewed in section 2.7.4. For background information, the reader is referred to Brown and Cunningham (1989). In addition, an interesting insight into conversation between humans and computers can be found in Gaines and Shaw (1984). Of particular note in the area of HCI guidelines is a document by Smith and Mosier (1984).

10.2.1. The MAPS Approach

The approach taken for the design of the MAPS user interface was largely experimental, relying on user feedback from an early stage. However, existing guidelines were not ignored, and where appropriate, text on the subject was consulted (eg. Smith and Mosier 1984).

The main strategy was to show a simple interface to the users in a demonstration system (MAPS1), and then allow user feedback to shape the interface for the first full prototype. A possible drawback with this approach is that users may not be made aware of the alternative methods of interface design available. In defence of the method used for MAPS, apart from the fact that the evaluations appeared to support the final design, two external factors were considered prior to the simple interface adopted for the demonstration system. Firstly, the constraint on
equipment at APRE dictated that mouse or icon based interfaces could not be adopted. Secondly, literature on interface design suggested only minor differences between menu driven, command language, and natural language interfaces (Hauptmann and Green 1983). They suggest that the structure and constraints of the underlying program may be more important than the mode of interface. In addition, as only limited manpower and equipment investment were adopted for the demonstration system, there was no pressure to continue with the same format used in MAPS1.

Brown and Cunningham (1989) suggest that menu driven systems, although having limitations, are best suited for casual or infrequent users. As the user population for the MAPS system fell into this category, MAPS1 (the demonstration system), adopted a simple menu driven format as a starting point. This was constantly refined with the introduction of each prototype leading to the final (MAPS3) system. Areas of interest regarding the MAPS user interface are discussed in the following sections.

10.2.2. Menu Items

Apart from the main menu, MAPS3 had between 3 and 4 items in a typical menu list. However, it must be noted that conflict in opinions exist on what the optimum number of items is. Lee and MacGregor (1985) identify a range of between 4 and 8. In a later paper MacGregor et al (1986)
are more specific, and suggest that for naive users, 4 to 5 items are suitable. Paap and Roske-Hofstrand (1986) contradict this, and suggest that 16 to 78 (assuming good grouping) can be adopted.

What this illustrates is that to some extent, a try and see method of design may be the appropriate choice. As MAPS1 was a quick demonstration system, the number of items could have been altered at a later stage, if user feedback indicated a need.

10.2.3. Hidden Functions

The largest change in design philosophy occurred between MAPS2 and 3. It became apparent from comments made by users in the respective evaluations that too many key strokes were required to perform commonly needed functions. Many queries arose about the absence of functions which actually existed in MAPS2, but were on additional menus, called up by pressing a function key. The philosophy change was to adopt a 'What You See Is What You Get' approach. This seemed to work well, particularly for naive users, and reduced the need for documentation. Evidence of this can be seen in the responses to question 4 (On first using MAPS, how would you describe the learning process) during the final evaluation. With reference to figure 9.14, when MAPS3 was evaluated both on its own, and in comparison with MAPS1, users found the learning process both easier and faster.
10.2.4. Response Delays and User Feedback

Due to technical reasons, all versions of MAPS, under certain conditions, had a delay when a user made a selection by pressing the appropriate key.

As a result of the complexity of MAPS2, actual time delays became more significant than found in the earlier demonstration system (MAPS1). Eleven subjects indicated the presence of delays, particularly during start up.

To tackle this problem, MAPS3 gave immediate feedback to the user after pressing a key. This is in line with the Smith and Mosier (1984) guidelines (User Guidance, Routine Feedback, 4.2.). Although comments made on the MAPS3 questionnaire were similar in number to MAPS2 (10 out of 20), none indicated a delay after function key presses.

10.2.5. Screen Layout

10.2.5.1. Window Layout

The final MAPS system (MAPS3), split the screen into four full width 'tiled' windows. Starting from the top line of the screen these were; Location indicator; Menu display; Input line; and function keys. The general opinion in literature on interface design more commonly supports the use of stacked windows. However, Bly and Rosenberg (1986), clearly found that although stacked windows were appropriate in many cases, there were exceptions. They
found that for inexpert users, with predictable straightforward tasks, a tiled arrangement worked better. The work conducted during the MAPS project would appear to further reinforce this theory, particularly in the case of knowledge based systems.

10.2.5.2. Commonly Used Functions

It is important for users to be able to quickly locate commonly used functions, and that they appear in the same area of the screen. MAPS3 had four frequently used functions keys, and these were highlighted and appeared immediately below the input window.

10.2.6. The Knowledge Program Interface

It became apparent that the knowledge being requested for inclusion in MAPS1 was mainly the processing of one or more mathematical equations. Few cases were found where the more familiar rule based expert system approach was required. It was therefore sensible to standardise the form of the interface to these individual knowledge programs.

The interface chosen adopted four tiled windows in a 'desk top' arrangement. That is, they made all the input and computed information visible on the screen at all times, in a similar manner to the laying out of papers on a desk, when processing information.
The response to this interface was good, and comments recorded during the evaluation were largely favourable (see section 9.4.3. table 9.5b question 8). The facility to alter any of the input values before final computation was seen to be particularly useful.

10.2.7. Presentation of Textual Knowledge

Although the majority of knowledge was based on the processing of equations, there were several cases where text needed to be presented for information.

It is generally recognised that accuracy of reading information from a VDU (Visual Display Unit) is increased as the length of text displayed is reduced (Creed et al 1988). Therefore text was reduced to short paragraphs wherever possible. Text was presented as light characters on a dark background. Apart from this being technically slightly easier, studies have shown that there is no apparent advantage to using inverse displays adopting dark characters on a light background (Oborne and Holton 1988).

10.3. The MAPS Evaluation Methodology

10.3.1. Practical Constraints

Evaluations are a particular problem in commercial and industrial environments, where time and resources are tightly controlled. Despite being primarily a research centre, The Army Personnel Research Establishment (APRE)

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had similar constraints on resources. There are problems regarding the availability of suitable subjects, and the time any individual can allocate to participating.

10.3.2. The Concept

There were three phases to the evaluation of MAPS, these being MAPS1, MAPS2 and MAPS3 (Final) evaluations.

MAPS1 was an early form of user feedback, and the evaluation had two distinct aims. Firstly, to obtain subjective data to help in shaping the design of MAPS2. Secondly, and of equal importance, to act as a tutorial introducing new users to the system, and thus encouraging use outside the evaluation. It was with these two goals in mind, coupled with manpower limitations, that the decision was taken for the developer of the software to conduct the user evaluation. This clearly had to be considered when interpreting the results. The sessions were informal and guidance was given where subjects were unable to proceed.

10.3.3. Choice of Subjects

Another limitation was related to the nature of the establishment, and security restrictions. It was not practical to bring in large numbers of subjects from outside the establishment, therefore only members of the Applied Physiology division were used. In view of the fact that MAPS was always intended for use only within the
applied physiology division of APRE, the sample of twenty subjects represented at least fifty percent of the user population. This made it a representative group.

10.3.4. Quality of Evaluation Results

A large volume of subjective data, in the form of adjective scales, was collected during the MAPS project, and the results looked particularly impressive. However, there are several points which need to be noted when judging MAPS on the basis of responses to such scales.

(a) No comparison was made with a similar software package.

(b) In the main, users were previously adopting a non-computer based method of enquiry handling.

(c) Some of the existing in-house software, had clearly not been designed with ergonomics in mind.

(d) The exercises were geared towards MAPS, with all the required data supplied, and the knowledge available in the MAPS system.

(e) The choice of adjective pairs may have an unknown effect on the results.

The above points were largely unavoidable, in most cases for practical reasons. However, as the results were predominantly used to point at weaknesses, and not qualities, in MAPS then it need not be a major problem.
10.3.5. Adjective Scales v Open Ended Comments

As already mentioned, the scale results tended to be very favourable, and had to be regarded with some caution. They did give a quick visual impression of overall opinion of the system, and simple descriptive statistics made them easy to compare with subsequent evaluations, thus allowing the identification of any trends. Very few subjects gave an indication that they found the scales difficult to complete, and observations during the session suggested that responses were made after careful thought. One scale was included that did not follow the same pattern as the rest, in that the ideal position was in the centre of the scale, the adjective pair being "too much - too little". The standard deviation for this scale during all three evaluations was as low as any of the other scales (see table 5.4, 7.4, and 9.4, scale 29).

In addition to the adjective scales, subjects were allowed to add comments, and, at the end of the questionnaire, to give the best and worse points of the system. It can easily be observed that subjects were willing to be more critical in their comments than in the scales. As the aim was to highlight weaknesses, much information could be gathered from these. At the same time, it is much more difficult to see shifts in opinion between evaluations than it is with the scales. The latter can be conveniently presented graphically.
The conclusion that can be tentatively drawn is that adjective scales and open ended comments complement each other, and are more powerful in combination than isolation.

10.4. On-site Development

10.4.1. Project Type

The MAPS project presents only one possible format for the development of a knowledge based system, and any discussion on the merits of on-site development needs to consider this. In many cases, practical constraints may mean the option to have the developer resident within an organization is not available. Considerations will include: availability of equipment; location; time scale and budget. Given that the option for on-site development is available, the following points may apply.

10.4.2. Advantages

On-site development can act as a catalyst for several well established goals for good system design. These include:

(a) User participation
(b) Knowledge of organizational requirements
(c) Good population profile
(d) Quick response to user suggestions
(e) Introduction of system to users
(f) Evaluation
(g) Maintenance of prototypes
As discussed in earlier chapters, particularly in the review of existing theory and applications (chapter 2), it is well documented that user-centred design is believed to lead to better software products. Having the developer of the software in the same location as the potential users helps to facilitate this in many ways, in particular user participation and feedback. Throughout the development of MAPS, a significant number of the design ideas started out with informal discussions with users during coffee breaks.

As the MAPS developer effectively became a member of the organization for the duration of the project, it made it easier to understand the organizational implications for the new software. The study of the existing enquiry system (see chapter 3), and consequently the role to be played by MAPS (chapter 4), were enhanced by on-site development.

Through informal knowledge elicitation, and general day to day contact with the users, a picture of their abilities could be drawn. It would have been easy to over estimate the level of computer knowledge amongst users. Some individuals had a genuine fear and mistrust of computer systems, and had problems with the basic concepts of storing and retrieving data. Despite a good understanding of the users' abilities and background knowledge, MAPS still used computer phrases such as 'software' and 'file' which it transpired caused problems for some people.
New versions of the MAPS system were introduced to users through seminars, but more importantly, through one to one tutorials of around 45 minutes duration. Clearly, the latter would not have been feasible without on-site development.

Each of the three evaluations were conducted over a period of around three weeks, with each subject taking around 45 minutes. An average day would include only one or two subject sessions. Again, this would have been made difficult, and costly, if visits had to be arranged to a client’s premises.

The author’s own experience of reporting faults in commercial software supplied the motivation to avoid this problem in the MAPS project. On-site development allowed a 'help desk' type service to be supplied in person and immediately, with any fixes being performed quickly.

10.4.3. Disadvantages

There are potential drawbacks to the adoption of on-site development, and these need to be considered. Many may not be apparent until well into the duration of the project.

If all goes well, the enthusiasm of future users of the finished system is raised as a result of the developer being closely involved with them. This may lead to a higher expectation of what early prototypes can achieve.
After promising a quick response to user ideas, the whole process can backfire if the response time cannot be maintained.

On a practical level, daily work output of the software developer may be affected adversely by the need to answer enquiries from the users. If work is carried out away from the site of the organization, enquiries could be handled in batches, as opposed to on a one off basis.

10.5. User Participation and Feedback

10.5.1. Demonstration Systems

Demonstration systems, or very early prototypes, were shown to be a useful source of early user feedback in the case of MAPS. MAPS1 was made available before major decisions had been made on any aspect of the system.

10.5.1.1. Advantages

With only limited resources available for the purchase of new software or hardware, the demonstration system gave the opportunity to test out ideas using existing facilities. It was intended that any weaknesses in the tools available could be identified, and suitable purchases made before the development of the first prototype. The result on this particular project was that a full system could be written using only existing tools.
The demonstration system also allowed feedback from the users on the appropriateness of this type of system to their overall job design. It is dangerous to assume that a knowledge based system will naturally improve enquiry handling.

10.5.1.2. Disadvantages

In cases where an early demonstration system proves to be popular with users, there can be a danger of raising expectations too quickly. Some individuals may try the system, find it does not yet perform the required functions, and consequently dismiss the long term project.

Although no major decisions need to be made prior to the demonstration system, there is a danger in influencing design by using ideas which can be achieved quickly and using existing facilities. In the case of MAPS1, the interface adopted a simple menu selection approach, with no windows or function keys.

In some special cases, it may be prudent to wait until a more comprehensive system can be supplied, before making it available to users. However, this will reduce the early involvement of users in the design process. Such cases would include situations where opposition to a new system may be strong, and an apparently weak offering may not help increase enthusiasm for the project.
10.5.2. Automatic Report Mechanism

All versions of MAPS included an automatic report mechanism (ARM). The ARM system recorded information on every user session with MAPS, and was described in full in section 5.3.5. Every keystroke was recorded, and any program errors were noted. Additionally, the duration of the session and where in the establishment the person logged in were noted.

This mechanism helped in many ways to facilitate a user-centred design methodology, completing the evaluation and feedback programme. Turn round time in dealing with program errors was shortened considerably, not relying solely on reporting of faults by users. Within minutes of a fault occurring, the process of investigation could start. This was helped by MAPS automatically sending a message to the developer's terminal at the point when any user entered the system, and again when they left.

Additional data could be obtained from the ARM system in the form of frequency of use. This allowed trends in the popularity of the package to be shown graphically (see figure 9.17), and possibly supply clues on the success of improvements and amendments.

There are some potential problems with such mechanisms, and these need to be considered when deciding to adopt a system of this type.
As MAPS was developed using the computer's operating system, and the report mechanism (ARM) entailed opening and writing to files on the computer's data storage disc, it could slow down the execution of the overall package. It may become sensible to reduce the complexity of, or to exclude completely, such a mechanism when the knowledge based system is declared complete and no further development work is intended.

It must also be remembered that some users may feel intimidated by having their every move recorded, and it could be seen as a 'big brother' type approach. In order to avoid this during the MAPS project, all users were asked in advance whether they would object to this monitoring taking place. No subjects mentioned the monitoring system in any of the three evaluations, in practice its existence appeared to have been forgotten.

10.6. Expansion of MAPS

Where systems are developed through a series of prototypes, as with MAPS, expansion is likely to be a rapid and continuous process. MAPS1 contained only a few knowledge programs that had been specifically requested by a handful of the users, and no additional utilities (eg. graphics, spellchecker). Certain factors need to be considered when planning the aforementioned expansion.
10.6.1. Keeping The User Informed

The basic tree structure of the knowledge base needs to be formulated before all the items are available in a working form, to supply the framework for the menu driven system. As a consequence of this, there may be items in a menu which do not as yet exist in a full form.

There is a danger that if a user tries to retrieve knowledge on a subject of interest, which exists in the menu structure but is not yet available, that they may be put off trying at a later date. There was some tentative evidence to suggest that this may have occurred during the MAPS development. In particular, after the introduction of MAPS2, the evaluation of MAPS2, and the introduction of MAPS3, peaks in usage occurred, which subsequently dropped back. The fall back may indicate that users explored the tree structure of knowledge, to see what was available and what was still missing, after which only entering MAPS when they knew the knowledge they needed was there.

To offset this, MAPS2 introduced a 'new news' facility, which was refined further in MAPS3 (see 8.5.4.). When a user logged in, if the system detected an item of news which had not yet been displayed to that particular user, then it would appear on the screen prior to the main menu. News items would detail recent additions to the knowledge base, or new utilities.
10.6.2. Tools For Knowledge Expansion

As the MAPS project proceeded, the need to be able to expand the knowledge base quickly and accurately, became important. It was publicised that suggestions for new knowledge were always welcome from the members of the organization. At the outset, each new knowledge program was developed on a one off basis, with only a small degree of standardisation. The only consistent factor was the front page with the option to begin and quit (see figure 5.10.). The programs were written in the high level computer language FORTRAN, and the need to duplicate sections of the program rapidly became apparent.

10.6.2.1. Standard Knowledge Program

To this end, a standard program was developed, built from a set of FORTRAN subroutines (see section 8.8). It had been noted that the majority of the knowledge being put forward for inclusion in the system was based around the computation of one or more equations. The standard interface was geared towards the processing of such equations.

This was found to save time from the point of receiving information about the equations from the users, to demonstrating a finished program. This encouraged more people to come forward with new knowledge for inclusion in MAPS. As it is often said that consistency is an important
factor in good interface design (eg. Shneidermann 1989b), the standard knowledge program helped in this direction.

10.6.2.2. The Development Environment

In the latter part of the MAPS project, to further aid the expansion of the system, and to supply access to the mechanism of MAPS after the departure of the developer, a development environment was produced.

Originally, it was only intended for use by the developer, to help in the day to day tasks of maintaining MAPS, but it was envisaged that in the long term, key members of the organization would have access to it. However, it was difficult to guarantee that the addition of new knowledge units would not disturb the structure of the existing knowledge tree, therefore further work would be needed.

It was found to be invaluable for editing the programs within the system, for adding and deleting user names from the access list, and for adding 'new news' on improvements and additions to the system.

10.7 Technical Development

It was the aim of this thesis to explore all aspects of the implementation of a knowledge based system into an organization, and this would not be complete without discussing the technical development of such a system.
10.7.1. Choice of Tools For The System Framework

Although expert system shells had advanced rapidly over the previous five years or so, they still had several limitations which made them unsuitable for the MAPS project. These included the following:-

(a) Poor interface design
(b) High cost
(c) Difficult to link with external software
(d) Recompilation during development
(e) Better suited to rule based knowledge than numeric computation.

The shells examined at the outset of the project had interfaces which were unsuitable for the naive computer user. They appeared to have been intended for individuals with an aptitude towards computers. They were not appropriate for infrequent users, and would have needed use of a manual to understand the options and commands.

Most of the shells examined for their suitability for MAPS were found to be very poor at linking with existing software, and consequently any new software purchased during the life span of the project.

With the possible exception of one or two expensive shells, any developing systems required recompilation after any alterations or extensions, thus slowing down the
progress of the project, and also not encouraging experimentation.

Lastly, they all seemed better suited to the processing of traditional rule based knowledge, and less apt at the processing of equations and the presentation of textual material.

After examination of other options such as special purpose languages and development environments, the decision was made to develop MAPS using the computer’s operating system and the high level language FORTRAN for the knowledge base. MAPS was therefore built up from a series of nested command procedures and subroutines. The subroutines were used as building blocks for each branch of the main menu, avoiding duplication of coding.

This offered several advantages over the options previously discussed, as follows:-

(a) Better control over interface design
(b) Easier links with existing and new software
(c) Lower cost
(d) No compiling of main shell during development

In the light of experience, some disadvantages to this approach could be observed, as follows:-
(a) Slower execution
(b) Less portability between different computers, due to the use of an operating system
(c) Reliability takes longer to achieve

Overall, the disadvantages which came to light did not outweigh the many advantages found. However, it must be said that the tools used in future projects must always take allowance of what is currently available on the market. During the four and a half years that the MAPS project had been running, (at the time of writing,) new shells, languages, and development environments became available, which have not been reviewed here.

10.7.2. Choice of Tools For The Knowledge Base

Although the computer’s operating system was found to be suitable for developing the main framework and menu structure of MAPS, the knowledge base itself required a different approach. As already mentioned, the choice for this was FORTRAN. This was partly due to the nature of the knowledge concerned, which was found to be mainly computational.

As the main system consisted of command procedures, the option existed to mix the use of different tools where the knowledge required it. A small inexpensive commercial expert system shell was purchased, not to develop the main structure of MAPS, but to be used for individual knowledge
programs where a rule based approach was appropriate.

10.8. Identifying Applications

Existing applications of expert system or knowledge based system technology were illustrated in tables 2.1 - 2.3. Most of these fall into the category of rule based applications, this being the familiar face of expert systems. What is not clear from published literature on the examples illustrated is how the expert systems fitted in with the goals of the organization, and how it integrated with other software. There seems to be a lack of a systems approach to the selection of applications.

It was identified at the beginning of this thesis that at the heart of most businesses or organizations is 'data'. Knowledge based systems are a tool for accessing data in a manner which facilitates the production of solutions to problems, in line with the primary goal of the organization. It would therefore be logical when, as a developer, you are approached to produce a knowledge based system to solve a highly specific problem, that you examine the wider implications.

Using the Army Personnel Research Establishment (APRE) as an example, we can fabricate possible errors in identifying the role for a knowledge based system. For example, if the author had been approached to develop an
expert system to ascertain whether a defence standard for exposure to impulse noise was being complied with; or, if not, what the corrective action would have to be. Then a system could be written using either FORTRAN or an expert system shell to solve the problem. It could be developed away from the site, then delivered and installed.

What could happen in this hypothetical situation is that although the noise exposure expert system may work extremely well, the individual concerned with noise exposure at the establishment may have no other reason to use the computer system. As impulse noise may only be a fraction of his/her overall job, it is possible that he/she may consider that the time needed to become familiar with use of the computer is not worth the resources it will then offer. Consequently, he/she may continue to use a pocket calculator as in the past.

If, as actually occurred in the MAPS project, a study of the entire organization had taken place, it would have become apparent that what was needed was an enquiry system which could help answer problems across the whole field of applied physiology, then help the user present the results as part of a larger report, thus making it worthwhile entering the computer system in the first place. The moral of the story is to look at the wider implications, whenever it is feasible. Naturally, the author appreciates that in many cases monetary
considerations may make a larger study impossible.

The second observation to make is that not all knowledge based system applications are related to rule based knowledge. MAPS also covered simple equation processing, and access to textual data, all under the umbrella of one knowledge base system. Critics may say that MAPS does not qualify as a knowledge based system if it does not always apply the basic components of such technology, in particular an inference engine to examine a data base of rules. It may be disqualified if it uses conventional methods as part of the process of helping the user reach a solution. It is the author's personal opinion that to put specific labels on certain software items can result in missing the opportunity to supply a 'total' solution to the organization.

10.9. Chapter Summary

Some of the experiences gained in the MAPS project have been discussed in the preceding sections of this chapter. The common factor amongst all of the points raised is their contribution to the goal of implementation of a knowledge based system into an organization.

The largest single factor contributing to the successful implementation of MAPS was probably on-site development. This facilitated better user feedback, and, of equal importance, a better understanding of the existing APRE
enquiry handling system. Although an overall plan was proposed at the outset of the project, many changes were made in the light of experiences gained. It is hoped that these experiences may help future developers to start with a programme requiring fewer alterations as work progresses. There is a need to translate the knowledge gained during the MAPS project into a form which can readily be applied by personnel embarking on similar projects in the future. Dictating the form that any such advice should take, is the technical background of the individuals wishing to use it. Efforts to produce guidelines for the implementation of general computer software in the past appear to have put the emphasis on completeness and technical content.

With tools to develop knowledge based systems becoming readily available, and at a relative low cost, more people are finding themselves with a directive to develop this type of software. It cannot be assumed that such individuals will have a solid background in either systems analysis or computing. It is not inconceivable that an otherwise non-technical manager may hold responsibility for such a project. Any new guidelines, if they are to be successful, should therefore make as few assumptions about the background of the reader as possible, while retaining useful material.
11. CONCLUSIONS AND GUIDELINES

11.1. Introduction

Following on from the issues raised in the discussion, in the light of the experiences gained over the four years of the MAPS project, and in line with part 2 of the original project aim, guidelines for the implementation of knowledge based systems into organizations are proposed in this chapter.

The guidelines described here are inevitably tailored to a project with a similar anatomy to that of MAPS, and knowledge based systems. However, they can be applied in principle to different projects, which may have further resources or additional limitations. They are intended to be informative to individuals with a wide range of technical backgrounds. They complement existing computer software guidelines, for example those by Smith and Mosier (1984), which offer greater detail and completeness.

11.2. Using The Guidelines

As a quick reference, this chapter can be read in isolation, and as such will hopefully point the way to good design strategy for the implementation of knowledge based systems into organizations. However, if the reader wishes to explore the reasoning behind any particular guideline presented here, then reference to the relevant section of the main body of the thesis is recommended.
### 11.3. The Guidelines

**GUIDELINE 1: Stages of The Project**

Figure 11.1 illustrates the stages in implementing a knowledge based system into an organization. It is likely that all the stages shown would be present within any project to implement a knowledge based system.

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</tr>
<tr>
<td>User profile</td>
<td>4a</td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>4b</td>
<td></td>
</tr>
<tr>
<td>(Matrix of user - IT interfaces)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition of the role for the new system</td>
<td>5</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>New system diagram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early demonstration system</td>
<td>6</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>Automatic Report Mechanism</td>
<td>6a</td>
<td></td>
</tr>
<tr>
<td>Knowledge base development</td>
<td>7</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>Knowledge Elicitation</td>
<td>7a</td>
<td></td>
</tr>
<tr>
<td>Nature of the knowledge</td>
<td>7b</td>
<td></td>
</tr>
<tr>
<td>Iterative prototyping</td>
<td>8</td>
<td>Chapter 7 &amp; 8</td>
</tr>
<tr>
<td>Choice of tools</td>
<td>8a</td>
<td>Chapter 9</td>
</tr>
<tr>
<td>Interface design</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>General issues</td>
<td>9a</td>
<td></td>
</tr>
<tr>
<td>Location indicator</td>
<td>9b</td>
<td></td>
</tr>
<tr>
<td>Movement within the knowledge</td>
<td>9c</td>
<td></td>
</tr>
<tr>
<td>Screen layout</td>
<td>9d</td>
<td></td>
</tr>
<tr>
<td>Output of results</td>
<td>9e</td>
<td></td>
</tr>
<tr>
<td>Exit from the system</td>
<td>9f</td>
<td></td>
</tr>
<tr>
<td>Evaluation techniques</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 11.1 - Stages in Implementation*
GUIDELINE 2 : Preliminary Decisions

GUIDELINE 2a : Planning Document

At the outset of a project, it is useful to set some preliminary landmarks, and determine the time scale for these. They should remain flexible in the light of later events. Given a three year project as an example, these landmarks may cover six month intervals. The resulting document should be made available to the user population, as part of an introduction to the project. Basic information should include the following:-

(a) Location of staff
(b) Time scale for Study of any existing system
(c) Approximate launch dates for versions of the software
(d) Plans for consultation with the users
(e) Proposed monitoring of progress

GUIDELINE 2b : First Introduction to the Users

Before any work takes place, the users should have the opportunity to meet with the developers. The proposed project should be explained to them, clearly identifying the goals. The session should be informal.

GUIDELINE 2c : Location of Developer

Wherever feasible, as much development work as possible should be conducted on-site. If more than one developer is
employed on the project, then those concerned primarily with overall system design, including interface design as opposed to detailed program coding, should be on-site.

GUIDELINE 3 : Survey of Existing Work

The scope and magnitude of the survey may be adjusted as appropriate. If work has been carried out on a similar project in the past, then the problems that were encountered could save effort on any new project. Any relevant published guidelines should be collated to give easy access at a later stage.

GUIDELINE 4 : Study of The Existing System

Before development of working software can commence, a detailed understanding of any existing system is required. This will be enhanced if the developer can be resident on-site during the project. Information flow and current resources are important.

GUIDELINE 4a : User Profile

It is vital to have a good understanding of the characteristics of the potential users of the knowledge based system. Important aspects include their level of computer knowledge, and their knowledge of the subject to be included in the knowledge base. The user profile should be reviewed after the early demonstration system
has been evaluated. Questions can be included to assess the level of expertise of the users.

GUIDELINE 4b : Documentation of the Existing System

Two diagrams may help in documenting the information gathered at this stage. Firstly a structure diagram of the existing system, showing knowledge sources, members of staff, and lines of information flow.

Secondly, a matrix can be constructed showing particular groups of users on one axis, and sources of knowledge on the other. Each box within the matrix will then represent an interface between personnel and knowledge. This will encourage a view of the problem from a functional level, without dictating which aspects of the system require the use of computer software. Each box can then be filled in with a code to represent an assessment of the effectiveness of the current links with knowledge sources.

GUIDELINE 5 : Definition of the Role of The New Software

Any new software should be viewed as a component of the existing information handling system. This can be represented by a structure diagram similar to the original one drawn up for the existing system in guideline 4b. This time the new knowledge based system can be represented, showing links with any existing resources.
GUIDELINE 6 : First Demonstration System

At an early stage, a demonstration system is a useful form of user feedback. If possible, it should be developed with minimum investment, in order to leave as many options open as possible for later versions.

GUIDELINE 6a : Automatic Report Mechanism

An automatic report mechanism built into the proposed software will give feedback at a detailed level throughout the project. This will facilitate a quicker response time to users' problems as well as software faults. Data on keys pressed, errors that occur, and duration of the session should be recorded.

GUIDELINE 7 : Knowledge Base Development

GUIDELINE 7a : Knowledge Elicitation

It is difficult to give a rule on what method of knowledge elicitation should be applied, as this will depend on the user's characteristics, and the nature of the knowledge. As with the use of an early demonstration system, ideas can be tried out without large scale investment. In many cases, a semistructured interview technique can be useful. This may be supported by the establishment of a route by which users can approach the developer with information, as and when ideas come to light.
GUIDELINE 7b : Nature of The Knowledge

The nature of the knowledge to be accessed through the system will strongly influence the development of the knowledge base. Three basic types can be identified:-

(a) Rule based
(b) Computation of equations
(c) Textual

For rule based knowledge, expert system shells are a useful development tool. If most of the knowledge is concerned with the processing of equations, then conventional high level languages such as BASIC or FORTRAN may be used to develop the software. A modular approach, with individual executable programs tied together in a tree structure, will help make expansion easier.

GUIDELINE 8 : Iterative Design of Prototypes

An iterative approach to the design of prototypes seems best suited to knowledge based systems, as less tends to be known about the suitability of interface design and knowledge base structure, than with conventional software. The cycle of events is:

Design
Implement
Evaluate
There should be no limit on the number of prototypes, although some indication to the users of the stages involved would be useful, as in the forward plan. Most of the user involvement will be derived from the evaluation stage of each prototype, however as much consultation as possible should be made during the design stage.

**GUIDELINE 8a : Choice of Development Tools**

The choice of suitable development tools for a knowledge based system will be dependent upon the following:-

1. Time scale of the project
2. Nature of the knowledge
3. Stand alone or integrated with existing software
4. Budget

In addition, two areas of the new system can be identified, and the requirements for each may differ. These are the shell for navigation around the knowledge base, and the knowledge base itself. In small systems, an expert system shell may fulfil both purposes. If the knowledge base is large and covers a broad area, one tool for navigation around the knowledge, and another for the knowledge base itself may be better. The knowledge base may be constructed from individual stand alone programs; this will allow different tools or languages to be used for different areas of the knowledge.
GUIDELINE 9 : Interface Design

GUIDELINE 9a : General Issues

Interface design needs to be largely experimental, and driven by user feedback. Guidelines for conventional software can be used where appropriate, but should not be adhered to religiously (eg. Smith and Mosier 1984). As with any software, but perhaps more so with knowledge based systems, it is probable that the user population will be unfamiliar with the technical aspects of computers. Consequently interfaces should be uncomplicated and avoid computer jargon. The need for user manuals should be avoided. A screen design including all available functions with no hidden menus works well.

GUIDELINE 9b : Location Indicator

In a system with a tree structure of knowledge, it is important to supply a means of navigating through the tree. A location indicator is useful only if full information is displayed on each branch of the tree visited, therefore giving an indication of the route back up to the top branch, or main menu.

GUIDELINE 9c : Movement Within The Knowledge Base

The nature of large knowledge based systems is such that users are likely to explore the full extent of the knowledge base at some stage, and facilities to encourage
this should be supplied. Two basic functions are required. A key to allow movement back up the tree structure in single steps, and a key to return to the top of the tree.

**GUIDELINE 94 : Screen Layout**

Two basic screen designs will normally be required, one for navigation through the knowledge, and another to process the knowledge. The latter will be tailored to the type of knowledge involved. Several general principles can be identified as follows:-

[1] Consistency should be maintained throughout the system, particular function keys should always perform the same task.


[3] Messages should assume no knowledge of computers and therefore should avoid ‘jargon’.

[4] Important functions should be highlighted, for example an exit/quit key.

[5] Users input should be confirmed on the screen. If a function key is pressed, a message should identify the key pressed. If an item is selected from a menu, that item should be highlighted.
GUIDELINE 9e : Output of Results

Although not applicable to all knowledge based systems, it may often be advantageous to offer a convenient method of obtaining a paper copy of any results. This should be simple and quick to operate, if possible on a single function key. The format of the output should follow any conventions used for report writing in the organization.

GUIDELINE 9f : Exit From The System

Users who have found the information they require often find it frustrating to have to make several selections before exiting the system. Wherever possible, a standard screen layout should include a key to leave the system directly, and this should be highlighted in some way.

GUIDELINE 10 : Evaluation Techniques

Evaluations can be both time consuming and costly in a commercial setting. Experts' time should be used thoughtfully. It may sometimes be useful to combine an evaluation session with a tutorial. This may be achieved by the presentation of a set of hypothetical problems to be solved by use of the knowledge based system. These may be graded so that the early examples give full instructions on how to complete the exercise, with a gradual reduction to presentation of the problem alone.

Data can be collected by two main methods. Seven point
paired adjective scales can be used, along with additional comments. A questionnaire may conclude by asking for the best and worst aspects of the software. Tape recordings during sessions can pick up on comments not recorded on the questionnaire.

11.4 Summary

The guidelines presented in this chapter are intended as a catalyst for further thought by developers of knowledge based systems. They are not conclusive or complete, and should not be seen in that way. Where appropriate, the points raised hopefully lead the reader to firstly review the relevant section of the account of the MAPS project, and secondly, to initiate further investigation. They are largely a summary of the material presented in the main body of the thesis.

MAPS has encountered many problems during its development, and the way in which these have been addressed may lead the reader to form better solutions to their own difficulties. The author feels that the content of this thesis can be used as a reference work, and hopefully the structure adopted will allow easy access to the relevant section. If time is available, reading the document from cover to cover will give a better insight into the philosophy behind the MAPS knowledge based system.
12. RECOMMENDATIONS FOR FURTHER RESEARCH

The work in this thesis represents a detailed examination of the process of implementing a knowledge based system into an organization. However, it has only pushed forward the techniques involved, with much remaining to be investigated or enhanced. One or two key areas can be identified as requiring particular attention in the near future:

(A) Expansion of the knowledge base by the expert/user.

(B) Interface design for the presentation of textual knowledge.

(C) Quick and easy methods of evaluation.

(D) Integrating knowledge based systems with existing conventional software.

(E) Improving methods of involving the users early in the development cycle.

A component of the original MAPS project criteria was to detail a method of extending the MAPS knowledge base into the future, after the departure of the developer. To this end, a development environment was created. However, it had severe limitations with regard to the knowledge of both MAPS and the computer system, required to operate it correctly. Access could only be given to an individual.
with all the required skills. Ideally, a method of allowing the experts themselves to expand the knowledge base of such a system as MAPS would be invaluable. The problem will face many large knowledge bases in the future. Without maintenance by experienced software developers, the knowledge would rapidly become outdated and incomplete. The problem facing researchers is to produce a development environment with the same level of integrity as the knowledge based system itself. There would have to be no possibility of corrupting existing knowledge, when expansion and updates are carried out by non-computer oriented personnel.

The interface produced for the processing of equations within MAPS appeared to be highly successful. However, the interface for the presentation of textual knowledge, although improving over previous methods, can still be greatly enhanced. It is possible that this may be achieved using an approach similar to hypertext. The problem is in creating the shortest possible route to the area of interest for a particular user, without having to scan through pages of text on the screen.

The evaluation method used during the MAPS project was devised to comply with restrictions imposed by the commercial nature of the project, in particular, the use of experts' time during a working day. It would be invaluable if a quick and easy method could be formulated
which would produce reliable results with minimum time and effort. This would spread the concept of software evaluation to areas of industry and commerce so far not reached.

It became clear during the MAPS project that knowledge based systems cannot exist in isolation from other resources within an organization. More expert system shells should recognise this requirement, and offer appropriate mechanisms.

The MAPS project was conducted in a busy organization with many demanding criteria associated with industry and commerce. The methods adopted throughout needed to reflect this, and produce results in line with the expectations of the organization. Much progress was made in developing techniques for the implementation of knowledge based systems into organizations which may not have been forthcoming in a laboratory environment. MAPS is a 'real' system, fulfilling a 'real' purpose.


CAHILL, M. J., and CARTER, D. C. M., 1987. OASIS – A knowledge based system for high-speed process control. In: Man-machine interfaces for intelligent knowledge based systems. (Colloquium by professional groups C5 of The Institute of Electrical Engineers.) (Digest No. 1987/107).


HM TREASURY, 1985. Expert systems, some guidelines. (Information technology in the civil service)


APPENDIX A

MAPS1 Technical Report
MAPS1 - Modular Applied Physiology system

TECHNICAL REPORT
-----------------
P.M. WADSWORTH

18:2:87
The host computer for MAPS1 is a VAX 11/750 running VMS.

MAPS1 is written as a series of VMS command procedures, in some cases nested. There are 10 items on the main menu, each of these is represented by a command procedure stored in the main MAPS1 subdirectory. 9 of the main menu items are assigned their own subdirectory .1 .2 etc., the tenth is a call to DBA. Apart from standard routines which are stored in the main MAPS1 directory, each of the command procedures only reads files from the subdirectory associated with its particular item of the main menu.

The details of the VMS command procedures are as follows:-

**KBSMAIN.COM**

This is the first command procedure to run when a user calls up the system. Its task is to identify the location of the 9 subdirectories and set an equivalent string to each of these. This string can then be used when the command procedure for one of the 9 items of the main menu requires to call up a Fortran program or a data file. If MAPS1 needs to be moved to another location on the computer, this is the only procedure which requires altering.

**KBS.COM**

This is the main shell of the system. The task of this procedure is to identify the user's selection from the
main menu. It will then call the command procedure associated with that item number (1-10). Error checks are performed whenever a user responds to a question. Therefore out of range and nonsense responses are trapped.

1.COM TO 10.COM

As already described, these are the command procedures associated with the 10 items of the main menu. Each one has approximately the same structure, therefore they form a shell into which can be added the calls to the knowledge base, stored in the appropriate subdirectory.

MECHANISM OF CALLING PROCEDURES

The first response requested from the user is whether they require access to a particular item of software or not. If the user requests access to specific software, the command procedure branches to a point at the bottom of the program where a selection can be made. If the response is 'no' the procedure continues to ask questions to select the required software or data.

Normally the single subject heading selected in the main menu is split into smaller subject areas, when a subject choice has been made, the user is offered different facilities, such as literature or prediction programs. If the choice is literature, the command procedure
branches to a subroutine which calls text files containing an introduction to the dba database, instructing the user to input the name of a dba file.

It then calls up the dba system.

Each command procedure has an 'ON ERROR' instruction so that in the event of one of the knowledge base programs failing to complete execution, control is first passed to the bottom of that particular procedure where a message is displayed and a flag is set. Control is then passed back to KBS.COM where, if the flag has the correct value, control is passed to the display of the main menu. Therefore after a program error, the user does not get lost in the system, and can simply make another main menu selection.

In addition, every command procedure in MAPS1 captures the use of control Y and transfers control to a displayed question asking the user if they wish to leave MAPS1. If they respond 'yes', control is passed to the end of KBS.COM where MAPS1 is terminated in the normal way. If they respond 'no', control is passed back to the main menu.
APPENDIX B

User Guide to MAPS1
The Knowledge based system project.

User Guide For:-

MAPS1 (V1.0)

(Modular Applied Physiology System)
1.0 INTRODUCTION

A three year project arranged between the A.P.R.E. and The Department Of Human Sciences at Loughborough University commenced on 1st July 1986.

The aim of this project is to develop, install and evaluate a Knowledge Based System (KBS) for use by the A.P.R.E. Applied Physiology Division. It is hoped that the development of such a system will serve as a facility in many aspects of The Applied Physiology divisions work. In particular:

A) Tasks of retrieval & interpretation of information
B) Preparation of letters & reports
C) Standardization & validation of divisional software

An important element of this type of project is to match the final product to the needs of the users. To this end it was decided that the majority of the development process take place 'on site' at the A.P.R.E. This gives an ideal opportunity for close user participation in the design stage, through day to day feedback.

To encourage feedback from yourself (the user), we have developed a demonstration KBS system. It is intended as an indication of the type of facilities which may be made available in a future system. It contains a sample of knowledge in areas which it is hoped will be of use to a small group of the final user population.

We would be very pleased to hear any comments on the design and structure of this demonstration program. With your help, the final system can be designed to meet your needs as closely as possible, and therefore serve as a useful aid to you in the future.

Thank you for your cooperation.
2.0 USING THE KNOWLEDGE BASED SYSTEM (MAPSl)

In order to access the demonstration system MAPSl (Modular Applied Physiology Enquiry System), a short command sequence is required in your login.com file. This can be arranged with myself (P.M.WADSWORTH).

Once this is installed all that is required to run the system is to type 'MAPS'.

The first few pages of text presented show information about MAPSl, you will then be asked if you require instructions on how to use the system. Please answer Y or N to this question. If you respond with Y, information will be presented on the use and structure of MAPSl.

You will then reach the main menu. This is the first level of selection and identifies your main area of interest.

Please respond to this by typing the code number required, or 'E' to exit from the system and return to DCL level.

A '*' against a category in the 'main menu' indicates that information/software is currently available on that subject.

If you select a category without a '*' then the next screen will display future topics to be covered.

The second screen will ask you whether you require access to a particular item of software or not. Please respond Y or N.

If you respond 'Y':

A list of available software will be displayed. You may then make a selection by entering the appropriate code number.

Alternatively you may enter:

'A' - To make another enquiry in the current subject area
'M' - To return to the main menu
'E' - To exit from the system

If you respond 'N':

You will be asked to make further selections or answer questions in order to guide you to suitable software.
If you do not understand a question or wish to know the reason behind it, type 'why' and an explanation will be presented. If no explanation is currently available, you will be asked again for a response.

### 2.1 HARD COPY PRINTOUTS

If you require a line printer copy of the output from your chosen software, simply print the results file. The name of this is shown on the title page of each program, and will be stored in your default directory.

The results file contains output from the most recent run of the program. A run is only completed when you type 'Q' to quit, therefore several sets of data can be recorded by using 'B' to begin the sequence again.

### 3.0 THE STRUCTURE OF THE KNOWLEDGE BASE

The knowledge based is organised in the form of a tree structure. When first entering MAPS1 you will be asked to make a selection from the level 1 main menu. The tree then proceeds down levels, working towards the users specific requirement. The general structure is illustrated below.

<table>
<thead>
<tr>
<th>MAIN MENU</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL 1</td>
</tr>
<tr>
<td>1 3 4 5 6</td>
</tr>
<tr>
<td>LEVEL 2</td>
</tr>
<tr>
<td>1 2 3</td>
</tr>
<tr>
<td>LEVEL 3</td>
</tr>
<tr>
<td>. 1 2 3</td>
</tr>
<tr>
<td>. . .</td>
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<td>. . .</td>
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<tr>
<td>. . .</td>
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<tr>
<td>. . .</td>
</tr>
</tbody>
</table>

NOTE:–

If specific software is requested at LEVEL 1A then the system will not pass to lower levels but will instead ask you to select from a list of available software.
3.1 MENU ITEMS

The headings used in the menu structure are as follows.

<table>
<thead>
<tr>
<th>LEVEL 1</th>
<th>LEVEL 2</th>
<th>LEVEL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical Fitness</td>
<td>1. Muscle strength</td>
<td>------</td>
</tr>
<tr>
<td>2. Anaerobic power</td>
<td>3. Aerobic power</td>
<td>4. Effect of training</td>
</tr>
<tr>
<td>5. Fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Clothing</td>
<td>1. Insulation</td>
<td>------</td>
</tr>
<tr>
<td>3. Anthropometry</td>
<td>1. Population measures</td>
<td>2. Effects of clothing</td>
</tr>
<tr>
<td>3. Comfort</td>
<td>4. Water requirements data</td>
<td></td>
</tr>
<tr>
<td>5. Development and Troop Trials</td>
<td>1. Military equipment</td>
<td>2. Load carriage</td>
</tr>
<tr>
<td>3. Lifting and carrying</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Speech communication</td>
<td></td>
</tr>
<tr>
<td>9. Army Occ. Health Research Unit</td>
<td>1. Fitness and health</td>
<td>2. Older age groups</td>
</tr>
<tr>
<td></td>
<td>3. TLV’s</td>
<td>4. Occupational Audiometry</td>
</tr>
</tbody>
</table>
4.0 KNOWLEDGE CONTENT OF MAPS1

For a listing of the current contents of MAPS1 please see the document 'MAPS - CURRENT CONTENT', ref. PMW/MAPS.CONTENT.

5.0 FUTURE DEVELOPMENT

As already detailed, MAPS1 is a demonstration system designed to illustrate the techniques that may or may not be adopted in the finished product. Please feel free to offer any suggestions for additional material or alterations to the existing content (including layout or spelling mistakes).

To do this either speak to me directly, or alternatively leave a message for me on the apbvax mail utility ([WADSWORTH]).
APPENDIX C

MAPS1 User Exercises
To help in the evaluation of MAPS, it would be useful for you to complete the following exercises. There is no specific time limit for each of the tests, so just work at your own pace. Try to complete the exercises without requesting help from the observer, although this will be available if you cannot continue.

1. As an introduction to the system please log into the computer in your own name and enter MAPS. Use the system exactly as you wish. Explore the different branches of the menu and obtain information of interest to yourself. When you have finished, leave MAPS and await instructions from the observer.

What follows is a selection of possible uses for MAPS. Please think of each one as an enquiry from an external source to APRE. The first example gives the greatest amount of guidance on how to obtain the information. The level of help will then be reduced to the point where the exercise represents the wording which may be used by a 'customer'.
Exercise A
**********

Enter MAPS and select Thermal Stress and Water Requirements from the main menu. Answer 'NO' when you are asked whether you require specific software.

Select Heat stress
Select Prediction
Select a clothed subject
Select the 'Gagge & Nishi' prediction
Select 'B' to run the model
Input the following variables to the model:

- Air Temperature = 32 C
- Mean Radiant Temp. = 32 C
- Air Speed = .2 m/s
- Relative Humidity = .5
- Intrinsic Clothing Insulation = 1 Clo
- Total Metabolic Rate = 200 W/m²
- External work accomplished = 0 W/m²
- Output time interval = 5 min.
- Exposure time to conditions = 1 hour

Exit from MAPS

Print out the results from the above model by using the 'PRINT' command to send the file GAGGE.DAT to a line printer.

Please rate this task on the following scale:

Easy | | | | | | | | | Difficult *2

Fast | | | | | | | | | Slow *3
Exercise B

***********

Find all the available literature on dehydration in the heat.

SOLUTION

.........

Enter MAPS and select Thermal Stress and Water Requirements.
Do not select specific software.
Select Heat Stress
Select Literature
Follow instructions and type REPORTS
Select F for find
Input the following details, typing return after each.

<table>
<thead>
<tr>
<th>Option</th>
<th>SHOW-ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyname</td>
<td>KEYS</td>
</tr>
<tr>
<td>Operator</td>
<td>CO</td>
</tr>
<tr>
<td>Value</td>
<td>DEHYDRATION</td>
</tr>
<tr>
<td>Connector</td>
<td>AND</td>
</tr>
<tr>
<td>Keyname</td>
<td>KEYS</td>
</tr>
<tr>
<td>Operator</td>
<td>CO</td>
</tr>
<tr>
<td>Value</td>
<td>HEAT</td>
</tr>
<tr>
<td>Connector</td>
<td>END</td>
</tr>
</tbody>
</table>

Type enter to start search
Note record numbers for future reference

Please rate this task on the following scale :

Easy |___|___|___|___|___|___|___| Difficult *4

Fast |___|___|___|___|___|___|___| Slow *5

364
Exercise C
**********

A 70 kg man is carrying a load of 15 kg, at a speed of 0.9 m/s up a dirt road at an incline of 10%. What would be the estimation of metabolic rate according to Pandolf et al.

The information you require can be found under physical stress and performance.

METABOLIC RATE = ............... W

Please rate this task on the following scale:

Easy |___|___|___|___|___|___|___| Difficult *6
Fast |___|___|___|___|___|___|___| Slow *7

Exercise D
**********

In a recent survey, a 23 year old male subject had the following skinfold measurements:

Biceps = 5.1 mm
Triceps = 7.2 mm
Subscapular = 12.4 mm
Suprailiac = 6.2 mm

What would be the best estimate of his percentage bodyfat?

PERCENTAGE BODY FAT = ........... %

Please rate this task on the following scale:

Easy |___|___|___|___|___|___|___| Difficult *8
Fast |___|___|___|___|___|___|___| Slow *9
Exercise E
**********

(I) What is the range and average sitting height of Guardsmen in the British Army.

RANGE = ...................... AVERAGE = ................

(II) What is the correlation between sitting height and shoulder height for Gurkhas in the UK.

CORRELATION = ................

Please rate this task on the following scale :

Easy |___|___|___|___|___|___|___| Difficult *10

Fast |___|___|___|___|___|___|___| Slow *11

Exercise F
**********

Measurements of the noise levels of a military weapon have been taken. The peak pressure found was 150 dB, the duration of this peak was 5 ms. No hearing protection is used, and it is estimated that individuals will be exposed to 100 of these impulses every 24 hours.

Are there any problems with this level of noise exposure, and what action needs to be taken, if any.

ANSWER ............................................................

Please rate this task on the following scale :

Easy |___|___|___|___|___|___|___| Difficult *12

Fast |___|___|___|___|___|___|___| Slow *13
In order to carry out maintenance on vital machinery, a mechanic needs to work in a hot environment. The environment in question has been measured, and the results were as follows:

- Air temperature = 35°C
- Mean Radiant Temperature = 35°C
- Air speed = 0.2 m/s
- Relative Humidity = 0.5
- Effective clothing resistance = 1 Clo
- Total metabolic rate = 250 W/m²
- Work rate accomplished = 0 W/m²
- Radiation Area Factor (Ar/Adu) = 0.7

The mechanic is unacclimatized to this type of environment, and is not particularly athletic. How long may he work in these conditions without any risk to his health from heat stress.

Please rate this task on the following scale:

Easy |___|___|___|___|___|___|___| Difficult *14

Fast |___|___|___|___|___|___|___| Slow *15
APPENDIX D

MAPS1 User Assessment Questionnaire
1. How would you describe your knowledge of computers and how they work?

Good |___|___|___|___|___|___|___| Bad

Extensive |___|___|___|___|___|___|___| Limited

2. How would you describe your knowledge of Applied Physiology?

Good |___|___|___|___|___|___|___| Bad

Extensive |___|___|___|___|___|___|___| Limited

3. On average, how often have you used MAPS1 in the past?

Score = 1
2 a. Not at all
3 b. Occasionally
4 c. Once a month
5 d. Once a week
6 e. Once a day
f. More than once a day

Answer .........
4. On first using MAPS1, how would you describe the learning process?

| Easy |   |   |   |   |   |   |   | Difficult |
|------|---|---|---|---|---|---|---|
| Fast |   |   |   |   |   |   |   | Slow |

Any comments:
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5. In your opinion, how would you describe the level of computer knowledge required to use the system?

| High |   |   |   |   |   |   |   | Low |

Any comments:
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6. What level of applied physiology knowledge was required?

| High |   |   |   |   |   |   |   | Low |

Any comments:
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7. At any time during the session, did you feel you were lost?  
(Y or N) ...... (Y=1 or N=2)  
*11 
If YES, what do you think was the problem:  
.................................................................
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8. How would you describe the layout of the screen?  

Good |___|___|___|___|___|___|___| Bad  
*12 

Clear |___|___|___|___|___|___|___| Unclear  
*13 

Uncrowded |___|___|___|___|___|___|___| crowded  
*14 

Informative |___|___|___|___|___|___|___| Uninformative  
*15 

Helpful |___|___|___|___|___|___|___| Unhelpful  
*16 

Any Comments:  
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9. How would you describe the Choice of labels/names for the menu options (eg. Clothing, Anthropometry, Physical Fitness etc.)?

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<td>Illogical</td>
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Any comments:

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10. When working in your own area of interest, how would you describe MAPS1 as a method of retrieving individual programs

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<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Slow</td>
<td>*25</td>
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Any comments:

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11. When working outside your normal area of interest, how would you describe the guidance given:

Good |__|__|__|__|__|__|__|__| Bad  *26

Clear |__|__|__|__|__|__|__|__| Unclear  *27

Helpful |__|__|__|__|__|__|__|__| Unhelpful  *28

Too much |__|__|__|__|__|__|__|__| Too little  *29

Any comments:
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12. Did the system appear slow to react at any stage?

(Y or N) ......  *30

If YES, at what point did the problem occur:
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13. Overall, how would you rate MAPS1 on the following scales? Please mark a cross on the line to represent your feelings.

<table>
<thead>
<tr>
<th>Easy</th>
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<th>*31</th>
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<tbody>
<tr>
<td>Fast</td>
<td>Slow</td>
<td>*32</td>
</tr>
<tr>
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<td>Useless</td>
<td>*33</td>
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<td>*34</td>
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<td>*35</td>
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<td>clear</td>
<td>Unclear</td>
<td>*36</td>
</tr>
<tr>
<td>Helpful</td>
<td>Unhelpful</td>
<td>*37</td>
</tr>
<tr>
<td>Uncrowded</td>
<td>crowded</td>
<td>*38</td>
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14. What did you feel was the best aspect of MAPS1?

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15. What was the worst aspect of MAPS1?

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Any further comments you would like to make?

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Thank you for completing this questionnaire. Your views and comments will be of value in designing MAPS2.
APPENDIX E

MAPS1 and MAPS3 User Exercises
(Final Evaluation)
To help in the evaluation of MAPS, it would be useful for you to complete the following exercises. There is no specific time limit for each of the tests, so just work at your own pace. Try to complete the exercises without requesting help from the observer, although this will be available if you cannot continue.

What follows is a selection of possible uses for MAPS. Please think of each one as an enquiry from an external source to APRE.
Exercise A
**********
Find all the available literature in the REPORTS database on dehydration in the heat.

Please rate this task on the following scale:

Easy |___|___|___|___|___|___|___| Difficult *4

Fast |___|___|___|___|___|___|___| Slow *5

Exercise B
**********
A 70 kg man is carrying a load of 15 kg, at a speed of 0.9 m/s up a dirt road at an incline of 10%. What would be the estimation of metabolic rate according to Givoni & Goldman

METABOLIC RATE = ................. W

Please rate this task on the following scale:

Easy |___|___|___|___|___|___|___| Difficult *6

Fast |___|___|___|___|___|___|___| Slow *7
Exercise C
**********

In a recent survey, a 23 year old male subject had the following skinfold measurements:

- Biceps = 5.1 mm
- Triceps = 7.2 mm
- Subscapular = 12.4 mm
- Suprailiac = 6.2 mm

What would be the best estimate of his percentage bodyfat?

PERCENTAGE BODY FAT = .......... %

Please rate this task on the following scale:

Easy | | | | | | | | | | | | Difficult *8

Fast | | | | | | | | | | | | Slow *9
APPENDIX F

MAPS1 B User Assessment Questionnaire

(Presented at the time of MAPS3 Evaluation)
3. Have you seen and used the MAPS1 system before Yes or No
Y or N

4. On first using MAPS1, how would you describe the learning process?

Easy

Difficult *7

Fast

Slow *8

Any comments:

..........................................................
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5. In your opinion, how would you describe the level of computer knowledge required to use the system?

High

Low *9

Any comments:

..........................................................
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6. What level of applied physiology knowledge was required?

High ___________ Low ___________ *10

Any comments:
....................................................................................................
....................................................................................................

7. At any time during the session, did you feel you were lost?

(Y or N) ...... (Y=1 or N=2) *11

If YES, what do you think was the problem:
....................................................................................................
....................................................................................................

8. How would you describe the layout of the screen?

Good ___________ Bad ___________ *12

clear ___________ Unclear ___________ *13

Uncrowded ___________ crowded ___________ *14

Informative ___________ Uninformative *15

Helpful ___________ Unhelpful *16

Any Comments:
....................................................................................................
....................................................................................................

383
10. When working in your own area of interest, how would you describe MAPS1 as a method of retrieving individual programs

| Good | __|__|__|__|__|__|__| Bad | *22 |
| Appropriate | __|__|__|__|__|__|__| Inappropriate | *23 |
| Helpful | __|__|__|__|__|__|__| Unhelpful | *24 |
| Fast | __|__|__|__|__|__|__| Slow | *25 |

Any comments:

................................................................................................................................
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11. When working outside your normal area of interest, how would you describe the guidance given:

| Good | __|__|__|__|__|__|__| Bad | *26 |
| clear | __|__|__|__|__|__|__| Unclear | *27 |
| Helpful | __|__|__|__|__|__|__| Unhelpful | *28 |
| Too much | __|__|__|__|__|__|__| Too little | *29 |

Any comments:

................................................................................................................................
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384
12. Did the system appear slow to react at any stage? (Y or N)  

*30

If YES, at what point did the problem occur:

.............................................................

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13. Overall, how would you rate MAPS1 on the following scales? Please mark a cross on the line to represent your feelings.

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APPENDIX G

MAPS1 & 3 User Assessment Questionnaire

(Comparison presented at the end of MAPS3 Evaluation)
4. On first using MAPS1 and 3, how would you describe the learning process?

Easy |

 Difficult *7

Fast |

 Slow *8

Any comments:

..........................................................................................................................
..........................................................................................................................

5. In your opinion, how would you describe the level of computer knowledge required to use MAPS1 and 3?

High |

 Low *9

Any comments:

..........................................................................................................................
..........................................................................................................................
6. What level of applied physiology knowledge was required?

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
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<tbody>
<tr>
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Any comments:
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8. How would you describe the layout of the screen?

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<thead>
<tr>
<th>Good</th>
<th>Bad</th>
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| ___        |      *

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<tr>
<th>clear</th>
<th>Unclear</th>
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| ___        |        *

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<tr>
<th>Uncrowded</th>
<th>crowded</th>
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| ___       |        *

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<tr>
<th>Informative</th>
<th>Uninformative</th>
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| ___         |                *

<table>
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<tr>
<th>Helpful</th>
<th>Unhelpful</th>
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</table>
| ___        |          *

Any Comments:
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10. When working in your own area of interest, how would you describe MAPS1 and 3 as a method of retrieving individual programs

<table>
<thead>
<tr>
<th>Good</th>
<th>Inappropriate</th>
<th>*22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate</td>
<td>Unhelpful</td>
<td>*23</td>
</tr>
<tr>
<td>Helpful</td>
<td>Unhelpful</td>
<td>*24</td>
</tr>
<tr>
<td>Fast</td>
<td>Slow</td>
<td>*25</td>
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</tbody>
</table>

Any comments:
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11. When working outside your normal area of interest, how would you describe the guidance given:

<table>
<thead>
<tr>
<th>Good</th>
<th>Bad</th>
<th>*26</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>Unclear</td>
<td>*27</td>
</tr>
<tr>
<td>Helpful</td>
<td>Unhelpful</td>
<td>*28</td>
</tr>
<tr>
<td>Too much</td>
<td>Too little</td>
<td>*29</td>
</tr>
</tbody>
</table>

Any comments:
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13. Overall, how would you rate MAPS1 and 3 on the following scales? Please mark a cross on the line to represent your feelings.

Easy | Difficult *31
---|---
Fast | Slow *32
Useful | Useless *33
Appropriate | Inappropriate *34
Logical | Illogical *35
clear | Unclear *36
Helpful | Unhelpful *37
Uncrowded | crowded *38
Any further comments you would like to make?

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APPENDIX H

MAPS3 Technical Report
INTRODUCTION

The host computer for MAPS3 is a VAX 11/750 running under VMS 5.2. It is additionally implemented on a microvax II under VMS 5.2. It is designed to be compatible with DEC terminals from a VT220 upwards. It is capable of running through REFLECTION 4 PLUS terminal emulator, via an IBM compatible PC.

As with the earlier MAPS1 and MAPS2 systems, MAPS3 is written as a series of VMS command procedures, which in some cases are nested. There are nine areas of knowledge on the main menu, plus general literature. Each area of knowledge is controlled by a command procedure, named with the appropriate item number (eg. 1.com). Item 10, general literature, is also controlled by a numbered command procedure.

Above the aforementioned ten command procedures, are two other procedures. The first one, called when a user first enters the system, is KBSMAIN.COM and the second is KBS.COM. Available to all the command procedures are a range of sub-procedures, which are detailed in the following sections.

Each of the areas of knowledge has its own subdirectory named 1 - 10. All the knowledge programs associated with that subject (including original source programs) are stored in the appropriate subdirectory.
The details of the VMS command procedures are as follows:

**KBSMAIN.COM**

This is the first command procedure to run when a user calls up MAPS3. Its task is to identify the location of the 10 subdirectories, and set an equivalent string to each of these. This string can then be used by any of the 10 command procedures, to locate the FORTRAN knowledge programs. If MAPS3 is moved to a different disc location, either on the same computer or not, this is the only procedure which requires alteration.

**KBS.COM**

This is the main shell of MAPS3, and is called by KBSMAIN.COM. The primary tasks of KBS.COM are as follows.

Firstly, the terminal characteristics, and the identification of the computer are checked, and appropriate error messages displayed if they are not compatible. It then checks a list of legal user names, and only allows processing to continue if the user's name can be matched. It then checks to see whether there is a MAPS subdirectory in that user's area: if there is not, it creates one, otherwise it moves to the existing one.

It opens a file to record data on each user session, and first writes the login time and location.
It then presents the main menu on the screen, and waits for a selection of subject area and option. At the same time, it will allow any of a range of function keys to be pressed, and will call FUNCTIONS.COM (detailed later) if required. Depending on the number of the subject area chosen, it will call the required command procedure from 1 - 10.COM. It will pass a parameter, identifying which of the three options has been requested (Direct, Guidance or literature). Control will always be returned to KBS.COM before a user exits MAPS3.

1.COM - 10.COM

As already detailed, these are the command procedures associated with the 10 items on the main menu. Each one has approximately the same structure, and utilizes the same sub-procedures. This allows them to form a shell into which different knowledge can be substituted.

The first operation is to detect which of the three options is required, and to branch to the appropriate area of the procedure. It will then display the required menu, with the use of several sub-procedures. As with KBS.COM, a range of function keys can be pressed, and control will be passed to FUNCTIONS.COM.

The sub-procedures used by 1 - 10.COM are detailed in the following sections.
LOCATE.COM

This procedure keeps track of, and displays information regarding, the location within the knowledge structure. This is displayed on the top line of any MAPS3 screen. The current screen is highlighted. It requires 2 parameters before it can operate. The first is a string to represent the name of the new screen. The second is an integer to identify the depth of the tree at that point. For example, if you are presenting the name of a screen which is immediately below the main menu, the number would be 2.

CHECK.COM

Whenever input is required from the user in any of the 10 subject command procedures, it is obtained through a call to CHECK.COM. The purpose of this procedure is to block, and report via an error message, any illegal input. To do this it requires several parameters, as follows.

1. The name of the variable being input
2. A prefix to identify the subdirectory containing the knowledge programs. (eg. 'W1','W2' etc.)
3. The name of a file containing the menu screen
4. The number of menu items
5. The name of the screen to be returned to, if previous key is pressed
6. Either OPT or PROG, depending on whether the menu items are options leading to the next level menu, or knowledge programs to be run.
A variable called GTO is set inside check.com, which identifies the path to be taken when resuming in the upper level procedure.

**FUNCTIONS.COM**

If CHECK.COM detects that a function key has been pressed. (The function keys generate a code between -J and -X), then a call is made to FUNCTIONS.COM. The only exception is if one of the four PF keys has been pressed, upon which other action is taken.

FUNCTIONS.COM includes routines to call all the range of utilities available at the foot of each MAPS3 screen. Examples are; On screen calculator; Label printer; spell checker; and help.

**ERROR.COM**

If one of the knowledge programs produces a FORTRAN error, an 'on error' statement sends control to a point in the program where ERROR.COM is called. This recovers the screen back to a MAPS3 layout, and displays a sensible message announcing that a program error had taken place. By pressing the ENTER key, the user is returned to the main menu, or the list of available software, depending on where the error took place.
SUBJECT_LIT.COM

This procedure is called when access to literature on one of the nine areas of applied physiology is requested. That is, the third option of the three available. This allows two methods of interfacing with the in house DBA database.

The first option is to allow MAPS3 to fully define the search definition. This search definition is stored in a file called search_def.ini, which is stored in each of the nine subject area directories. This file is then read by DBA.

The second option is to allow the user to select keywords, titles etc. This information is then passed to a file called search.ini, which in turn is passed to DBA.

SUBJECT_LIT.COM takes two parameters when it is called from one of the nine higher command procedures. Firstly a string identifying which of the two options has been requested. Either DEF (for MAPS3 to determine search criteria), or NOTDEF (to allow the user to input keywords etc.). If DEF is used, the second parameter identifies which subject area is required. This is achieved by telling the procedure which subdirectory to draw search_def.ini. For example 'W1' for physical fitness.
REF.COM

At certain stages in MAPS3, the user is given the option of displaying key references on a particular subject. These are displayed by REF.COM. It requires three parameters.

1. The name of the file containing the references
2. A symbol determining which subdirectory the file is stored in. For example 'W2' (clothing)
3. the program label to return to, if the previous key (PF1) is pressed

GENERATING THE SCREEN LAYOUTS

Each screen in MAPS3 is generated from a text file with the suffix .SCR. These contain the text to be displayed, plus escape codes which can be interpreted by a DEC VT220 upwards, or a suitable terminal emulator.

KNOWLEDGE PROGRAM NAME FORMAT

In order to automate the calling of knowledge programs, a method of coded program names has been adopted. These draw their structure from the menu level, and the number on each individual menu. For example 3_2_PROG_1.EXE. This will represent item three on the first area of interest menu; item two on the next level; and finally item one on the list of suitable knowledge programs.
APPENDIX I

Notes on the use of scales
Notes On The Use Of Scales

In the following exercises and the subsequent questionnaire, you may be required to respond to questions using a scale. Please mark a cross in the BOX which best describes your feelings. A mark in the centre of the scale indicates that your feelings are neutral. It is better to respond relatively quickly to each scale, as this will represent your views more closely.

An example response may be as below:

**Question

How would you describe your views on Public transport?

**Response

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APPENDIX J

Publications Arising From This Research
This paper is concerned with the integration of a knowledge based system into an organization. It is an introduction to the first stage of a longer term project. The software discussed is a demonstration system known as MAPS1. This is a knowledge based system in applied physiology, designed as an aid to enquiry handling, through an interface with existing data bases and software, coupled with expert system technology.

The evaluation of the 'prototype/demonstration' system involved 20 current or future users. A series of exercises were completed using MAPS1 and then a questionnaire completed. The significance of the results are discussed.

INTRODUCTION

Recent developments in ergonomics, should allow traditional systems techniques for use in the design of man–machine systems within organizations (e.g. Meister et al 1965, Singleton 1974), to be combined with advances in the human factors of interface design (Villiges 1987) and conceptual and technological advances in computer software and hardware to provide an integrated methodology. This methodology can then be used to implement expert or knowledge based systems into organizations, such that they are compatible with the users of the system and with the aims of the organization. This paper reports on the first phase of a project to provide a knowledge based system in applied physiology for an organization. Smaller knowledge based systems have been developed in the past and have been shown to provide utility to a user population (e.g. Smith and Parsons 1987). The software described in this paper is a relatively large package, to be developed over a three
year period, and is likely to raise new issues in this area.

The organization in question is the APRE (The Army Personnel Research Establishment) in Farnborough, Hampshire. APRE is the Human Factors establishment for the British Army and is concerned with the physiological, psychological and ergonomic aspects of the soldier. The Applied Physiology Division of APRE is concerned with the physiological limitations of the soldier and the interaction between his protective clothing and equipment, the environment, and his performance.

The activities of the Applied Physiology Division often result in the collection and processing of large volumes of experimental data, as well as the searching and retrieval of research reports and relevant literature. Answering day to day enquiries can involve personnel in slow, time consuming searches of the aforementioned information. APRE became aware of the growing technology in the area of knowledge based systems, and looked into the feasibility of adopting this in the solution to their problem.

MAPS (Modular Applied Physiology System) is a custom built system for the use of the Applied Physiology Division of APRE. It is being developed under a three year research agreement with Loughborough University.

As part of the development process, a demonstration system was made available to the users at an early stage. The aim of the demonstration system was to supply an initial form of user feedback. To this end a system known as MAPS1 was developed and installed by the authors at APRE, and it is the fundamental structure, implementation, and evaluation of this system which is described here.

AIM

The aim of the final MAPS package is to serve as a knowledge base in applied physiology, with additional features encouraging its use for report generation. The intended user population are the original suppliers of the knowledge base, the aim is therefore to improve an existing, mainly noncomputing, method of accessing information.

USES OF THE SYSTEM

A user may enter MAPS for a number of reasons, these being the following:

1. To answer an incoming enquiry on the users own subject area, and/or outside the users normal area of interest.

2. To process new experimental data
3. To obtain information to help in the generation of a new report

4. to run a specific program that the user is already aware of prior to entering MAPS.

5. As a teaching and training aid.

The demonstration system MAPS1 offers most of the above facilities in a prototype form. It has been developed sufficiently to allow solutions to a range of real problems within APRE, it is therefore a practical tool in addition to a demonstration package.

**METHOD**

**User Model**

MAPS1 caters for all levels of computer knowledge in its design. Within the projected user population, the widest possible range of computer experience exists. MAPS1 only assumes that the user can log in to the computer system, print files and log out again. All possible errors are checked and reported in a straightforward manner, without the use of computer jargon.

In contrast, a basic understanding of applied physiology can be assumed, as the user population is primarily contained within the applied physiology division. A direct route to software is available, however, if knowledge outside the user's domain is required, guidance is given by MAPS.

**Knowledge elicitation**

As MAPS1 is a demonstration system, it was necessary to include software which would fulfill a need for the potential users. This would hopefully encourage its use and hence feedback.

Knowledge elicitation took the form of semi-structured but informal interviews. This informal method was made possible because the researcher was working within the organization, throughout the development.

**Structure and implementation**

MAPS1 is installed on a VAX 11/750 computer running the VMS operating system. It is written as a series of VMS command procedures calling FORTRAN executable programs, and linking with existing databases.

The layout of the knowledge content is in the form of a menu-driven tree structure. There are ten items on the main menu, of which nine are subject areas within applied physiology, and the tenth gives access to general literature. In subsequent menus, the subject area is
further subdivided until the users actual area of interest is identified.

A menu of facilities is then offered, this may include statistics, prediction or literature. MAPS1 then asks a series of questions to arrive at the most suitable software for the users task/enquiry. A "WHY" facility exists to expand on the questions, in order to help the user respond correctly.

As each menu is displayed, a line at the base of the menu indicates which commands are available to move around the tree structure.

Output from MAPS1

Each FORTRAN program within MAPS1 has a standard front end, offering the option to begin a run, or quit and return to a MAPS1 menu. Whenever a program is first run a results file is opened and output is written to it from the program. When quit is selected this, file is closed. Users will find these files in their default directory, when they leave MAPS1.

RESULTS

Usage

To aid in the day to day evaluation of MAPS1, a file is written every time a user enters the system. This includes such information as the time and place of the login, which menu options were chosen, whether 'help' or 'why' were used, and if any errors took place. From an inspection of this file, at the time of writing, MAPS1 had received a healthy level of interest. It has been noted that, in the first instance, many people logged in simply to see what the system could do. A pattern then emerged, that indicated that, usage had become more selective, with users entering MAPS1 to perform a specific task. From verbal reports, and through adapting the MAPS1 knowledge content, cases now exist where MAPS1 can be shown to have saved individuals many hours work, when compared with existing methods of knowledge retrieval.

Evaluation

A series of seven exercises were devised to be completed using MAPS1. These were graded in respect of the amount of guidance given for their completion. The first exercise simply involved the subject in following a set of MAPS1 instructions, whereas the final task merely described the information required.

Grading the tasks in this way, resulted in an effective tutorial session in addition to an evaluation. After each exercise, the subject was asked to respond on a seven point adjective scale (Osgood 1957). On completion of all seven
exercises, a questionnaire was completed, comprising of a series of questions and adjective scales similar to those adopted earlier.

Summary of results

Results of scale values are not presented here, but several patterns did emerge. In general, users found MAPS1 easy to use, and found the learning process very quick. However, some points for improvement were identified. In particular the use of 'computer language'. This had been kept to a minimum, but some had escaped the development process. An example being the phrase 'type return' which resulted in many people attempting to spell out return on the keyboard, when the correct response was to press the 'return' key. Other issues were raised which will be highlighted in the discussion.

DISCUSSION

It is clear that the field of expert, or knowledge based systems is a rapidly growing area, and there are many examples of this. Having taken a look at several of these, a pattern seems to appear. In a significant percentage of cases expert system shells, or languages, have been used to process a clearly defined set of rules. The system thus existing in isolation, designed to solve one particular problem. However, there is a slow but steady movement towards the integration of expert systems with conventional software. An example of this can be seen in PAYE, a tax expert system (Torsun 1986). There are signs of a growing awareness of the need to integrate with existing software, or even adopt an expert system as a subset of a more conventional package. This was identified by Bramer (1986). MAPS1 is not an expert system in itself, but draws on expert system technology where the task dictates.

The MAPS project is seen by the authors as an opportunity to study the entire design process, relating to the production and integration of knowledge based systems into the organization. The concept of initial prototyping in order to obtain early user feedback, appears to be highly appropriate in this type of project. Combined with the location of the developer within the same location as the future users of the final system, this has resulted in a fast turn round when processing suggestions by the users. One aspect of the design process, specific to this type of software, was drawn to the authors attention during the evaluation of MAPS1. It is important to indicate clearly to the user when they are leaving the knowledge based system to run an external program or database. An attempt was made to achieve this in MAPS1, by the employment of a standard title page to each external program. It would
appear that this needs modifications to ensure that the changeover is readily apparent. If this problem is not overcome, there is a tendency for the user to become confused, and attempt to use MAPSI commands when in a called FORTRAN program.

Additional advantages to the introduction of a knowledge based system are becoming apparent as the project proceeds. At present, desk top micros are in use. By accessing one major knowledge based system, a method of quality control on the individual programs made available through MAPS can be operated.

MAPSI and subsequently the final MAPS system, will represent a marriage between the new technology of expert, or knowledge based systems, and a development of the more traditional ergonomics approaches to overall system design (eg. Singleton 1975).

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THE DESIGN, DEVELOPMENT, EVALUATION AND IMPLEMENTATION OF AN EXPERT SYSTEM INTO AN ORGANIZATION

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SUMMARY

MAPS (Modular Applied Physiology System) is a computer based expert system designed to provide knowledge in the area of human applied physiology. It has been implemented at the British Army Personnel Research Establishment (APRE). This paper describes the process of this implementation. It illustrates the use of established HCI guidelines, together with an ergonomic approach to design procedure. MAPS is intended for users who are experts in applied physiology, but are unfamiliar with computer technology and terminology. The results of user evaluations are discussed, and conclusions drawn as to the validity of the design procedure adopted.

INTRODUCTION

The APRE is the Human Factors establishment for the British Army and is concerned with the physiological, psychological and ergonomics aspects of the soldier. The Applied Physiology (AP) Division of APRE is particularly concerned with the physiological limitations of the soldier and the interaction between his protective clothing and equipment, the environment, and his performance. The activities of the AP division often result in the collection and processing of large volumes of experimental data, as well as the searching and retrieval of research reports and relevant literature. Answering day to day enquiries could involve personnel in slow, time consuming searches of this information. There was a need for an efficient method of information retrieval, presentation, and interpretation, hence the requirement for MAPS.

AIM

The aim of the project was to improve an existing method of enquiry handling, and produce a computer based system to facilitate
easy access to information in various forms. It should take into account the profile of the user population, the frequency of use, and existing software/hardware.

METHOD

User Profile

From a study of APRE staff, it could be seen that the majority of potential users, although experts in particular areas of applied physiology, were unfamiliar with computers, and some had no experience at all. There was, however, a small percentage of individuals with a good knowledge of computers and how they work. Any new software would therefore have to cater for a wide range of computing ability, but could assume some expert knowledge in applied physiology.

System Goals

Several goals could be identified for the MAPS system, as follows:-

1. It must not rely on any prior knowledge of the computer or its operating system.
2. It must be usable without the need to refer to any documentation.
3. It must not use any computer 'jargon'.
4. It must be robust, and able to cope with any user input.
5. It must be a logical progression from the existing method of enquiry handling.
6. It must link with any appropriate existing software.
7. It must have an expandable knowledge base.

Design Procedure

The first stage of the procedure was to survey projects already completed or in progress in the area of knowledge based systems. It could be seen that the most common case was that of a relatively short time span, with a well defined problem, with software developed off site and then installed on completion. The end result was an expert/knowledge based system which was free standing, designed to solve one or two isolated problems. Given the longer duration of the MAPS project (three years), and the requirement for a modular system integrated with existing software, it was felt that an on-site development approach should be adopted.
MAPS1 - Demonstrator

In order to initialize an early form of user feedback, a demonstration system was made available to users inside the first three months, known as MAPS1. It contained some knowledge of use to particular users, but it was primarily designed as an indication of the type of system we were hoping to create. MAPS1 included an automatic report writing mechanism, recording details of each user session, so day to day feedback was available.

MAPS1 was evaluated using 20 potential/existing MAPS1 users. Each subject answered a range of simulated enquiries using the package. They then completed a questionnaire, and responded on a selection of adjective scales similar to those put forward by Osgood (1957).

MAPS2 and 3

The results of the MAPS1 evaluation, together with an analysis of use from the report mechanism, were then incorporated in the design of the first prototype, MAPS2. A similar process of evaluation was then used on this version to produce MAPS3.

The last stage of the procedure was to perform a more detailed evaluation of MAPS3, from which the final MAPS system could be produced. Brief user documentation was drawn up, together with guidelines on the expansion of the knowledge base.

Choice of development software/hardware

Several approaches were considered for the development of the system, in particular the choice of software tools. After investigation, it was clear that the range of 'off the shelf' expert system shells would not be suitable for this application. They did not offer the flexibility required to link with existing software, and more importantly, the interfaces adopted would not suit the naive computer user. They appeared better suited to individual problems which can be described in terms of a well defined set of rules.

The second approach would have been the adoption of a development environment or a particular expert system language. Several of these were investigated and although one or two could be described as versatile, for the considerable cost involved, they offered little advantage over using conventional languages and operating
systems.

The third approach, and the one adopted, was to develop a system from scratch using existing software and the operating system.

MAPS itself is written in the computer's operating system (VAX 11/750 running VMS), as a series of nested command procedures. The knowledge base being primarily a set of FORTRAN 77 executable programs. Links are made with existing databases, graphics packages, and, when appropriate, a simple expert system shell.

The user Interface

It was envisaged that there would be two extreme classes of use for the MAPS system. Firstly, it must present no problem for a user who has little or no knowledge of the computer and MAPS. Secondly, it must cater for a highly competent computer user, who is a regular user of both the computer and the MAPS system.

MAPS supplies a working environment for enquiry handling which aims to perform all the tasks required, without a need to leave the package and use the computer's operating system.

The concept behind the design of individual MAPS screens is that all the required information is visible on the one screen, there are no hidden facilities. Given this goal, the problem is to avoid a cluttered screen, especially when viewed by an experienced user. An example of a typical MAPS3 screen can be seen in figure 1.

With reference to figure 1, the MAPS screen is split into 4 windows. The top window indicates the location within the knowledge tree, and all previous menus. The large centre window displays the current menu or question. The one line window below the centre is the response point for menu selection. The lower most window displays the function keys and their meaning, the main four functions appear just below the response window. All input to the keyboard is checked and MAPS error messages displayed after illegal input. It is therefore intended that regardless of a users input, MAPS should not finish abruptly, and should always indicate the situation with its own messages.

A Typical Enquiry

On first entering the system the user is presented with the main menu. This has two distinct halves. The left hand side of the
Fig. 1. A Typical MAPS Screen layout

screen lists nine areas of applied physiology, the right hand side lists three options within the chosen subject area. The options are; direct to programs, guidance, and literature. The user first identifies his area of interest from 1-9, he then selects the appropriate option. Selecting the 'direct' option will take the user straight to a list of the available knowledge programs, where a program can be selected and run. Selecting the guidance option means he/she will be asked additional questions to identify the most appropriate knowledge programs to solve the given problem. The literature option links the user with a database containing all the reports held by the establishments library.

At any stage during the MAPS session, one of the functions shown on the bottom of the screen can be selected to help with the enquiry. These range from a help key and an explain key to an on screen calculator and a spellchecker.

RESULTS

In summary, MAPS enables a user to select a subject area, obtain guidance where required, run a suitable program and, if required, list, print or store the results. The user may also carry out literature searches and other tasks by links with existing/new software packages. This can all be achieved without direct use of
the computer through the operating system.

MAPS is in regular use at APRE, and many examples can be found where the process of enquiry handling has been greatly enhanced. The evaluations at each stage of development have shown any problems with the interface, enabling corrections to be made on the subsequent version. Some of these points are described in the discussion.

DISCUSSION
The existing Situation

The existing situation at APRE was potentially the type of environment to be found in many similar organizations, it is therefore useful to analyze the design procedure adopted and form some general guidelines. It could be seen at the outset that there was a weak link in the original method of enquiry handling used at APRE. The following statements could be made about the existing situation:

1. There existed a large body of recorded technical knowledge.
2. The recording methods varied from conventional filing systems to software on a variety of mini and micro computers.
3. New knowledge was constantly being added.
4. Access to this knowledge was time consuming and inefficient.
5. Existing computer software and hardware was not being used to the full.

The first observation made was that the potential user population was largely unfamiliar with computer systems and software. Although some users utilized micro computers, very few were familiar with the establishments network of mini computers. This resulted in there being very little use of existing software such as the library database of past reports.

It was suggested by James (1981) that often the assumption made about the users knowledge of the computers was much too high, and that this dated from a time when most users of computers were the individuals involved in building them in the first place. This may be a little pessimistic, but there is certainly a call for careful consideration of the users abilities in this area.
From a study of the existing system, it was decided that an enquiry handling software package was required which would be available on the network of VAX mini computers, and that this package should be useable by all staff, regardless of computing ability.

The Demonstration System

The first stage was to introduce a demonstration system. This created interest in the project and identified to the potential users the type of package we hoped to create. This, coupled with the decision to develop the software on site, supplied an early form of day to day feedback. Users were effectively involved in the design process from the outset, made easier by the automatic report writing. This allowed a move towards 'user-centered design', and at a greater level than one way involvement, the drawbacks of which were described by Damodaran et al (1981). The demonstration system also contained knowledge of use to one or two everyday problems, thus giving a certain amount of utility.

There are problems with the introduction of early demonstration systems, and these were highlighted during this project. There is a danger of putting some users off the system, by presenting incomplete work. It could be that after using MAPS1 several times and finding that on every occasion the area of knowledge that was required had not yet been installed, a user may assume that later versions will have the same gaps in its knowledge. They may consequently lose interest in the whole project. Some evidence of this was found, but by close day to day communication with the users this can be avoided. A useful MAPS feature was a new news facility which presented notification of new features to users who had not read the news item before. The alternative approach would have been to develop MAPS off site and then install it on completion, therefore the first system users would see would be complete. The advantages of a demonstration system probably outweigh any advantages of completeness offered by the second approach.

Computer 'Jargon'

Although one of the goals of MAPS was to avoid the use of any computer jargon, it was found after the evaluation of the first system (MAPS1) that some unexpected text did cause difficulties and this was corrected. Terms such as 'software' and 'type return'
needed to be avoided. This illustrated the need to assess the abilities of the user population very carefully at the outset.

One Package

The concept behind MAPS was to create one package which the user would remain in for the duration of his/her session on the computer. It therefore needed to supply all the basic facilities required to perform the task of answering an enquiry. As MAPS also aims to supply all the necessary information on its use within the confines of one standard screen layout, it is completely machine independent from the viewpoint of the user.

Integrating Existing Software

Another advantage of a system such as MAPS is the drawing together of existing packages such as databases, graphics and statistics. An obstacle to the use of these facilities, in the absence of MAPS, can be the requirement to remember a key word in the first instance to run them. Additional guidance on the package concerned can be supplied by MAPS on the screen, just prior to running it. Incorporating tasks in the evaluation of MAPS requiring the use of existing software, helped to highlight problems in the design of their user interfaces.

The need for expert systems to be integrated with existing conventional software, and for their incorporation and use in information retrieval systems, has been realized for some time (Bramer 1986). MAPS is intended as a step in this direction.

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The Design, Implementation, And Future Development Of Knowledge Programs For A Knowledge Based System

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This paper describes the process used to design a standard interface for the use of knowledge programs contained within a knowledge based system (KBS). The system in question being MAPS (Modular Applied Physiology System), in use at The Army Personnel Research Establishment (APRE) in Farnborough. The concept is to adopt a tiled window layout, giving a 'desk top' appearance to the screen. There is a logical position for messages, input data, and output data. The design procedure is described, together with future ideas on KBS development.

INTRODUCTION

The Army Personnel Research Establishment (APRE), is the Human Factors establishment for the Army, and is concerned with the physiological, psychological and ergonomics environment of the soldier. The Applied Physiology (AP) Division of APRE is interested in the physiological limitations of the soldier, and the interaction between his protective clothing and equipment, the environment, and his performance. During the course of their work, a large volume of data is collected, for example; past reports, survey results, mathematical models, and information on standards. It was proposed that a knowledge based system (KBS) be developed to help give better access to this collection of information. MAPS (Modular Applied Physiology System) is the result. It has been developed over the past three and a half years under an agreement between Loughborough University and APRE. It has been designed to help a population of around thirty experts, to answer day to day enquiries, and as a tool in further research.

The MAPS interface (Wadsworth and Parsons 1988), has been designed with the naive computer user in mind. No user documentation, or knowledge of the computer system itself, is required to use MAPS. A weakness displayed in many commercial
packages, is to assume an understanding of computers, or of their operating system; resulting in frequent use of computer terminology. The MAPS interface has been in use for some time and has been evaluated at APRE, described in Vadsworth and Parsons (1989).

AIM

The aim of this particular unit of the MAPS project was to develop a user interface for the individual knowledge programs within the system, with a similar goal as that set out for MAPS itself. An earlier knowledge program interface has been in use for some time, and has been received well by users (Towle et al 1989). However, it was felt that in the light of subsequent evaluations, improvements could be made.

METHOD

A set of criteria was formulated for the new interface, based on previous experience with the main MAPS system, and the results of two evaluations. It had been identified earlier in the project, that the user population included a significant number of people who had no previous knowledge or experience of using computers. However, it could also be seen that a certain level of knowledge in applied physiology could be assumed. The other important factor was that it was anticipated that most users would be using MAPS relatively infrequently. The goals for the new interface could therefore be described as follows.

1. It should assume NO knowledge of the computer system
2. It should not require reference to a user manual
3. It should supply sensible 'English like' error messages
4. It should be suitable for infrequent users

Three methods were considered for the interface design. The first being a simple textual display with questions presented and responses from the user, the screen being cleared after each question. The second was to adopt windows stacked on top of each other, with the option to return to the previous window, to correct input. The third, and the one selected, was to use a set of 'tiled' windows, which would be visible throughout any run of the program.

The three methods were shown informally to a selection of potential users, and their responses noted. It seemed from this initial study that the tiled layout showed the greatest promise.

The chosen interface was developed using Fortran, together with a screen management system available through the VAX VMS operating system. It was decided to make the structure of the program modular, in order to allow quick adaptation of the coding to each of the knowledge programs in MAPS. In addition to the layout chosen for processing equations, a second was selected for the presentation of textual information. These two screen
Figure 1 - Screen layout for equation processing

Figure 2 - Screen layout for text presentation

MODEL FOR METABOLIC RATE PREDICTION OF BODY LOAD CARRIAGE

The following model was derived by Kivohi and Goldman. Details of the study can be found in:


The report is entitled: "Predicting metabolic energy cost."
Figure 3 - Standard first page

A typical program run

On first entering the MAPS system, the user will be asked a series of questions to identify his/her area of interest. This is in the form of a series of menus, on a screen layout which includes function keys and a location indicator. When MAPS has identified the relevant area, it will present the user with a 'knowledge program'.

This will start with the front page in figure 3. If there is relevant background information to the knowledge, then text will be presented in a form similar to figure 2. Movement is possible both forwards and backwards, via the keys indicated on the bottom line of the screen. In the top right hand corner is a page count, as in figure 2 this is the first page, the backwards key is not visible. If the user wishes to skip the text and proceed to the processing of any relevant equation, then he/she can press the space bar. When the last page is reached, the program will proceed to the screen layout seen in figure 1.

Figure 1 shows an arrangement of tiled windows or boxes. Above each box is a title indicating its purpose, for example INSTRUCTIONS. This box displays text relating to the input the
program is expecting. It will include any rules relevant to the validity of the input, in this case a legal range of values. Below the instructions box is an INPUT box, where a flashing cursor draws attention to the need to type in a value. Below this box is a MESSAGES box. This will display a message if an illegal value is input, indicating a possible reason for the problem. For example 'Value out of range, please retype'. Other information may be displayed in this box if needed. Lastly, the box on the right of the screen is a DATA box. Each time the user types in a legal value into the input box, it will be echoed, together with a label, in the data box.

When the final required value has been typed in correctly, the user will be asked whether he/she wishes to alter any of these. If the answer is yes, by using the cursor arrow keys, the appropriate value can be highlighted in the data box.

Finally, the INPUT box will be redrawn in reverse video, to display the results of the program. When the return key is pressed, the user will be back at the first page (Figure 3).

RESULTS
The knowledge program interface had, at the time of writing, been available to MAPS users for around two months. Although it has not yet been formally evaluated, comments made by users suggest that it is an improvement over the earlier simple question and answer interface. It will be subject to a detailed evaluation at a future date.

Two alternatives for the presentation of text interface were evaluated using eight MAPS users, and the one described in this paper (Figure 2), was found to present the optimum amount of text, with the most logical key layout for movement between pages.

DISCUSSION
Many interfaces in the past few years have adopted the stacked type of window design, where the windows appear as a pack of cards. This has been appropriate in many cases, but recent experience by the authors has shown that in the case of the user who has little or no knowledge of computers, and who only infrequently uses a particular software package, this method is the least suitable. The visibility of several stacked windows on one display screen appears to crowd the screen layout, and the naive computer user is concerned by the partially visible information on previous windows. The route back through windows is not always apparent. If, however, the screen is split into three or four distinct areas, then the connection between these is more clearly understood. Tiled window systems have been used in connection with new areas of interface technology such as hypertext (Shneiderman 1989), with great success. With the onset of multi-media systems, involving graphics, videos and text, a tiled layout is likely to become the standard.

CONCLUSIONS
This paper has described a user interface for knowledge programs called through the knowledge based system, MAPS. The same design strategy could be used for conventional software,
particularly where the expected user population includes infrequent/computer naive individuals. The tiled method of window presentation appears to offer a better alternative of displaying several sets of information on a screen at the same time. Advantages over the stacked layout include the ability to see a logical connection between the contents of different windows, and cross reference when needed. For example, in the case of the MAPS knowledge program interface, a user may review the data he has previously entered, and be able to see the results without losing the record of his/her input.

Knowledge based systems, or expert systems, are being used in many new areas each year, and there is a clear need for a user-centred design approach. MAPS has been developed on-site at APRE, with daily contact between the developer and the users. The interface for the knowledge base, described in this paper, has evolved over three releases of MAPS, after consultation with the users at each stage in a formal evaluation, in addition to day to day feedback. The authors hope to further develop the interface in future versions of the MAPS system, in the light of users' experiences.

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