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An Investigation of the Appropriateness of Computer-Based Instruction to the Royal Australian Air Force CISCON Mustering

Linda M. New

AFIT/GIR/LAR/95D-7

AN INVESTIGATION OF THE APPROPRIATENESS OF COMPUTER-BASED INSTRUCTION TO THE ROYAL AUSTRALIAN AIR FORCE CISCON MUSTERING

THESIS

Linda M. New, Flight Lieutenant, RAAF

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THESIS

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Linda M. New, BBus

Flight Lieutenant, RAAF

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Preface

The subject of this thesis, training of Communications and Information Systems Controllers (CISCONs) in the Royal Australian Air Force, is a topic that has been of interest to me since the new CISCON mustering was formed at the end of 1992. At that time, I was supervising two CISCON personnel and I witnessed, and shared, their frustration in dealing with the management of a computer system without adequate training. My problems at that time, however, were small compared to those faced by the Base Information Systems Officers (BISOs) at each RAAF base, who had many more CISCON personnel and computer systems to deal with. I sincerely hope that the results of my thesis may do a little to ease their load.

My sponsor in this thesis effort was the Directorate of Communications and Information Systems (DCIS) in Canberra, Australia. Thanks must go to FLTLT Jude Mattner who provided me with assistance and information during my research.

Dr Freda Stohrer has greatly assisted me in my thesis effort, particularly in the written portion. I am deeply indebted to her for the polish and professionalism she added to my thesis, as well as the guidance and support in my research.

To my husband Terry, thank you for your complete support, especially on those days when nothing was going right. Your contribution often went without thanks, but never went unnoticed.

Linda M. New

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Abstract

Currently, the Royal Australian Air Force (RAAF) uses traditional methods of training for all of its personnel, including the newly formed Communications and Information Systems Controllers (CISCON) mustering. The formation of this mustering and the concurrent formation on every RAAF base of a Base Information Systems Centre (BISC) brought to light training needs that were not being met. Using many different forms of stimulation to activate learning, computer-based instruction (CBI), in particular multimedia, represents an alternative method of presenting training.

This research investigated the applicability of CBI to the RAAF by matching its features with the training needs of the CISCONs and demonstrated the application of multimedia design principles to a specific CISCON course. An analysis of BISC training needs suggested that CBI will operate as effectively as it has in similar studies thoroughly documented in the literature. This thesis has also demonstrated in a practical way the importance of considering the many multimedia design principles when designing CBI using an existing training course. This thesis directly supports the use of CBI to train CISCON working at the BISCs and further suggests that the RAAF should consider CBI for all of its future training.

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I. Introduction

General Issue

In 1993, a new mustering called Communications and Information Systems Controllers (CISCON) was formed by the Royal Australian Air Force (RAAF) by combining two former musterings, Electronic Data Processing Operators (EDPOP) and Communications Operators (COMMSOP). This new mustering was formed in response to the RAAF's recognition of the importance of having personnel at the non-commissioned level trained in aspects of computer and communications systems administration and management.

The RAAF has recognised that it no longer needs as many personnel (and in the future may need none) to perform such duties as basic data entry and message handling, but requires personnel to manage the communications and information systems (CIS) that have automated these tasks. In particular, the RAAF needs trained administrators and support personnel to staff positions in the newly-formed Base Information Systems Centres (BISC). These centres were formed in recognition of the increase in the number of CIS that require proper systems administration and management at the base (BISC) level.

The newly formed CISCON mustering is composed of members whose carried-forward experience does not quite meet the requirements of the new mustering,

particularly the new and demanding job requirements for positions in the BISCs. The formation of this new mustering has a heavy training implication which requires the investigation of alternative training methods to those the RAAF has used in the past. The RAAF needs to train its CISCONs quickly and with minimal time away from the job to best meet the needs of an operational BISC.

Specific Problem

The training burden created by the formation of a new mustering must be addressed as quickly as possible to avoid degradation to the operational capability of the RAAF. The traditional training methods used by the RAAF have centred on attendance at courses conducted at training bases necessitating the removal of trainees from their primary place of work.

Many new technological developments in computer-based instruction (CBI), in particular multimedia and hypermedia, have made it possible to train large numbers of people in a short time at their primary place of work. Simultaneous with the development of these new technologies has been the establishment of many guidelines and generally accepted principles for the correct application of multimedia and hypermedia technology to specific training needs. These new developments warrant the investigation of the general applicability of CBI to the training needs of CISCONs and a detailed look at how the multimedia development principles can be used to improve the training delivered. This detailed look will demonstrate the application of these principles against a specific CISCON training course.

Research Questions

The following research questions were investigated in researching the solution to the problem outlined above:

1. What basic core of knowledge do new BISC personnel need?

2. What is the range of preparation among personnel employed at the BISCs?

2. Can a properly-designed CBI course, using a framework developed from existing guidelines and principles, meet these training needs?

Investigative Questions

To answer these questions, the following research was undertaken:

1. a survey of personnel currently serving in BISCs to determine their current experience and level of training reached, current CISCON training problems, and the impact of these training problems on the operations of the BISC.

2. a review of the current literature on CBI to determine its overall applicability to CISCON training needs, and a detailed look at multimedia and hypermedia systems to establish a framework of principles for the development of multimedia courses.

3. a demonstration of the application of this framework to a particular CISCON training course using the course terminal objectives (CTOs) and course lesson plans.

Scope of Research

The collection of personnel data was limited to those CISCONs who held a position in the BISCs on each RAAF base at the time the survey was taken in April, 1994.

There are CISCON positions on each RAAF base outside the BISC and also in staff appointments within each Command/ Headquarters. However, because of the novelty of the majority of BISC duties, the BISC positions represent the most challenging new positions in terms of training requirements. The CISCON training problems investigated were limited to an analysis of their impact on the BISC operations.

Limitations

The design of a multimedia-based course will emphasise the requirements and training objectives of the BISC PC (Personal Computer) Operations course.

Definition of Terms

The keywords listed below will be used throughout this thesis. In addition, Appendix A contains definitions of common RAAF (and Australian) acronyms for the benefit of non-RAAF readers of this thesis, as well as an explanation of common computing acronyms for the benefit of all readers:

Keywords:

Authoring Systems: a comprehensive, high-level computer package used to create a multimedia presentation.

Hypermedia Systems**:** Also referred to as interactive multimedia: an extension of multimedia systems with the added feature of being able to link to other documents, applications and networks.

Suggestions For Further Research

Multimedia systems: Systems that go beyond the management and display of textual information by incorporating a variety of communications media, such as sound, graphics, computer animation and motion video (Zwass, 1992:867).

Mustering: a RAAF term used to classify a group of workers performing a common function.

Synopsis of Thesis Chapters

Chapter 1 presents the background to the problem, a statement of the specific problem to be researched, the major research questions, scope and limitations of the research, and a definition of key terms. Chapter 2 reviews the current literature in the field of computer-based instruction and assesses the significance of current technological developments: multimedia and hypermedia systems. The literature review identifies generally-accepted principles for the successful development of multimedia training courses. Chapter 3 describes the methodology used to investigate solutions to the research questions outlined in this chapter. Chapter 4 contains an analysis of the data collected from the personnel currently occupying positions in the BISCs and a discussion of the general applicability of the findings of the literature review to the training needs of CISCONs. Chapter 5 outlines the application of multimedia development principles to a specific CISCON training course, the BISC Personal Computer Operations Course. Chapter 6 presents a summary of the conclusions drawn in previous chapters and outlines the potential applicability of the findings of this thesis to other RAAF training needs.

II. Literature Review

Chapter Overview

This literature review summarises research on the applicability of CBI in various training environments. It presents the features of CBI that may apply to the general training needs at the BISCs and presents the specific attributes of multimedia applications that may have particular relevance to the training requirements of the BISC PC course. A detailed discussion of how these characteristics apply to the RAAF, and the CISCON training needs, will be presented in later chapters.

Forms of training using computers have been around since the mid 1960s under various names such as computer-based instruction (CBI), computer-aided instruction (CAI) and computer-managed instruction (CMI). At the time of its first use, many educators, workplace trainers, and course developers, were encouraged by the potential of the new technology to assist them in training more people at lower cost.

Many researchers have studied the effect of CBI on an individual's ability to absorb more knowledge in a shorter time. Many agree that the early stages of CBI did not fully exploit the potential of computer technology -- dull classroom routine was merely replaced with dull computer routine (Beer, 1992:192). Educators discounted the use of the computer in training and continued with traditional, instructor-led classroom teaching.

In the last few years, however, many new technologies have emerged, and more thought has been put into the proper way to use the computer in training. These new technologies have the potential to revive the flagging interest in computers in the classroom. Educators, however, must ensure that the mistakes of the past are not

repeated and that this technology is applied to CBI in a way that best suits the student, not the technology. Research has shown that this is achieved by designing CBI courses to match the requirements of training.

Faster, more efficient training is a major part of maintaining a strategic advantage in the marketplace or preserving operational capability for all corporations, including military organisations. New training techniques, such as those presented by CBI, are needed to supplement traditional classroom-based training. Today's organisations must be able to train their employees in geographically diverse areas in a consistent, cost-effective and accelerated manner.

Structure of Review

This literature review:

1. describes CBI and its main features;
2. summarises its past effectiveness;
3. describes the new technology of multimedia and its potential for use in CBI;
4. describes in detail the characteristics of multimedia; and
5. comments on the current direction of CBI, in particular workplace training.

Description of CBI

Definition. In simple terms, CBI provides a learning experience based on the interaction between a student and a computer. The computer provides a stimulus to which the student responds. The computer then analyses the response and provides feedback to the student (Allan, 1993:65). The interaction is achieved by the presentation

of a module of instruction via a series of computer screens, usually followed by a short question and answer (Q&A) session conducted on the computer. The student proceeds to the next module of instruction or reviews the previous module, depending on the results of the Q&A session. The decision to proceed can be made by the student or the computer.

The RAAF has adopted the term CBI to describe its use of the computer in training. The RAAF *Manual of Training Policy and Procedures* defines CBI as follows:

> Computer-Based Instruction is the umbrella term used to describe those components of instructional systems which employ computer technology for the conduct or management of training. CBI may be divided into computer-assisted instruction (CAI) and computer-managed instruction (CMI). CAI refers to the use of computer technology for the conduct of instruction, e.g., a student studying text and graphics at a computer. CMI refers to the use of computer technology to assist management activities such as scheduling of instructional events, measuring and recording of student performance and assignment of training resources. (DEFAIR, DI(AF) AAP 2002.001, 1994: 1)

The computer and other associated technologies are used to improve students' skills, knowledge, or academic performance (Okolo, 1993:1). CBI can be used to train in all sorts of subject areas from primary school subjects such as mathematics, spelling, and grammar, to workplace training subjects such as aircraft maintenance and computer systems administration. The courses can be used as the initial mode of instruction or as the basis for refresher courses in particular subjects.

Main Features. CBI is built on the premise that it must present learning materials in a format different from the text book to stimulate the student's interest. The computer presents information in a step-by-step format at a pace that the student determines. Students are in full control of how fast they will progress through the instruction. The

computer summarises concepts continually to ensure understanding. Questions are asked periodically, usually at the end of the presentation of a module of instruction.

Feedback is provided to the student at the student's level of understanding, based on the responses to the questions, and the student has the choice to review the past module or to continue. The instruction can be individualised to a student's skill levels and can concentrate on areas in which the student demonstrates weakness and fast-track through areas where the student has shown proficiency. The instruction is provided in a consistent order and format each time, and the student can suspend or resume a session at any time.

Kelly Allan presents a useful case study of a Canada-based retailer who uses CBI extensively to train sales associates in areas from customer service skills to family budgeting. A typical CBI course is described thus:

> The length of the course is 90 minutes. It presents information screens in a step-by-step format. The computer asks questions approximately every four to five minutes. It summarises concepts continually. Students move forward in the program by achieving mastery of the concepts. If students don't master a concept, the program moves them into a brief review path before moving them to the next concept. The program also presents short case studies. It quizzes students on the concepts presented in each case study using true-or-false, multiple-choice, match-up or short-answer questions. (Allan, 1993:66)

CBI differs from traditional classroom training in three major ways: interactivity, in-progress testing and reinforcement, and trainee self-sufficiency (Ganger, 1990:86). A properly designed interactive training program shapes itself around a student's individual needs. Related to interactivitiy is the built-in testing and reinforcement or remedial training incorporated in effective CBI programs (Ganger, 1990:86). The computer can

recognise the level of understanding of the student and thus deliver instruction at an individual level. Effectively written CBI tutorials are also self-contained; the student should not need to refer to any outside material, thereby enabling trainee self-sufficiency. To summarise, the main features of CBI are:

1. step-by-step format,
2. self-pacing,
3. individualised instruction,
4. summary of concepts,
5. periodic questioning,
6. provision of feedback,
7. consistent format and content,
8. interactivity, and
9. trainee self-sufficiency.

Dean (1988: 169) identified other benefits of particular relevance to organisations which face problems of widely dispersed employees, shift-work, and short-term urgent requirements. These benefits, for both students and training departments, are summarised as follows:

1. More Effective Use of Student Time. Most students complete a CBI course, having met the objectives, in significantly less time than with conventional courses. The time saving is called "learning compression" and is becoming widely accepted as an important factor in justifying CBI. In addition, less knowledgeable students are often inhibited from asking questions in class. There is no stigma attached to repeating and reviewing sections of a CBI course.

2. Availability of Training. The training is available when the trainee is ready for it. Classroom-based training is seldom economic, and not usually very effective for very small groups. Companies of all sizes have circumstances where one or two

employees are ready for the next stage of their training, but have to wait until more are ready before the course can be run. A CBI course can be taken by the students as and when they become ready, without any delay.

3. Reduction of Travel time and Expenses. In cases where offices are dispersed over a wide area, travel and accommodation costs may be a major factor in justifying CBI. It is also an easily quantifiable cost.

4. Meeting of Special Short-term Requirements. There may be occasions when changes in policy, operating procedure, or legislation require a substantial proportion of the company's employees to undergo a short amount of training fairly rapidly. For such short-term requirements, CBI can effectively communicate the new policies or procedures without major disruptions to normal operations.

5. Non-removal of Student from Primary Place of Work. A manager may be more willing to allow a student to take a course if he knows that the student is readily available to sort out any serious problems. The student can schedule a certain amount of time per day or per week to dedicate to the course, while still performing his primary duties.

6. More Effective Practical Training. A lot of practical training, whether workshop-based or on-the-job (OJT), has a very low student/teacher ratio -- often one to one. In addition, OJT can be fairly haphazard; the skills that the trainee learns can depend on the work going through the factory or office at the particular time he is there. The use of simulations is also valuable and particularly applies in computer-related areas such as computer operator and data entry clerk training.

7. Timeliness of Training. CBI can be available at any time of the day or night. It is possible to make the training material available around the clock for shift workers, and it is a way of more effectively utilising night-shift workers, where the workload may not be as heavy.

8. Reduced Instructor Involvement. Once the course has been developed, the instructor should find that time spent delivering the courses will be very low. Some CBI courses may still require a local instructor to support or enhance the material by monitoring exercises, giving feedback, discussing problems. This time, however, will be spent more effectively in elaborating on points the students do not know, rather than labouring on points that they do know.

9. Fast Incorporation of Amendments. Training material that is very volatile is ideally stored in computer format for ease of updating. In areas such as computer systems management, where hardware and software training requirements change rapidly, training materials can be kept up-to-date.

10. Easier and more Accurate Monitoring of Student Performance. The ability of CBI to monitor and record statistics on the performance of individual students can lead to considerable savings in the time of trainers in supervising, marking and recording the results of students' tests.

11. Constant Incentive to Improve the Courses. The collection of data on student responses and the paths students take through a course, together with their recorded comments on modules and the students' performance statistics, give the

trainers a regular reminder to re-evaluate and improve the course. This gives the training manager a regular means of assessing the effectiveness of the course.

Summary of Past Effectiveness

The impact of CBI on student learning has been widely researched. Studies have shown that CBI can deliver content in 30% to 40% less time than classroom instruction (Allan, 1993: 68) while the cost of technology adds only 2% to 4% of the overall cost of a training facility with an accompanying increase of 20% to 40% increase in learning (Bowsher, 1990: 206). However, these statistics are hard to generalise across all types of training environments because of the many differences in training needs, budgets, and existing capabilities. Small studies have shown that particular CBI programs are effective; however, the individual natures of most programs make it difficult to apply such research statistics across the board.

Research has also shown that it is difficult to get hard research data because of the pace of technology -- in the time it takes to prove a CBI method or program more useful than traditional methods, the program's technology is obsolete. Chris Dede, director of the Center for Interactive Educational Technology at George Mason University says:

> By the time we do a definitive study of something like multimedia and establish after five years of large-scale efforts that it is 40 per cent better in terms of students' mastery and requires only 60 per cent of the time that traditional classroom instruction takes, that form of multimedia will be obsolete. (Jacobson, 1993: A27)

It is also difficult for researchers to show specifically what technology contributes because they cannot easily isolate the role of the teacher who uses it (Jacobson, 1993:A27). No computer will ever motivate individual students as well as a good teacher.

Some educational experts have not been convinced of the value of CBI because the supporting evidence, where available, has been based on small analyses of individual programs. These experts argue that it is doubtful whether research alone can ever make a convincing case for the superiority of instructional technology (Jacobson, 1993: A27). Others say that the call for research is misguided, in part because the value of technology should be self-evident by now. Judith Boettcher, director of education-technology services at Pennsylvania State University, headed an EDUCOM project in 1991 aimed at identifying successful applications of instructional technology. Asking for research evidence, she says, is like insisting on data to prove that for most people headed from New York to Los Angeles, taking a plane is better than walking (Jacobson, 1993: A28).

What the experts do agree on is that in the past, the application of computer technology to training and education was misguided and inefficient. Course developers made the mistakes of translating material verbatim into computer form and expecting miracle results in students. These early attempts did not recognise the importance of using the computer for what it does well: providing feedback and simulating reality. It is commonly agreed that with traditional computer-based instruction, the student usually falls asleep (Beer, 1992: 192).

Seymour Papert is the director of the Epistemology and Learning Group of the Media Lab of the Massachusetts Institute of Technology. He poses this question:

> Why is it that "megachange" has occurred in such fields as telecommunications, medicine, entertainment, and transportation, yet the ... classroom has evolved very little since the early part of the century? (Hill, 1994:36)

Papert contends that computers have failed to revolutionise schools.

One of the reasons for this is may be that it was more lucrative to develop computer applications in fields other than education. Another is that educators were wary of using computers because of their own lack of experience and used them as support for the status quo rather than an instrument for change (Hill, 1994:36). The main reason, however, is that the development of computer applications for education was not being done in the correct way to use the best features of the medium and educators were discouraged by the lack of results.

New Technology

General Description. Multimedia and hypermedia systems are the new technologies within the computing world, and already many applications have been developed for use in education and training. Within the context of RAAF training technology, multimedia has been simply defined as the use of a combination of audio and video computer technologies to communicate information and may be considered a subset of computer-based instruction (DEFAIR, DI(AF) AAP 2002.001, 1994: 2).

Multimedia systems, however, are more than just an extension of CBI. These new systems have taken advantage of the latest pieces of equipment developed, including

videodisc players, touch sensitive screens, CD-ROM, computer animation, enhanced sound quality, and links between many different documents and applications. A fuller definition of multimedia describes it as the computer-controlled interactive medium that integrates in real time external visual and audio inputs with computer-generated text, graphics, animation and audio (Shelton, 1993: 694). Hypermedia, also characterised as interactive multimedia, dynamically links and manages organised nodes of information containing multiple symbol systems and images within a given medium or across different media (Park, 1993:63).

Multimedia Use in Business. Many institutions in industry, business, government and education, are using multimedia products in numerous innovative ways. Shelton (1993:698) describes many areas for application of multimedia. One is education, where publishers distribute textbooks and other educational material on CD-ROM and IVD (Interactive Video Disc). Another is simulation, where airlines train aviators in simulated instrument landing service procedures, and the military trains soldiers in simulated wargaming. Industrial, commercial, and government organisations use multimedia programs to train employees, investors, and military personnel (Shelton, 1993: 699).

Training is the area in which multimedia is most commonly used. According to Neil Fox, manager of multimedia services at TRW (a multibillion dollar automotive and aerospace company): "Every company out there has certain business problems which multimedia addresses very well - - one of them is training." (Bottoms, 1994:70). TRW uses interactive multimedia extensively in training new executives. Hewlett-Packard is using CD-ROM as part of its multimedia technical training program for customers (Spitz,

1992:39). Fortune 500 corporations are investing heavily in multimedia (Shelton, 1993: 699). A projection by IBM for its internal education program indicates that by the year 2000 not only will individualised instruction (via multimedia) become fully integrated into IBM's education curriculum, but it will become the dominant approach, encompassing with it many aspects of traditional instruction (Reisman, 1991:280).

Characteristics of Multimedia

Many significant characteristics denote the transition from older forms of CBI to multimedia. Reisman (1991: 282) lists these major characteristics as:

1. Use of pictorial and audio material. The power of multimedia courses is the use of less text than CBI; text is replaced by audio, still and motion video, and graphics.
2. Compaction of the "system". Older forms of CBI generally used a separate workstation for each medium. Media such as filmstrips could require a separate room. Multimedia significantly compacts the system. All media are delivered via a single display, which has the additional capability of mixing the media, such as overlaying text and graphics on video.
3. Integration of instruction with other applications. The evolution of multimedia instructional systems illustrates the integration of the instructional application into the mainstream of data processing.

4. Increased learner control. To a course author developing CBI, "learner control" probably referred to one of the then-perceived advantages of CBI: preventing the student from seeing the answer to a question. The interpretation of this term has now changed to denote a set of functions that enables individual students to take a course in the manner most suitable to them. Multimedia systems treat students with a little more respect, and increased learner control now means that the student can fully control the pace, time, and place of instruction.

5. Use of the touch-sensitive screen for input. Not all multimedia applications require the use of such a screen. This mode of input has been important in areas such as product information for public access, where keyboards do not traditionally fare well. Many multimedia training courses accept either touch-screen or keyboard input from students. The development of the touch-screen has good potential for reducing the reliance on typing skills.

6. Increased Use of Simulation and Problem-solving Modes. Two CBI-derived learning modes, simulation and problem-solving, are well-suited to interactive video (a form of multimedia), particularly when realistic motion is required.

7. Use of Authoring and Presentation Systems as Media Managers. An authoring system is a program used to create a CBI or multimedia course; a presentation system is the associated component of the authoring system used to deliver the course (i.e., a run-time system). The development of 4GL (fourth generation language) authoring systems has enabled educators without programming skills to build multimedia training packages with little effort.

Potential of Multimedia Technologies for Use in CBI. Reports about the potential of multimedia instruction range from sensational claims that it will radically alter the schools of the future to fears that its use will weaken reading skills (Jones, 1992: 209). Despite the very attractive capabilities of multimedia technology, authoring systems to implement these capabilities, and the widespread availability of generic courseware, integration of multimedia instruction into standard education curricula, in both industrial training and academic education, has been slower than expected. (Reisman, 1991: 287). This situation remains true even though a growing number of studies show multimedia instruction to be superior to traditional instruction. In addition, students invariably give high approval ratings to multimedia courses (Reisman, 1991: 287).

Educators who were discouraged by older forms of CBI should not discount multimedia as merely a passing fad in the technology game. Is multimedia technology worth a second look? In a word, yes (Wong, 1994:58). William Gates, CEO of Microsoft Corporation, despite his obvious bias towards multimedia, makes a pertinent comment about its power:

> Research shows that people learn in a variety of ways, by seeing, hearing, and doing. Multimedia software stimulates all of those learning paths by offering information through pictures, written text, sound, animation, and video to help teachers develop creative, interactive teaching tools that present information in all the ways people really think and learn. (Gates, 1994: 1705)

A 1994 survey of Information Systems (IS) managers' and directors' attitudes toward multimedia revealed the following perceived benefits (ranked in order): hands-on instruction, interactive nature, self-paced learning, flexibility, convenience, and cost-effectiveness (Wong, 1994: 60).

The same survey identified the biggest drawbacks of multimedia CBI as the high cost of initial development and updates, the length of time required to develop applications and presentations, and an occasional lack in effectiveness and customisation in meeting an individual corporation's training need (Wong, 1994: 60). Cost and time are two of the most important decision factors in a modern corporation. The cost of creating full-screen, full-motion digital video is high; users need hefty processing power and storage (Raskin, 1994: 210). Authoring systems, used to develop multimedia applications, can be high-priced; additional costs include laserdisc players, large colour screens, CD-ROM drives, audio and video systems. In terms of development time, just one hour of interactive multimedia CBI can take 80 - 200 hours to produce in-house (Wong, 1994: 58).

To counter this, other experts report that the option of instructor-led training is generally even more costly and not completely satisfactory either. While instructors can create classroom courses for less money than CBI programs, there is a growing belief among CBI advocates that the cost of training geographically dispersed users wipes out any advantage of instructor-led training. CBI is more expensive to develop, yet it is more cost effective to reproduce and distribute (Wong, 1994:60). The purpose of this thesis research, however, is not to present a cost-benefit analysis of the use of multimedia. There are advantages and disadvantages to its use, as there are with any method of training, which are important to point out to present a more rounded view of its potential.

Guidelines for Design of Interactive Multimedia.

Any organisation must decide whether to use multimedia for training purposes, based on technological, economic, and organisational feasibility. Once that decision is made, the hard work of ensuring that the multimedia-based courses are designed to address the specific training requirements begins. This requires guidance from disciplines such as cognitive science, psychology, technical communication, course design, screen design, and many other areas that contribute to a framework or model for the development of interactive multimedia courseware.

While interest in interactive multimedia continues to grow, thus far its activities have been driven more by technological capacity than research and theory. Typically, guidelines for interactive multimedia design are based not upon empirical evidence, but on the intuitive beliefs of designers (Park, 1993: 63). A great deal of relevant research and theory on traditional computer-based learning systems exists, but little has been extrapolated to the design of interactive multimedia (Park, 1993: 63). Some of the more important studies relating to multimedia training design are detailed in the following paragraphs.

Park and Hannafin Study. Park and Hannafin's extensive analysis organised existing research and theory into an overarching framework and derived from this framework principles and implications for the design of interactive multimedia (Park, 1993). The research was organised according to three foundations: psychological, pedagogical, and technological; and three basic sources: general, component, and primary. The foundations represent fundamental influences affecting the design of

learning systems. The sources represent the extent to which principles are rooted in generalisable research and theory, work involving individual technologies, or specific activities in interactive multimedia. Table 1 (Park and Hannafin, 1993:64) details the framework developed by Park.

TABLE 1

A FRAMEWORK FOR ORGANISING RESEARCH AND THEORY RELATED TO INTERACTIVE MULTIMEDIA

	FOUNDATIONS		
SOURCES	**Psychological**	**Pedagogical**	**Technological**
General	The learner's role in processing information	Instructional research, theory, and strategies	The potential of technology to redefine teaching and learning
Component	The learner's ability to process information with component technology of interactive multimedia	Instructional strategies available with component technologies	The capabilities of specific interactive multimedia technologies
Primary	The individual's role in processing information via interactive multimedia	Design strategies and guidelines specifically evolved for interactive multimedia	The capabilities and limitations of interactive multimedia technology

From this framework, Park extracted a set of empirically referenced general principles and their implications for the design of interactive multimedia. This extensive set of principles in itself forms an ideal model against which to match each specific training

requirement in the development of a multimedia training course. Table 2 (Park and Hannafin, 1993:68) details this set of principles.

TABLE 2

PRINCIPLES AND IMPLICATIONS FOR THE DESIGN OF INTERACTIVE MULTIMEDIA

Principle	Implication
1. Related prior knowledge is the single most powerful influence in mediating subsequent learning.	Layer information to accommodate multiple levels of complexity and accommodate differences in related prior knowledge.
2. New knowledge becomes increasingly meaningful when integrated with existing knowledge.	Embed structural aids to facilitate selection, organisation, and integration; embed activities that prompt learners to generate their own unique meaning.
3. Learning is influenced by the supplied organisation of concepts to be learned.	Organise lesson segments into internally consistent idea units.
4. Knowledge to be learned needs to be organised in ways that reflect differences in learner familiarity with lesson content, the nature of the learning task, and assumptions about the structure of knowledge.	Linkages between and among nodes need to reflect the diverse ways in which the system will be used.
5. Knowledge utility improves as processing and understanding deepen.	Provide opportunities to reflect critically on learning and to elaborate knowledge; encourage learners to articulate strategies prior to, during, and subsequent to interacting with the environment.
6. Knowledge is best integrated when unfamiliar concepts can be related to familiar concepts.	Use familiar metaphors both in conveying lesson content and designing the system interface.

TABLE 2 (continued)

PRINCIPLES AND IMPLICATIONS FOR THE DESIGN OF INTERACTIVE MULTIMEDIA

Principle	Implication
7. Learning improves as the number of complementary stimuli used to represent learning content increases.	Present information using multiple, complementary symbols, formats and perspectives.
8. Learning improves as the amount of invested mental effort increases.	Embed activities that increase the perceived demand characteristics of both the media and learning activities.
9. Learning improves as competition for similar cognitive resources decreases and declines as competition for the same resources increases.	Structure presentations and interactions to complement cognitive processes and reduce the complexity of the processing work.
10. Transfer improves when knowledge is situated in authentic contexts.	Anchor knowledge in realistic context and settings.
11. Knowledge flexibility increases as the number of perspectives on a given topic increases and the conditional nature of knowledge is understood.	Provide methods that help learners acquire knowledge from multiple perspectives and cross-reference knowledge in multiple ways.
12. Knowledge of details improves as the instructional activities are more explicit, while understanding improves as the activities are more interactive.	Differentiate orienting activities for forthcoming information based upon desired learning; provide organising activities for information already reviewed.
13. Feedback increases the likelihood of learning response-relevant lesson content, and decreases the likelihood of learning the response-irrelevant lesson content.	Provide opportunities to respond and receive response-differentiated feedback where critical information is involved, but avoid excessive response focusing when incidental learning is expected.

TABLE 2 (continued)

PRINCIPLES AND IMPLICATIONS FOR THE DESIGN OF INTERACTIVE MULTIMEDIA

Principle	Implication
14. Shifts in attention improve the learning of related concepts.	Differentiate key terms, concepts, and principles through cosmetic amplification, repetition, and recasting.
15. Learners become confused and disoriented when procedures are complex, insufficient or inconsistent.	Provide clearly defined procedures for navigating within the system and accessing on-line support.
16. Visual representation of lesson content and structure improves the learner's awareness of both the conceptual relationships and procedural requirements of a learning system.	Provide concept maps to indicate the interrelationships among concepts, and hypermaps to indicate the location of the learner relative to other lesson segments.
17. Individuals vary widely in their need for guidance.	Provide tactical, instructional, and procedural assistance.
18. Learning systems are most efficient when they adapt to relevant individual differences.	Interactive multimedia must adapt dynamically to both learner and content characteristics.
19. Metacognitive demands are greater for loosely structured learning environments than for highly structured ones.	Provide prompts and self-check activities to aid the learner in monitoring comprehension and adapting individual learning strategies.
20. Learning is facilitated when system features are functionally self-evident, logically organised, easily accessible, and readily deployed.	Employ screen design and procedural conventions that require minimal cognitive resources, are familiar or can be readily understood, and are consonant with learning requirements.

The principles developed by Park provide an excellent theoretical foundation for the development of multimedia courses. Other studies have concentrated on more practical aspects, including screen design, placement of text, use of illustrations and graphics.

Grabinger Study. Grabinger examined viewer judgments about a set of twenty computer screens in terms of readability and ease of study (Grabinger, 1993). Appendix B contains samples of the screens used by the Grabinger study with their resulting ranking from the study (ranking of 1 means most desirable). The study identified constructs that could guide the design of computer screens used to display information in computer-assisted instruction, hypermedia, or on-line help applications (Grabinger, 1993: 35). Table 3 presents eight text element variables and associated values used in Grabinger's study.

TABLE 3

TEXT ELEMENT VARIABLES AND ASSOCIATE VALUES

Element	Values	
1. Line Length	Short	Long
2. Directive Cues	Present	Not Present
3. Paragraph Indication	Spaced	Indented
4. Status Bar	Present	Not Present
5. Line Spacing	Single	Double
6. Functional Areas	Present	Not Present
7. Text Columns	Single	Double
8. Illustrations	Present	Not Present

Using combinations of these variables, Grabinger collected viewer judgments using the paired-comparison tests. Participants in the study were asked to examine and compare each screen according to "how much [they] would like to read and study from the screen if it were an actual screen in a computer lesson" (Grabinger, 1993: 54).

These screens were judged using a series of three factors which were "loaded with adjectives" (Grabinger, 1993: 69). The factors and associated adjectives were:

1. Factor 1: attractive, readable, easy to study, interesting, inviting, dynamic.
2. Factor 2: neat, clean, organised.
3. Factor 3: planned, structured, controlled.

Grabinger used statistical analysis techniques to rank these screens in order of desirability using the above factors. The screens in ranked order were: Screen 9, 12, 2, 7, 18, 19, 4, 1, 11, 14, 6, 3, 8, 10, 5, 17, 20, 16, 13, 15. In this study, Screen 9 was chosen as the most desirable, with Screen 15 being the least desirable. Grabinger's results revealed that the definition of functional areas with space, boxes and lines, and the use of headings, directive cues, and spaced paragraphs combined to present a planned, controlled, organised and structured appearance (Grabinger, 1993: 70).

The study also revealed two important dimensions relevant to screen design. Organisation was the most important dimension identified by the study participants as they were choosing screens from which to study (Grabinger, 1993: 70). The second dimension identified was visual interest. Screens that are plain, simple, unbalanced, and bare are perceived as undesirable. From the two dimensions of organisation and visual

interest, Grabinger (Grabinger, 1993:71) identified three major design recommendations that can be applied to the design of multimedia documents:

1. Provide a macro level of organisation. Organise the screen into functional areas. Decide where status and progress information, navigation buttons, content displays, control buttons, and illustrations will be located. Use graphic devices such as shading, lines, and boxes to separate one area from another. Screens 1, 2, 4, and 9 in Appendix B were chosen by Grabinger as good examples of this.
2. Use structure to create a micro level of organisation. Designers should consider how the screen can reflect the structure of the content. Generally, according to Grabinger, users prefer screens that use headings, directive cues, and spaced paragraphs to indicate the hierarchy of the content. Grabinger chose screens 8, 9, 10, and 17 as examples of this.
3. Provide visual interest. Designers should consider the visual interest of the screen. Viewers dislike screens that are plain or full of text without any headings, directive cues, lines, shading, buttons, titles, or illustrations (such as shown in screens 12, 15, and 16). Grabinger believed that a variety of well-organised text elements enrich the environment and make it more interesting to explore. He also stated that excessive complexity results when too many elements or too much information is crammed on the screen.

Gittelman and Park Study. This study argues that CBI provides an opportunity to manipulate a variety of instructional strategies that are difficult or impossible to

incorporate with other media (Gittelman, 1992:27). This study reports a detailed investigation of the use of animation and feedback in CBI.

Two hypotheses were tested by Gittelman and Park:

1. Animated visual displays would be more effective than static visual displays if animation was selectively used to support the specific learning requirements of a given task.

2. The effectiveness of intentionally mediated feedback (knowledge of results or explanatory information) would be minimal if natural feedback - the system's automatic functional reaction to external inputs - was available and the subject had the basic knowledge needed to understand the system functions.

Not surprisingly, in testing the first hypothesis, Gittelman and Park found that animated visual displays are more effective than static displays. However, the most important result of this test was that visuals, whether animated or static, facilitate learning only when their attributes are applied in congruence with the specific learning requirements of the given task (Gittelman, 1992:28). In layman's terms, this means that visuals are effective tools to use in designing CBI courses, but developers shouldn't animate unless it is necessary for the student to visualise some sort of movement in order to understand the concept.

The study also supported the second hypothesis. This support of the second hypothesis provided evidence that additional feedback to students using CBI packages, perhaps in the form of an instructor, would be unnecessary if the CBI system itself provided feedback **and** the student had the basic knowledge to understand the system.

These results are not surprising either; rather they emphasise the potential effectiveness of CBI to provide feedback and the importance of ensuring students are comfortable with the medium.

Brooks Study. Brooks claims that many hypermedia applications fail the basic mission of providing clear, simple, concise assistance to users of the application. With the many capabilities available to developers, such as sound, animation, multiple fonts, extensive graphics, colour, and hidden layers of additional information, hypermedia documents have become design nightmares (Brooks, 1993:422). At the present time, Brooks claims there are no established conventions or principles for hypermedia design. Brooks has made a start in this important area by outlining what he considers should be the main goals of online screen design, which he derived from four common print-media design principles. These four main goals are outlined below:

1. Design Goal 1: Simplicity.

   a. Keep design elements to a minimum: use only one or two fonts; use as few navigational controls as possible; and avoid too many boxes, borders, and decorative graphics. Establish a consistent background that is maintained throughout.

   b. Repeat the placement and format of major document-wide elements such as headings, text blocks, and navigational controls. Do not move these basic elements, so the student can concentrate on what is new on the screen - new information, questions, titles, illustrations.

c. Avoid piling up special effects. It is not necessary to use bolding and italics and outdenting to make a title stand out.

2. Design Goal 2: Appropriateness.

a. Keep design elements as well as content in a tone appropriate for the sponsor of the online document (for example, the RAAF).

b. Do not simply dump word processing files or screens of spreadsheets online. Hypermedia applications that require scrolling through screen after screen of text files are inappropriate uses of the technology. Use the technology to enhance the word processing files by presenting them in a different way, using graphics if appropriate.

3. Design Goal 3: Function.

a. Provide the user with multiple means of controlling his or her navigation through the document to encourage more than browsing or watching. This should encourage more interactivity with the student using the package.

b. Provide help explaining or showing how the hypermedia application functions when the user opens the document, and maintain access throughout the user's interaction.

4. Design Goal 4: Economy.

a. Do not spend too much time or money creating an online application.

b. Do not let the available equipment or technology determine the hypermedia design.

Humphreys Study. Humphreys stated that in the process of converting paper-based manuals to electronic format the screen should not be a direct facsimile of the page (Humphreys, 1994:623). His study identified three major differences between hyperdocuments and paper-based documents:

1. Physical Differences. The screen is smaller than a normal page. This doesn't mean that you cram more information into a smaller area; instead you have to chunk information so it will fit. This leads to another problem. In paper documents, you can assume that readers will read paragraphs in order. Hyperdocuments, however, are open-ended. Now you have to design chunks of information to be autonomous.

2. Organisational Differences. In a hyperdocument, readers can get lost easily because windows are constantly appearing, disappearing, and overlapping each other. The typical access aids inherent in print documentation (page numbers, headings) disappear in hyperdocuments.

3. Rhetorical Differences. Readers come to hardcopy text with a great many expectations and a great deal of previous experience and skill at handling text. Just as hyperdocuments require a paradigm shift for authors, they require a comparable shift for readers.

Humphreys states that careful consideration of these three main differences between online documents and paper-based documents will greatly assist the effective design of hyperdocuments.

Humphreys also made some interesting observations about the design of hypermedia documents (hyperdocuments) that can be equally applied to the design of CBI (Humphreys, 1994:621). He quoted Brockmann (1990: 56) as claiming that 75% of what designers need to know about designing hyperdocuments comes from the principles of paper documentation. He suggests some of the following principles that are used in designing paper documents still need to be done in designing hyperdocuments:

- Develop task oriented systems
- Chunk information into smaller blocks with language to fit the reading behaviour of adults
- Design balanced formats using white space and other visual cues functionally.
- Edit and test

Summary of Published Studies. These studies define the principles and establish the methods most important in the design of a multimedia application. How these principles can be applied to an existing, paper- based training course, will be demonstrated in Chapter 5.

Unpublished Studies - Practical Aspects. The published studies detailed above provide valuable information, in a theoretical sense, on the results of research currently being conducted on multimedia design. As a supplement to these published studies, designers experienced in developing multimedia training applications were consulted to provide advice on many of the practical aspects of multimedia development.

Jeff Carter, a multimedia systems analyst with a Dayton-based communications and training corporation, uses a compact set of guidelines for interactivity when designing multimedia training packages for corporate clients. This set of guidelines was adopted from the book "The Desktop Multimedia Bible" (Burger, 1993):

1. Keep the interface simple, intuitive, and uniform.
2. Make the content interesting and compelling.
3. Don't make people read much more than titles.
4. Don't base choices on colour or sound alone if you wish to compensate for human deficiencies.
5. Make it obvious where the user is and what actions are expected of them.
6. Test, test, test.

Jeff Carter has supplemented these guidelines with more practical tips based on his experience in dealing with clients:

1. It is important to determine whether text is the best way to distribute information. A few simple sentences are much better than huge amounts of video, audio, and animation/graphics.
2. Provide instant tactile feedback to the user to aid in the understanding of navigation.
3. Instruct the user when appropriate but never assume the user will wait for instructions. Make navigation and selection instantaneous for the user, or have some 'wait' object present so the user will know what is going on.

4. Strive for consistency when creating multimedia items. This includes matching your design to that of current software systems. For example, if menus are to be used, place them where most menus are currently placed (in DOS boxes, this is usually at the top, but in a simulation environment, such as a car or aircraft, they are usually at the bottom).

5. Reliability is the most important factor in multimedia design. The worst scenario for any user is to have the system malfunction because of software bugs. The end result is user confusion and a drop in confidence in the software.

Tim Underwood, a training officer of AT&T Global Information Systems in Dayton, Ohio, (formerly NCR Corporation), has experience in developing an IVD curriculum to train the company's personnel officers. Here are some of the key advantages he identified from this experience in using computers to develop courses and train personnel: learners enjoy learning, increased motivation, privacy, individualisation, mastery of learning, instructional consistency, increased retention, increased safety, reduced cost, reduced learning time, and increased access (Underwood, 1994).

<u>Current Direction of CBI</u>

Despite some disadvantages, most experts agree that multimedia promises a great deal to the world of corporate training and will do much to correct the CBI mistakes of the past. Different factors will drive the choice of training technology in the modern corporation. The training needs of this decade are so immense that most organisations will seek technologies that provide the greatest return on investment, address a range of

educational and instructional needs of an increasingly diverse and heterogeneous work force, and incorporate actual work and company-specific procedures and policies within the training materials (Ganger, 1990: 91).

In order to justify the use of expensive multimedia technology in course development, the instructional courseware must meet three criteria: it must satisfy a need not otherwise easily met, be closely integrated into the curriculum, and enhance the quality of the learning experience (Jones, 1992: 211). The use of commonly accepted guidelines and principles can contribute much to the achievement of these three criteria. Studies on the effectiveness of multimedia suffer from the same problems as analyses of traditional forms of CBI: lack of hard research data because of the time required to conduct in-depth reviews and the inbuilt obsolescence of current technologies. However, the potential of multimedia to complement other forms of training with its different, interactive, hands-on approach to learning, cannot be denied.

Experts advise corporations to be wary of multimedia marketing hype; it may be costly and have a negligible influence on the effectiveness of their instruction. Use multimedia wisely, where it is most effective, and do not replace older CBI technologies or even traditional classroom-based instruction if they already meet the training need. It is unlikely that CBI, multimedia or otherwise, will entirely replace instructor-led classroom training; the two should complement each other (Wong, 1994: 63). Once the decision has been made to use multimedia in training, the experts agree that it is vital to use a well-defined set of design principles and guidelines to properly match the strengths of the CBI course with the specific training needs (Park, 1993:82).

Summary

Computer-based instruction has been present in some form almost since the development of the computer in the 1950s. From CAI to CMI to CBI to multimedia instruction, all computer training packages have suffered to some extent from inflated expectations that have inevitably led to dissatisfaction for some users. Some studies have shown the early forms of CBI to be effective in reducing instruction time and increasing retention of material; other experts claim that inappropriate application of computers in education has replaced classroom tedium with computer-based tedium.

Multimedia are the latest developments in CBI. Their potential has not yet been proven empirically, as detailed reviews are time-consuming and the pace of technology is swift. Corporations must carefully assess their training needs and their training budget before committing themselves irrevocably to any form of CBI. Once a commitment is made, careful consideration must be made of how to properly use the new technology, taking advantage of the many guidelines and principles that are continually being established through lessons learned and experience. The fast pace and competitive nature of business coupled with students' demand for interesting, interactive, colourful methods of learning mean that any form of training that is slow and boring is destined for the scrapheap.

The Royal Australian Air Force is an organisation that could possibly benefit from the use of multimedia-based training. The CISCON mustering, as an example, exhibits characteristics that suggest this technology could be appropriate - geographically dispersed and in need of courses that are self-paced, individualised and deliver information

with consistent format and content. Once the decision to use CBI has been made, one of the important steps is the correct design of the multimedia course, using an existing curriculum as a foundation, to best take advantage of the unique features of the medium. The following chapters will describe this process.

III. Methodology

Chapter Overview

This chapter outlines the methodology used to answer the specific research questions relating to the basic core of knowledge needed by new BISC personnel, the range of job preparation among personnel employed at the BISCs, and whether a properly-designed CBI course, using a framework developed from existing guidelines and principles, meet the training needs of the CISCONs. Firstly, the population studied and the data collection methods used to determine the specific training needs at the BISCs are described. Secondly, the research techniques used to gather information on the principles and guidelines for the design of CBI are outlined. Finally, the way in which these principles will be used as a framework for application against a specific CISCON training course are illustrated.

Population of Interest

The population of interest for the study comprises all CISCONs who were employed in the BISC at each RAAF Base in April 1994. There is a BISC located at each of these RAAF Bases, located across Australia - Amberley, Williamtown, Richmond, Edinburgh, East Sale, Pearce, Fairbairn, Darwin, Tindal, Townsville, Wagga, Williams, Number 1 Central Ammunition Depot (1CAMD) and Glenbrook - a total of 14. Each BISC is headed by a BISO (Base Information Systems Officer), generally a junior officer (depending on the size of the BISC) of any category (e.g., Supply, Administrative,

General Duties, Special Duties). Across all of these BISCs there are approximately 90 CISCONs (as of April 1994) employed in IS duties.

This population has the potential to change dramatically for a number of reasons. Firstly, the establishment and manning of the BISCs in 1993 were done quickly and before a proper assessment was made of the personnel who would be required to perform the tasks successfully. Many BISOs are finding that the manning levels do not match the workload. Secondly, the Review of Air Base Support (RABS) project, currently being undertaken RAAF-wide, may have a significant impact on manning levels of the BISCs. It is outside the scope of this thesis to consider the effect of RABS on the operations of the BISC, except to mention that it may impact manning levels, and consequently numbers of CISCONs who may require training.

Data Collection Methods

The first two research questions posed in Chapter 1, i.e., core knowledge needed and job preparation of CISCONs at BISCs, required collection of data on the level of training already reached, any gaps in training, and possible impact of these training needs on the operation of the BISC. Since the establishment of the BISCs, no formal post-implementation review (PIR) has been conducted of the BISCs, and therefore there was no existing data. A survey instrument had to be developed to collect this information.

The time and distance constraints in developing a suitable instrument and administering it to all members of the population in each of the 14 locations in Australia prevented the use of normally ideal research procedures in every respect. Data were

collected on the population of CISCONs described above by asking questions of the 14 BISOs (their superiors) on behalf of all of the CISCONs who work for them. A census study of the BISOs was undertaken to ensure that a representative sample of opinions and issues was received.

In April 1994, a questionnaire survey was conducted of all the BISOs. The survey gathered data on many aspects of BISC operation, including experience/qualifications of BISO and staff, training courses completed, manning of the BISC, computer systems supported, higher-level support. The complete survey is reproduced at Appendix C. The survey questions that are relevant to this thesis concern experience levels of CISCONs in each BISC (questions 11, and 12), training issues (13, 14, and 15), manning (17, 18, 19 and 21) and general issues (31 and 36). The survey data, in particular the section on opinions, was gathered on a confidential basis and hence any quotations that I have taken from the surveys will be referenced by the citation format (Survey, 1994).

Design of Research Instrument

The survey sent to the BISOs was an exploratory instrument designed to provide information on qualitative issues such as opinions on training gaps and confidence levels of their subordinates. The survey did not aim to establish any causal quantitative relationships relating to this information but was intended to illustrate that training needs do exist and that they are, in some form, impacting the effective operation of the BISC.

Both structured and unstructured questions were selected for the survey. Some of the questions were designed merely to provide background information to the operation of

the BISC - for example, questions relating to the qualifications of the BISO, manning levels, systems supported by the BISC. Other questions, such as the section on personnel and training issues, were designed to provide information specifically related to training needs. The two sections titled "Opinions" and "General" use unstructured questions designed to elicit any important issues that may not have been specifically addressed by the structured questions of previous sections.

Validity of Survey

The survey was mailed to respondents who were given approximately two months to complete. Respondents were assured that confidentiality of responses would be maintained at all times. This method reduces some of the situational factors that sometimes introduce error in data collection - such as lack of time to complete a survey and lack of assurance of confidentiality. As the survey was in written format and completed by the respondent, there was no possibility of influence of the interviewer on the answers.

As the number of respondents was small, it was not difficult to achieve a 100% response rate. The complete response rate to the surveys ensures that the information and opinions gathered are representative of the population. All of the BISOs were extremely helpful and some provided information over and above that which was requested.

Qualitative Techniques

The methods used to answer the third research question, i.e., principles of proper design of CBI, continue the qualitative nature of this research. Two specific techniques

were used to establish the guidelines and principles for the development of CBI: secondary data analysis and experience surveys.

Secondary Data Analysis. The first step in this study was a search of the secondary literature. Much valuable information on the development and potential effectiveness of CBI has already been collected and reported. The literature review of Chapter 2 revealed that sufficient studies have been conducted to establish the basic premise that CBI training is more effective than traditional classroom training. A thesis study performed at AFIT in 1990 evaluated a CBI program for Storage and Distribution used in the USAF and revealed its superiority over traditional training methods (Donavon, 1990). It would be inefficient for this thesis to try to prove quantitatively that CBI training would be more effective than the current classroom-based training that CISCONs receive based on these previous similar studies.

Further secondary data analysis revealed that, once CBI has been chosen as a training medium, a proper framework of principles and guidelines must be used to match the features of multimedia to specific training needs. This was considered to be a more valuable extension of the research on CBI development and one that would most greatly benefit the RAAF. Thus, an extensive search of the existing literature was performed identify these principles.

Experience Survey. The experience surveys were designed to complement the secondary data search. While published data are a valuable resource, seldom is more than a fraction of the existing knowledge in a field put into writing (Cooper, 1995:119). An experience survey seeks information from persons accomplished in the field of study. A

personnel officer from AT&T Global Information Systems (Dayton Ohio), experienced in the development of multimedia training packages, was consulted. In addition, a multimedia systems analyst from a Dayton-based communications and training corporation (corporation name withheld) provided some valuable guidelines used in the creation of multimedia presentations and training packages. The information gathered from these experience surveys was integrated with the published data identified in the literature review to form the framework for development of multimedia courses.

Development of Framework

The final part in the description of the methodology used in this study is an explanation of how the training needs identified in research questions 1 and 2 can be satisfied by the guidelines and principles revealed by research question 3. The framework of multimedia development principles identified in the literature review was applied against the lesson plans and CTOs of the BISC PC Operations Course to demonstrate the development of a multimedia course which would best meet the training need. Each principle from the framework was considered and translated into practical rules that can be used by RAAF training instructors in the development of future courses.

Summary

The methodology used in this study is mainly qualitative in nature. A census questionnaire survey was used to establish the existence of training needs at the BISCs. Secondary data analysis and experience surveys were used to identify principles for

guiding the development of multimedia training courses. The next chapter will describe in detail how this framework can be used with the BISC PC Operations Course.

IV. Analysis of CISCON Training Needs - Survey Results

Chapter Overview

This chapter analyses the results of the 1994 survey of the BISOs and determines whether a training need exists for CISCONs working at the BISCs. By matching the training needs identified in the BISO survey to the features of CBI, the RAAF's need for more effective CISCON training is compared to CBI's ability to satisfy this need. The chapter concludes with a brief look at the current direction of CISCON training, which sets the scene for a detailed look at the application of the principles of multimedia design to a specific CISCON training course in Chapter 5.

Analysis of Survey Data

Population of Interest. In April 1994 all CISCON personnel working at a RAAF BISC were surveyed. When the BISCs were established, the non-commissioned personnel to fill BISC positions came from various sources. The former RAAF Data Reporting Sections (DRSs), made up of members of the former EDPOP mustering, formed the nucleus of the BISC, with other positions filled by the transfer of personnel currently performing computer system administration duties from other sections and units on the base.

Duties of BISC Personnel. After formation, the BISCs took on the duties previously performed by the DRSs as well as a plethora of duties assigned to Base level IS support. Base level IS support is defined as the management of day-to-day operations of IS on the base (DEFAIR DI(AF) OPS 8-31, 1993:3). Examples of specific BISC services

are control of IS maintenance contracts, system administration, system operator tasks, minor fault rectification (software and hardware), minor software modification, rectification, and enhancement, and "Help Desk" facility for user queries (DEFAIR DI(AF) OPS 8-31, 1993:3).

As mentioned in Chapter 3, all CISCONs working in the BISCs were surveyed in April 1994. The complete survey used is reproduced at Appendix C. The complete responses to the questions that are relevant to this thesis (questions 11, 12, 13, 14, 15, 17, 18, 19, 21, 31 and 36) are reproduced at Appendix D as raw data. For ease of reference, this data was summarised or tabulated in Appendix D as much as possible. However, some responses were difficult to tabulate without losing important comments from the original response, so these responses were left in their original narrative form. To retain confidentiality, the responses are merely listed with no acknowledgment of the particular source. Respondents were not required to answer all questions. It is from the responses reproduced at Appendix D that I have drawn the conclusions outlined in the following paragraphs.

Experience Levels. In general, experience levels in the BISCs vary. All personnel are competent in the duties of their previous mustering (either COMMSOP or EDPOP) and, at the time of the survey, were rapidly gaining experience in the duties of the other mustering (either COMMSOP or EDPOP) through the use of rotating shifts and on-the-job training (OJT). Most, however, have little or no experience in the new BISC duties -- management and administration of the CIS on the base.

Staff at one BISC could not even load Windows onto a PC until shown by the BISO (See, for example, Survey, Appendix D, Question 11, part 7). Many BISC staff had little more experience than the users they were expected to support. Those staff who did have experience with PCs have gained this knowledge through their own personal dealings with PCs outside of the BISC -- mainly at home. One BISO commented that one of his staff "has a PC at home and is definitely a hacker. He is the most IS literate of my staff" (Survey, Appendix D, Question 11, part 11). Another commented that the lack of IS expertise in the BISC is their greatest problem (Survey, Appendix D, Question 11, part 7).

Training Issues. At the time of the survey, less than 1 percent of personnel at the BISCs had completed any formal IS training. Responses to the survey show that all had done the CISCON conversion course, a RAAF course designed to cross-train members in either COMMS or EDP, depending on which mustering the trainee came from (Survey, Appendix D, Question 13). Responses also point out that many different courses had been undertaken by BISC personnel at civilian training institutions using SCPE (Short Course at Public Expense) funds. These courses were intended to provide training for the new BISC duties and included Windows for Workgroups, LAN awareness, Introduction to UNIX, and other introductory computer courses. However, this training was only available on an ad-hoc basis and was wholly dependent on the availability of base funds for training, the ability of BISC shift-workers to attend courses, and the availability of suitable courses in the local community. These variables make it virtually impossible to ensure that all CISCON staff at all BISCs receive uniform training. Other BISC staff were

undertaking, on their own initiative, Associate Diploma and Degree courses in IS under DFASS (Defence Force Assisted Study Scheme) sponsorship. In addition, the RAAF is currently sponsoring other CISCONs full-time at TAFE to gain IS qualifications.

Confidence Levels. The learning curve at each BISC is very steep for new personnel. The survey shows that the confidence levels were generally very low because of lack of experience and training but growing as hands-on learning increased (Survey, Appendix D, Question 14). Members who have had training/education/prior experience were reasonably confident but those new to the job had little or no confidence and required constant supervision.

Training Gaps. The survey revealed many perceived gaps in CISCON training (Survey, Appendix D, Question 15). CISCONs were not trained for the BISC role before the BISCs were formed and will not develop expertise for some time. One BISO commented that currently CISCONs do not exist -- they are simply COMMSOPs and EDPOPs by a different name (Survey, Appendix D, Question 15, part 5).

The survey revealed that basic CISCON training is required to cover the following areas to prepare personnel for duties in the BISC:

1. Operating systems - including DOS, Windows, Windows for Workgroups, UNIX, OS/2.

2. Networks - in particular Novell, basic data communications.

3. Hardware aspects - PC and peripherals basic hardware, computer configuration.

4. Software - basic software familiarity, database design.

5. Maintenance - of PCs and peripherals.

6. Support - technical and user support, basic fault finding.

A survey comment by one of the BISOs summarises general feelings about training and experience issues in the BISCs: "Without an organised and structured training program that is implemented RAAF-wide for CISCONs, BISOs are going to have to try and train their staff using SCPE funds as best they can. This will result in a haphazard, inconsistent training regime for CISCONs that will not best serve the RAAF's interests and will further compound the poor morale that exists in the rank and file at present" (Survey, Question 21, Part 2, 1994).

Manning. In addition to the lack of experience and training, the reduced manning at most BISCs has made it difficult to achieve successful day-to-day operations with completion of all tasks -- both short-term and long-term tasks. After establishment of the BISCs, personnel were to be transferred to the BISC from other areas of the base, in accordance with Defence Instruction DI(AF) OPS 8-31. Generally, each squadron operating a computer system was allocated positions within the squadron for the performance of computer system administration and management tasks on either a part-time or full-time basis. These system administration tasks were transferred and amalgamated under BISC control when the BISCs were formed, with the manning to follow.

At the time of the survey, however, the majority of BISCs had undertaken these additional tasks, but had not received the additional personnel. The main reason that manning had not been transferred to the BISCs was because the majority of positions within squadrons assigned to computer systems administration were part-time positions;

for example, a pilot who acted as the part-time administrator for the squadron's computer system when not flying. The CO of the squadron complied with the requirement to transfer these duties to the BISC when it was formed, thus ridding his pilots of annoying and time-consuming secondary duties. However, in most cases, the COs did not comply with the requirement to transfer to the BISC the manpower needed to support these systems, particularly in the situations where the computer positions were only part-time. It is extremely difficult to transfer half a position.

In general, at the time of the survey, most BISCs were manned to do the DRS shift work only -- a 24-hour responsibility that had been transferred to the BISC. Other BISC tasks were done on a piecemeal basis. One BISO noted that most of the time was spent on routine day-to-day computer administration tasks with little or no time for long-term strategic or contingency planning (Survey, Appendix D, Question 19). BISOs had made many attempts to remedy the manning situation through submission of Excess Tasking Reports (ETRs) and negotiation with base executives for the transfer of positions and had reported some successes. However, proposed changes to base manning levels due to the Review of Air Base Support (RABS) have delayed any proposed transfer of manning to the BISCs. RABS is currently a major ongoing review and discussion of its effects on BISC manning, though important, is beyond the scope of this thesis. It is important to note, however, that RABS could seriously affect the manning levels of the BISCs, as noted by BISOs in the survey (Survey, Appendix D, Question 17, Question 18 part 2 and 8).

Excess Tasks. A consolidated, non-exhaustive list of tasks from the BISCs that were not being done at the time of the survey follows:

1. system administration roles across nearly all systems,
2. systems analysis of current systems,
3. software audits/unit visits,
4. preventative maintenance of hardware,
5. timely response to problem resolution (user support),
6. contingency and strategic planning,
7. database and application configuration,
8. security, accreditation and evaluation,
9. help-desk management,
10. network planning,
11. monitoring workload and practices, computer performance optimisation,
12. adequate end-user training,
13. development of standard operating procedures (SOPs), and
14. maintaining current versions of software.

Some of these tasks are being done at some of the BISCs. The tasks that are being done, however, depend largely on the availability of trained personnel and time, rather than on a priority that may have been set by the BISO or base executives. This list represents a cross-sectional view of the tasks not being done at the time the survey was taken.

Impact on the BISCs. The analysis of the data gathered from the BISCs reveals that there are varying problems resulting from low experience levels, lack of formal training, and manning deficiencies. These deficiencies have hampered each BISC's ability to do the duties for which it was established -- support of base level information systems. Many of the duties listed in the previous paragraph are vital to the success and long-term strategic operation of computer systems. The RAAF has made, and is continuing to make, a large investment in information systems infrastructure and equipment. Without proper maintenance and support and adequate training for the personnel responsible for computer hardware and software maintenance, this investment will be largely wasted and will result in outdated, incompatible, and unsupportable systems.

Application of Survey Data to Research Questions.

The analysis of the survey data presented above has answered the first two research questions presented in Chapter 1: "What basic core of knowledge do new BISC personnel need?" and "What is the range of preparation among personnel employed at the BISCs?" The survey data have shown that the basic core of knowledge required by CISCONs working at the BISCs relates to the skills required to manage the day-to-day operation of computer systems supported by the BISC. The survey revealed that these skills include knowledge of operating systems, networks, hardware and software, PC maintenance, and support.

The range of preparation among personnel employed at the BISCs at the time of the survey was very narrow. BISOs identified many gaps in the current training offered to CISCONs by the RAAF. Experience and confidence levels were generally low.

Applicability of CBI to RAAF CISCON Training

The third research question asked whether a properly-designed CBI course, using a framework developed from existing guidelines and principles, can meet the training needs of CISCONs. In order to answer this question, the features of CBI must be related to the CISCON training needs to determine the general suitability of this form of training to the BISC situation. Following this discussion, Chapter 5 takes a detailed look at the principles of multimedia design as applied to a specific CISCON training course to show that multimedia courses must be carefully designed to meet the specific training requirements.

General Suitability of Multimedia in BISC Training. The survey of all BISOs revealed many gaps in current CISCON training. Most personnel had had no formal training in the tasks they were now expected to perform in the BISCs. In particular, the BISOs saw the need for:

1. short courses that covered as many computing topics as possible (Survey, Appendix D, Question 15),
2. minimal time away from primary duties because of manning shortages and shiftwork (Survey, Appendix D, Questions 15 and 18),

3. consistent training to ensure that all BISC personnel across Australia were trained in the same way in the same subject areas (Survey, Appendix D, Questions 15 and 21), and

4. training requiring minimal supervision of the student because of lack of supervisory staff (Survey, Appendix D, Questions 18 and 21).

The literature review of Chapter 2 pointed out many features that distinguish CBI from traditional classroom training (Dean, 1988:169). The following comparison of these features and the requirement for CISCON training shows that, in general, CBI could effectively meet the training needs identified in the survey. The paragraphs below summarise conclusively the match between BISC training needs and the strengths of CBI outlined in Chapter 2.

1. <u>More Effective use of Student Time.</u> Recruits to the CISCON mustering, and indeed any RAAF mustering, do have varying degrees of education and ability, despite minimum standards for entry. The use of CBI in the BISCs could mean that more capable recruits could build on their Basic CISCON training more quickly and spend more time at their primary duties.

2. <u>Availability of Training</u>. A lot of CISCON work involves shift-work, as communication centres and some computer systems have to be operated on a 24-hour basis. The possibility to undertake training courses during the inevitable "quiet" periods of the night-shift provides an attractive opportunity to maximise the use of personnel.

3. Reduction of travel time and expenses. In the RAAF, CISCONs are located at bases all over Australia, and most CISCON training takes place at one training base, RAAF Wagga. Air travel in Australia is not cheap and scheduled flights by RAAF aircraft are not as regular as might be preferred and do not go directly to Wagga. Most RAAF scheduled flights terminate at RAAF Richmond, some 5-6 hours by car travel from RAAF Wagga. RAAF Travel and Subsistence Funds (T&S) are always severely limited, so RAAF aircraft are generally used rather than commercial flights, despite the amount of time required to travel. Rather than requiring the students to come to the training, sending the training to the students could significantly reduce the expense of travel, in both T&S and the often hidden cost of personnel time wasted whilst travelling.

4. Meeting of Short-term requirements. For changes in policies or operating procedures and even the short-notice introduction of a new computer system, CBI courses could effectively communicate the new policies or procedures without major disruptions to normal operations. The need for cross-training that arose as a result of the formation of the CISCON mustering is an example of a short-term urgent requirement. This cross-training of the members of each old mustering had to be completed quickly and with as little operational detriment to the BISCs as possible.

5. Non-removal of student from primary place of work. The downsizing currently going on in the RAAF has impacted the CISCON mustering. The need to maintain 24-hour operations in some areas has made it difficult to release personnel for

training. Part-time CBI courses available at the place of work could alleviate some of this manning strain.

6. More effective practical training. The aim of BISC training for CISCONs is to teach skills related to the management and use of communications and information systems. Much of the content of such a course (or courses) would be of a practical nature requiring a low student/teacher ratio to be effective. OJT can be very haphazard, as some communication centres and BISCs in the RAAF are busier than others and handle different systems and process different work, despite attempts at standardisation. CBI courses could present practical information on a one-on-one basis.

7. Timeliness of training. CISCONs need to be proficient in a diverse number of areas - basic and advanced EDP, basic and advanced communications, tactical communications, BISC operations. After recruitment and completion of the Basic CISCON course, CISCONs can be posted to a wide variety of positions in areas such as communication centres, BISCs, DRSs, and specialist IT positions. The Basic CISCON course, which is currently 26 weeks long, needs to prepare the recruit for a possible posting into any of these areas, and necessarily has to be general in its coverage of the variety of topics. The needs of each particular position cannot be met by the Basic CISCON course before the recruit assumes the new duty. A CBI course designed to present training specific to the particular duty, available for individual use at the place of work (e.g., the BISC) could overcome these problems.

8. <u>Reduced Instructor Involvement.</u> The use of CBI in the BISC could integrate OJT with computer training. The trainee's work supervisor could also spend time assisting and monitoring the CBI, and would be able to relate what the student is learning more realistically to the work environment. CISCON instructors at Wagga could spend less time developing courses and more time teaching other, more specialised courses that are in higher demand.

9. <u>Fast Incorporation of Amendments</u>. Hardware and software training requirements change rapidly due to the rapid pace of the computer industry. The training requirements for CISCONs in the BISCs clearly show this changeability. Much of their training needs to be tailored to the specific pieces of hardware and software that they are responsible for managing. The number and types of computer systems requiring BISC management can change from year to year as new peripherals are added, new software is acquired, and completely new systems are introduced. Updating paper-based courses and lesson plans is very time consuming.

10. <u>Easier and more accurate monitoring of student performance.</u> The performance of students on particular CISCON courses could be automatically monitored by the CBI program itself. This would lead to considerable savings in the time of RAAF instructors in supervising, marking, and recording the results of students' tests.

11. <u>Constant Incentive to Improve the Courses.</u> The nature of CBI could allow student comments to be recorded, in addition to automatic calculations on

statistics such as failure rate on certain types of questions. These comments and statistics would give the course designers a regular reminder to re-evaluate and improve the course. The need to continually improve courses is of particular relevance to BISC training, which would have to be constantly monitored and updated, due to the volatile nature of the subject matter.

Current Direction of RAAF CISCON Training

The amalgamation of the EDPOP and COMMSOP musterings to form CISCONs and the concurrent formation of the BISCs in 1994 created an immediate and enormous training burden. A basic CISCON course had to be designed that would teach the fundamentals of COMMs and EDP as well as introduce the new concept of BISC operations. Other more specialised courses were required that would concentrate on more fully preparing CISCONs for the duties required of them when working in the BISCs.

Personnel currently in the CISCON mustering with experience ranging from less than one year to more than twenty years needed immediate updated training in the new tasks the mustering would present. The new BISCs created a training need that no existing RAAF course could fill. Personnel at Headquarters Training Command (HQTC) undertook these training tasks and designed courses that would attempt to meet all of these requirements. These courses ranged from introductory and advanced attendance courses to basic and advanced consolidation workbooks to be completed in the workplace. Figure 1 shows the current CISCON training and assessment program.

	COMPULSORY TRAINING	SITE SPECIFIC TRAINING GENERAL TRAINING
WOFF		Associate Diploma in Information Systems
FSGT	WOFF PROMOTION CSE	Advanced Certificate in Information Systems
SGT	FSGT PROMOTION CSE	UNIX System Administrator
CPL	SGT PROMOTION CSE	Telephone and Landline Supervisor
LAC/W	CPL PROMOTION CSE	DISCON Operator Supervisor
	CISCON ADVANCED CONSOLIDATION WORKBOOK Extends for up to 12 months. If the Corporal's promotion Course is also completed in this 12 months, the student may be promoted provisional on passing the CISCON Advanced Consolidation Workbook	Tactical Communications BISC Personal Computer Operations DISCON Switch Operator COMPSYSOPAIROP
	CISCON ADVANCED COURSE 5 Weeks Prerequisite to CPL Promotion Course	
	minimum 24 months in rank	
AC	**CISCON BASIC CONSOLIDATION WORKBOOK** Extends a minimum of 12 months from the end of CISCON BASIC. Satisfactory completion of this course enables reclassification to LAC	CAMM Operations
	CISCON BASIC 26 weeks	

Figure 1. CISCON Training and Assessment Program

Current IS training for CISCONs is provided through four avenues (CISCON Newsletter 1/94, 1994: 2):

1. Attendance courses at RAAFSTT (RAAF School of Technical Training);
2. Civil schooling; (full-time attendance at civilian institutions);
3. Short Course at Public Expense (SCPE) training; and
4. Microsoft/Aspect Office Automation Training (a training course run by a company called Aspect, providing training to all users of the Microsoft Office Automation Suite on each RAAF Base).

The avenues of training outlined above are all traditional attendance courses and have many of the usual disadvantages associated with classroom-based teaching. Attendance at courses at RAAFSTT requires students to be away from their primary places of work. Full-time civil schooling means that the student is absent from work for periods ranging from a few months to three years. SCPE training, as previously mentioned, is dependent on the availability of funds at a particular base and of suitable courses in the local area. The Microsoft/Aspect Office Automation training is designed basically for users of Microsoft applications such as Word, Powerpoint, and Excel. This training is not designed to cater to the needs of BISC personnel to learn how to manage these software applications.

Summary

This chapter has shown that CBI training applies to CISCON training and has the potential to overcome many of the disadvantages associated with the RAAF's traditional

forms of instruction. Chapter 5 will demonstrate how the principles of multimedia design identified in Chapter 2 can be applied to a specific course that has relevance to BISC training needs.

V. Application of the Principles of Multimedia Design to a Specific CISCON Course

Chapter Overview

In the past, traditional forms of classroom teaching have adequately met all RAAF training needs. Currently, however, RAAF educators are finding that training needs are changing very rapidly and traditional methods are no longer as viable. The formation of the CISCON mustering and concurrent formation of the BISCs on every RAAF Base have created rapidly changing training needs. In addition, recent developments, both theoretical and practical, show significant improvements in the use of computers in training. The training pressures being felt by the RAAF combined with the obvious attractions of CBI will lead RAAF educators to other forms of training in the near future.

Another pressure being faced by the RAAF is competition from the commercial sector for RAAF training. The RAAF has already lost responsibility for some of its training to civilian institutions. Following evaluation of certain training activities under the RAAF Commercial Support Program (CSP), the NSW TAFE Commission was awarded the contract to provide training for aerospace systems, aircraft and avionics fitter courses, and a range of general trade training courses at RAAFSTT (RAAF News, 1994:1). The RAAF will be compelled by competition from civilian training institutions to develop faster, more efficient ways of training its personnel. Otherwise, the RAAF will risk losing the responsibility for all of its training to outside commercial interests. I contend that it is not a matter of whether the RAAF will consider CBI for training, but when. When the RAAF realises that the use of CBI may make its in-house bids for retention of training

under CSP more competitive, RAAF educators will need guidance on how to convert existing paper-based training courses into courses using multimedia and hypermedia technology.

Selection of an Appropriate Course

RAAFSTT provides general IS training (i.e., training relevant to BISC needs) in the CISCON Basic and Advanced Courses. Further, a number of specialist courses have been developed, including the BISC PC Operations course, CISCON PC/LAN Manager, CISCON Data Communications, and UNIX System Administrator. All of these courses are classroom-based attendance courses. One of these specialist courses, the BISC Personal Computer Operations Course, will be used in this thesis to demonstrate the application of multimedia design principles. This course is the most suitable for the initial consideration of the conversion of RAAF CISCON courses to CBI-based training packages because its CTOs (Course Terminal Objectives) represent the basic core of knowledge that a CISCON requires to perform the tasks required in a BISC.

BISC Personal Computer Operations Course

This course (herein referred to as PC OPS course) is conducted as a four-week, full-time residential course at RAAF Wagga. The objective of the course is to graduate CISCON personnel capable of supporting PC operations in all RAAF IS environments (CISCON *Newsletter* 1/94, 1994) and in particular, to graduate students capable of performing computing-related tasks appropriate to BISCs (Penton, 1994:1-2). The course is described as giving theory and practical instruction in the operation and

maintenance of PCs. The instruction includes installation, configuration, and elementary troubleshooting, enabling the graduate to assist PC users in the workplace. The basic features of RAAF standard software packages are also covered (*CISCON Newsletter* 1/94, 1994). Appendix E lists the syllabus objectives (CTOs) of the PC OPS course.

CISCON Instructors from RAAF Wagga made available to me the training manual used for this course, the *BISC Personal Computer Operations Workbook*. This comprehensive document contains 9 chapters and approximately 250 pages. Each chapter presents a module of instruction, in keeping with the syllabus objectives as outlined in Appendix E, as well as a review exercise at the end of each chapter.

When faced with the task of converting a paper-based training course into one incorporating CBI, RAAF instructors must use, as a starting point, the written manuals, syllabus, and course terminal objectives applicable to a certain course. Chapter 2 has already explained that 75% of the principles one needs to apply in designing computer-based documents come from the principles of paper documentation (Brockman, 1990: 56). Having the course outline for the PC OPS course greatly simplifies the task of converting the course to an electronic format. The same rules of sentence construction apply and the same rules of clarity and grammar still apply. The manual provided to me for the PC OPS course contains all of the requirements -- the written course, syllabus, and course terminal objectives -- and the ideal starting point for designing a CBI version of the manual.

The course workbook is a comprehensive manual. Due to the size of the manual, I have chosen, as a sample, Chapter 2 of the manual, which covers the topic of PC Hardware. This chapter is about average in length (28 pages) and contains a healthy mix

of text, graphics, theory, and practical examples. This mix provides great opportunity to demonstrate how multimedia can improve the presentation of the training material -- through the use of animation, sound, colour graphics. This chapter has been reproduced in its entirety at Appendix F so that readers of this thesis can see the material to which I am applying the multimedia design principles. This chapter has been reproduced as close to its original form as possible; however, some of the graphics did not scan well.

To demonstrate the application of the multimedia principles more clearly, I have designed a series of computer screens using the material of the *PC OPS Manual.* These screens were designed using Microsoft Powerpoint and are merely for visual presentation of the principles. As these screens were designed to be included in this thesis, some visual techniques were not used -- for example shading, colours -- so that the screens would present well in paper format. The design of real screens for use in a CBI program would involve the use of a more sophisticated authoring tool.

Starting Point

At this point, it is useful to recall again Horton's 75% principle. The first step in the process of converting the *PC OPS Manual* to an electronic format is to remember that 75% of the process is already contained within the existing document -- 75% of the collecting of information, planning, drafting, and revision of the document. In addition, the successful use of this manual to teach several BISC PC OPS courses indicates that the original process of collecting, planning, drafting, and revising the manual has already been proven and should be retained as the basic framework for the computer version.

The first page of the *PC OPS Manual* (refer to first page of Appendix F) contains the title of the manual, a graphic of the internal structure of a computer, and a RAAF Crest of the School of Technical Training. This layout lends itself well to an introductory screen -- one that identifies the subject and provides some visual interest. Figure 2 shows a simple example of what this introductory screen could look like.

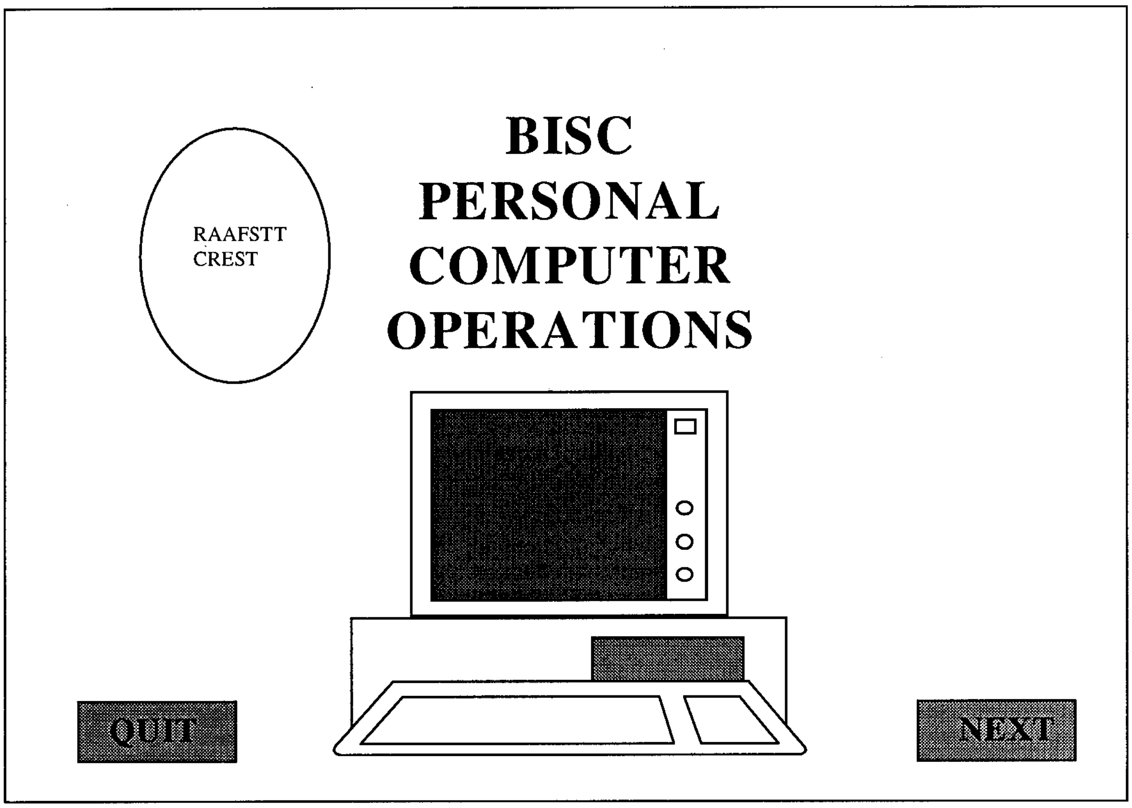


Figure 2. Sample Introductory Screen

The name of the course is introduced, the sponsor of the training program (RAAFSTT) is identified, and a simple graphic provides visual stimulation to the student. The screen also presents the option of continuing to the next screen or quitting the program (see the two buttons QUIT and NEXT).

Next, page two of the manual lists the Table of Contents. It is important to give online readers the same type of guidance. As Humphreys points out:

> Readers come to hardcopy text with a great many expectations and a great deal of previous experience and skill at handling text. The books they are familiar with have a physical appearance that acts as an analog to their structure and organisation. Readers can tell how far they are from the front or back just by looking. This isn't true online. People lose their sense of 'textual wholeness' online. (Humphreys, 1994:624).

Therefore, like the Table of Contents in the *PC OPS Manual*, the on-screen Table of Contents should become a navigation aid for students in the CBI version. Park and Hannafin's second principle for the design of interactive multimedia implies that introducing the structure of the lesson helps learners select information by directing their attention to relevant features (Park and Hannafin, 1993:70). Figure 3 shows how the Table of Contents can "navigate" a student through the program.

The student is presented with a Table of Contents. If the student chooses to progress through the material in the order in which it is presented, he should select the NEXT button. Note that the NEXT button is located in the same location as the previous screen. If the student wants to review material in a different order, any of the chapters can be chosen by pointing to the title of the chapter and clicking on it. For example, choosing "Chapter 2" will lead the student to a table of contents for chapter 2, where the student can make a further choice of material to study. This point-and click method of moving to another page uses the basic techniques of hypermedia, discussed in Chapter 2.

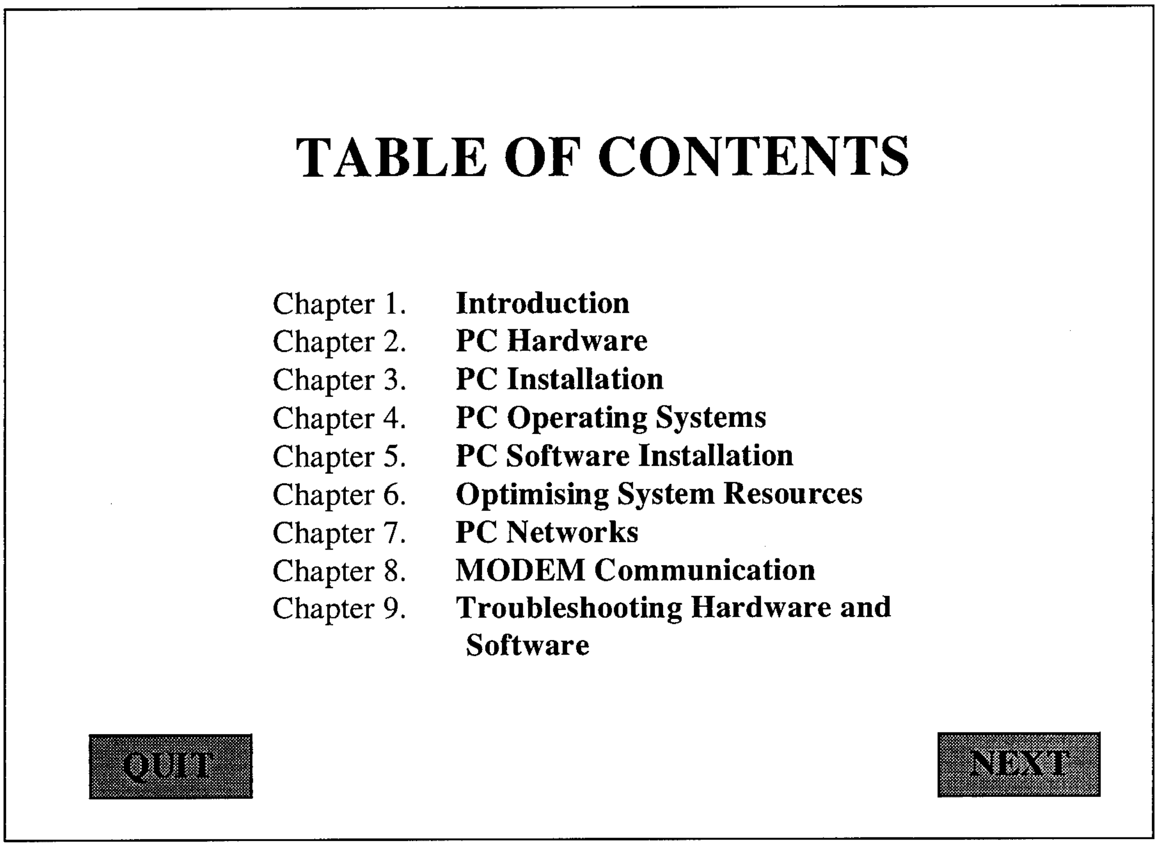


Figure 3. Sample Table of Contents Screen

The program should be sophisticated enough to keep track of the progress of the student -- i.e., which modules of material have been reviewed and at what time -- so that the student can suspend and resume a session at any time. The way in which this table of contents should be properly presented on the screen leads us to the next step - screen design.

Screen Design

The next logical step in the conversion of the manual is the consideration of the physical limitations of the screen. As Humphreys points out, the screen is smaller than a normal page. Instead of cramming more information into a smaller area, the designer has

to chunk information so it will fit (Humphreys, 1994:623). Chunking information requires that one block of text should be complete in its meaning. A student should be able to click on a subject area, read the "chunk" (a sentence, a paragraph, a screen, more than one screen), and fully understand the main point of the text without having to refer to other chunks.

It is at this point that the Grabinger study is useful. He recommends three design principles: provide a macro level of organisation, use structure to create a micro level of organisation, and provide visual interest (Grabinger, 1993). Figure 3 demonstrates one method of providing macro and micro levels of organisation. The macro level of organisation is the master Table of Contents, which leads to a micro level (a chapter table of contents) if the student selects one of the chapters. The provision of visual interest was demonstrated in Figure 2, the sample introductory screen and will demonstrated further throughout this chapter).

In selecting screens for each individual module of instruction within this chapter, Grabinger's screen designs produced at Appendix B should be used at a reference. The screens that Grabinger identified as more desirable (those ranked 1 through 10) should be given higher consideration. The less desirable screens (those ranked 11 - 20) serve as examples of the pitfalls of screen design to avoid. I will draw attention to particular screens of Appendix B in later examples of screen design.

Application of Design Principles to the Chapter Sections

"Overview". Chapter 2 of the *PC OPS Manual* begins with an overview of the chapter. The overview of chapter 2 presented in the manual is quite long - one short and one long paragraph. This overview is certainly too much to present on one screen. One of Brooks' tips for hypermedia design is not to simply dump word processing files online: applications that require scrolling through screen after screen of text files are inappropriate uses of the technology (Brooks, 1993:425).

One of the first steps of screen design should be to choose the maximum amount of text that the screen should hold, bearing in mind Grabinger's findings that users do not like screens that are cluttered with too much text and/or graphics (Grabinger, 1993). The size of the font to be used will be important here -- headings that are in a large font size may take up too much of the screen. Brooks recommends choosing only one or two fonts throughout the document (Brooks, 1993:423). One font should be used consistently throughout the document for text, with a slightly bigger font for headings.

Given the amount of information that is contained in the overview of Chapter 2, I suggest presenting it as 3 to 4 screens (or as one screen with scrolling capabilities) with accompanying graphics as appropriate. Figure 4 shows my sample screen for this overview section.

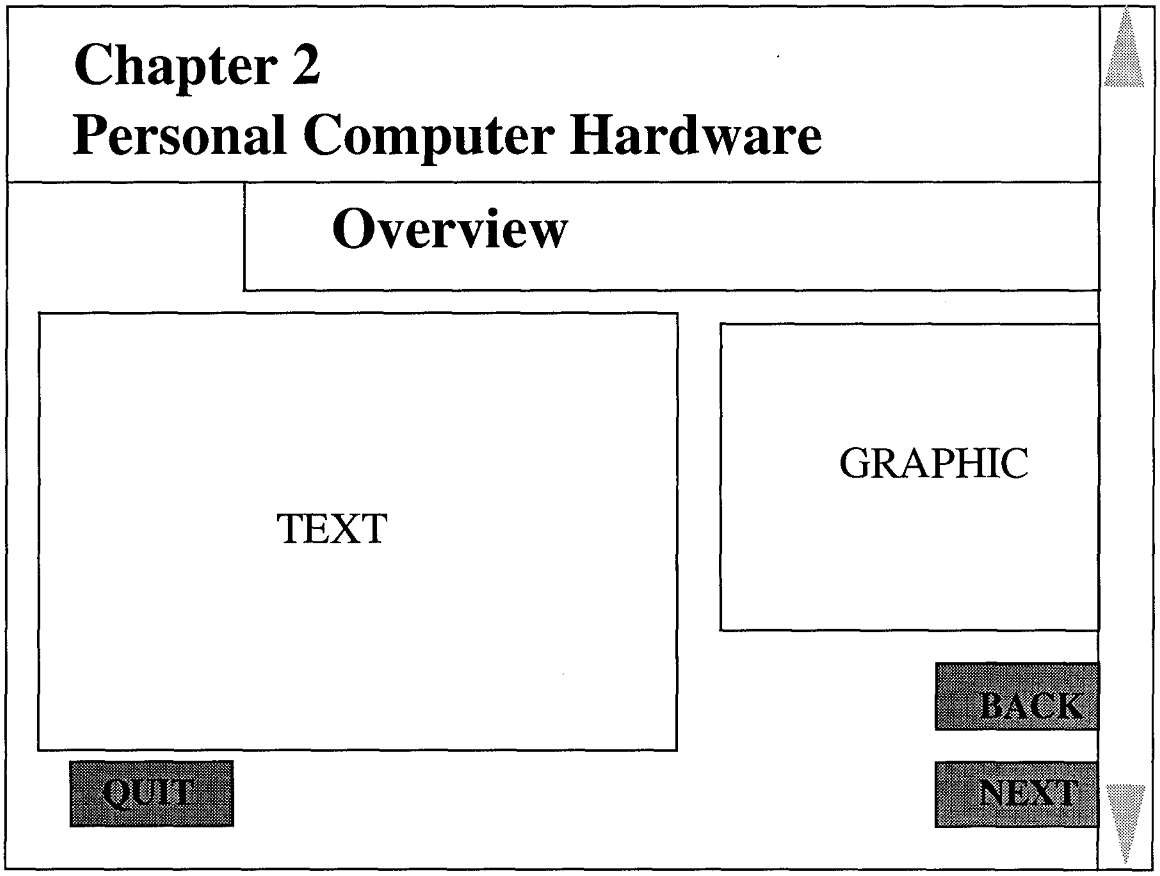


Figure 4. Sample Overview Screen

The amount of text displayed in the text box of Figure 4 will depend on the font size chosen. Brooks recommends that a font no smaller than 12 points be used for paragraphs of text (Brooks, 1993: 423). I have used the same font size for the headings of all three screens displayed so far - Times New Roman size 32. Each screen that relates to Chapter 2 of the *PC OPS Manual* must have the "Chapter 2 PC Hardware heading at the very top of the screen. Thus, at all times, students can identify where they are, and thereby alleviate some of the "lost in hyperspace" problem.

Each of these screens should have navigation controls that allow the student to go back and forth as many times as required. In Figure 4, the arrows at the size of the screen

represent the scroll bars that the student would use to advance the page. The placement and format of these navigational controls, as well as the headings and text blocks, should be repeated throughout the document (Brooks, 1993:424). Basically, this standardised placement means that the button that a student would press to advance to the next screen should be in the same place on each and every screen, with the same size font and same size box. In Figure 4, this is represented by the use of the NEXT, BACK, and QUIT buttons, which are in the same place as previous screens, the same size, colour, and with the same font.

In designing the screen of Figure 4, I have implemented some of Grabinger's screen design principles by ensuring that the screen is balanced, not too cluttered, and organised into functional areas (heading, text, graphics). I used boxes to separate one area from the other. I based the design of this screen on Screens 7, 9, and 10 of Appendix B, which demonstrate use of navigation tools (arrows), space, headings, and graphics. I have also employed some of Brook's principles by keeping the design elements simple and providing the user with multiple means of controlling navigation (buttons and scroll bars) to encourage more than browsing or watching.

The background for each screen should be consistent, with the use of some different colours for interesting variation. This background provides the user with a comfortable mental model for the document as a whole and allows the user to interact with the learning material by applying familiar processes and strategies (Brooks, 1993: 423). As an example, one colour background could be used for all table-of-contents screens, another colour for all chapter-overview screens, and a different colour for all

instructional screens. The designer must take care must be taken not to use screen backgrounds that are either too gaudy or make the text difficult to read. Thorough testing of the screen design will ensure its readability.

"Objectives". Chapter 2 of the *PC OPS Manual* then lists the objectives of the chapter. These objectives can be presented in simple bullet form on one screen, and linked in some way to the review session at the very end of the chapter. This linkage would enable the student, on completion of the final review session for the chapter, to understand how the material just presented is linked to the chapter objectives. No graphics would be needed to illustrate these objectives, and it would be preferable to list all the objectives on one screen rather than split them between two and thereby risk splitting the student's attention. Figure 5 shows the sample screen for the chapter objectives.

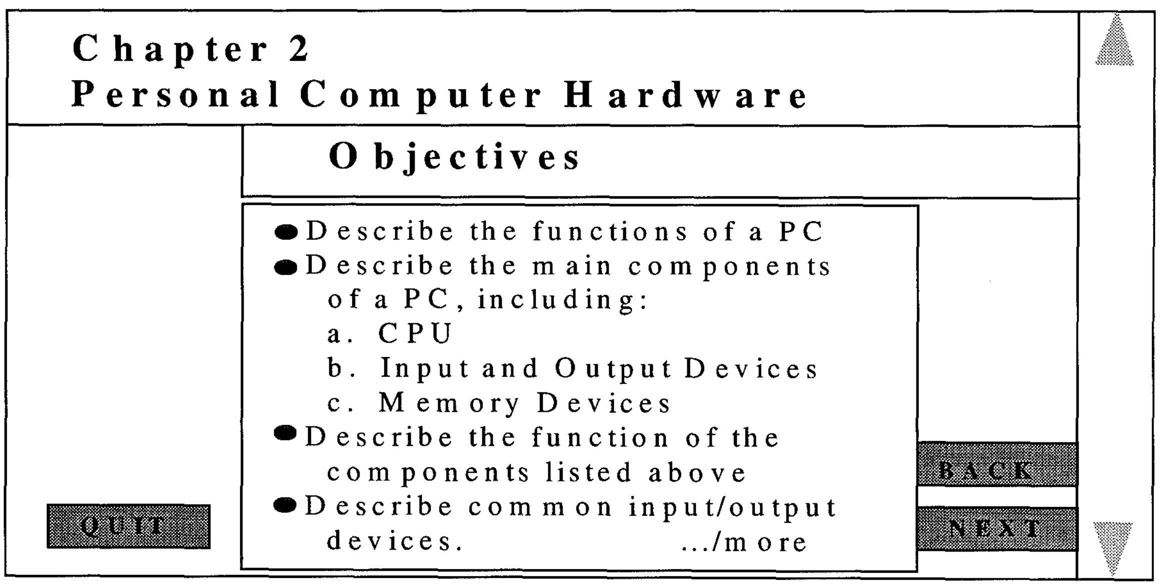


Figure 5. Sample Objectives Screen

This sample screen does not contain all of the objectives listed in chapter 2 of the *PC OPS Manual* because of the font size needed to enable the text to be read on paper. On the screen, a smaller font size would allow all the objectives to fit on one screen. If the objectives did not fit on one screen, I have demonstrated the use of the .../more navigational aid in Figure 5, which indicates to the student that more information relating to the same topic is contained on the next screen.

"History and Types of Computers". The next part of the chapter describes the history of the computer and types of computers. The material is presented in the manual as large blocks of text, supplemented by a couple of fairly uninteresting graphics. The text on the history of computers in the manual is rather dull, and the text on the types of computers does not contain a graphic of a recent computer. This text could be made more interesting on the screen by taking advantage of the features of multimedia -- using audio, video clips, still or moving graphics to illustrate the operation of early computers. Figure 6 shows how multimedia could be incorporated into screen design.

This screen presents a module of text (incomplete in the figure because of the font size), accompanied by a graphic. When the student clicks on the graphic, the CBI would take the student to a multimedia portion of the program where the operation of the "rotating shafts and gears" of early computers can be demonstrated using full animation and sound.

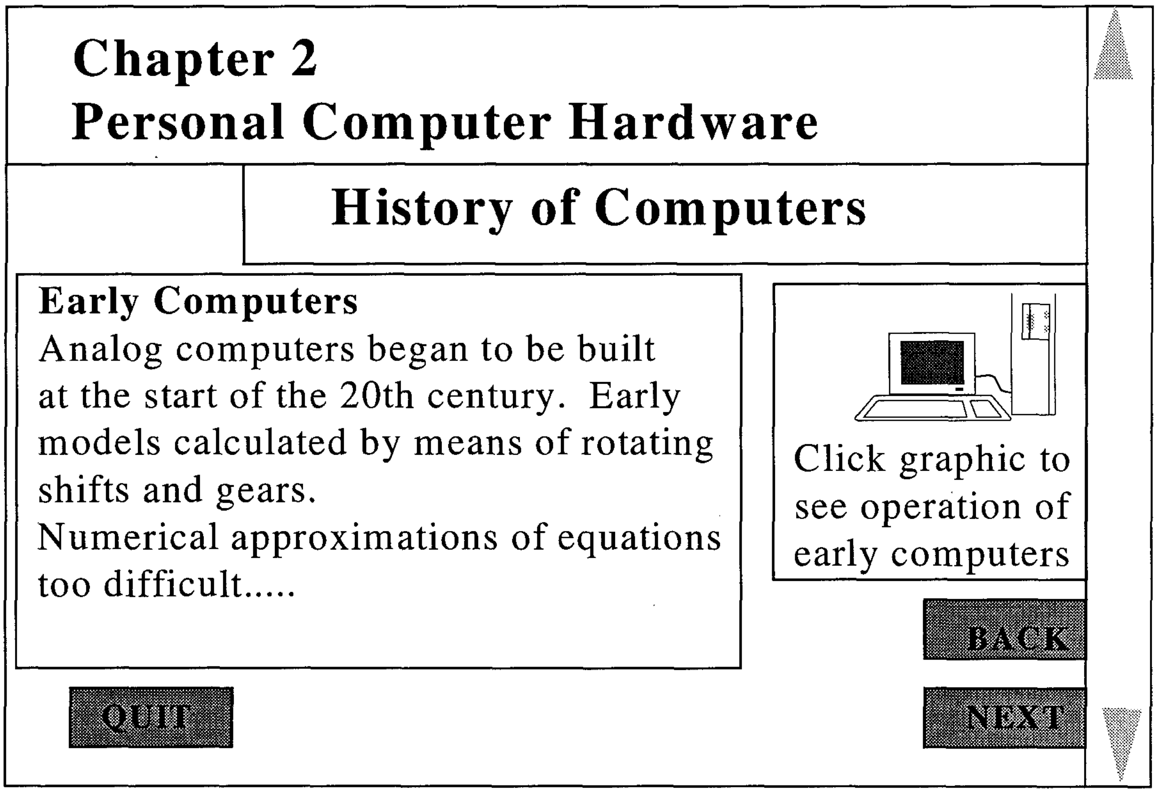


Figure 6. Sample Screen Demonstrating Inclusion of Multimedia

Due to the volume of the text in this section of the chapter, it would obviously have to be presented as a series of screens with only one or two paragraphs of text per screen, with liberal use of headings and space. Much of the text could be replaced by visual aids. The difficult part is presenting the information about the history and types of computers so that students can identify with what they are learning. Park and Hannafin's sixth principle states that knowledge is best integrated when unfamiliar concepts can be related to familiar concepts (Park and Hannafin, 1993: 72). The presentation of the material on the history of computers could be made more meaningful by using metaphorical references to objects with which the student is familiar -- for example, TV screens, programmable VCRs, video games, or even by relating modern day computers

(with which the student may be familiar) with older types. Figure 7 shows how familiar concepts (a modern day computer) can be compared with unfamiliar concepts (an early mainframe computer).

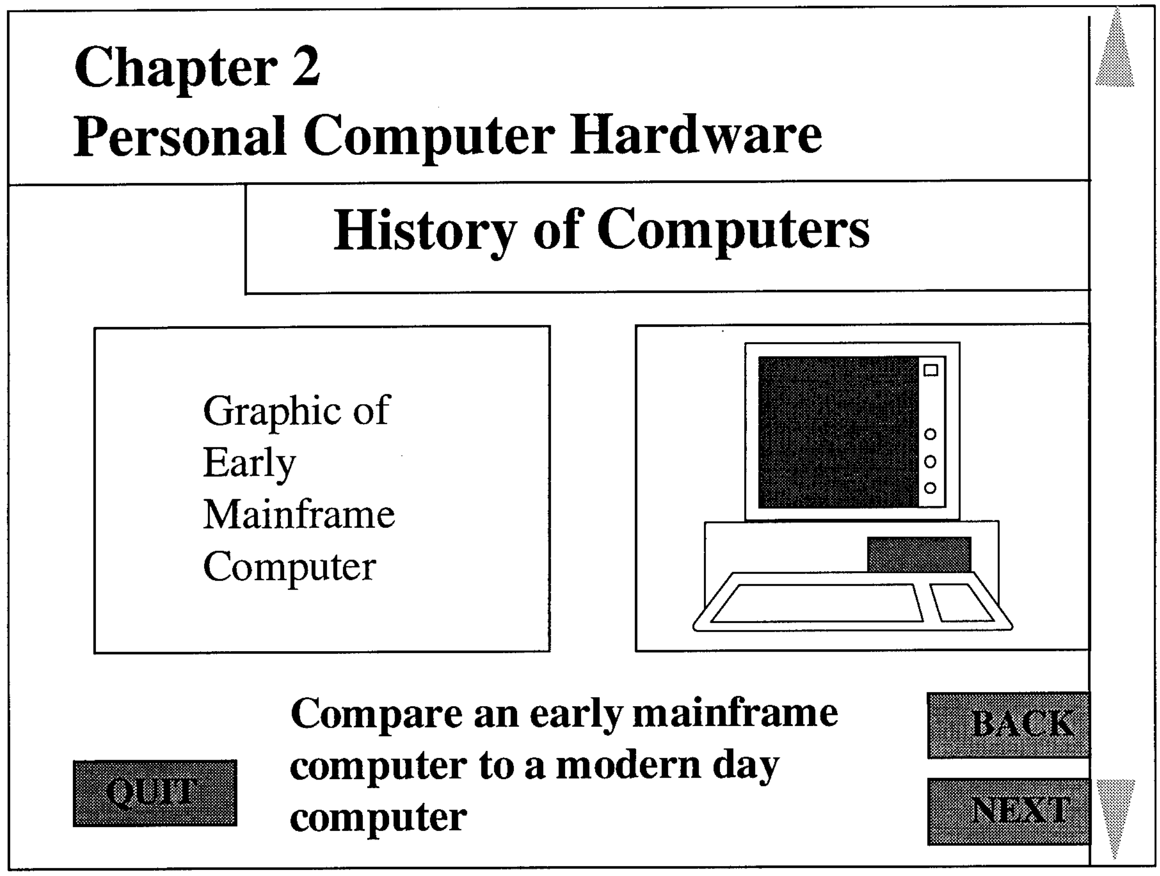


Figure 7. Sample Comparison Screen

"<u>Number Systems</u>". The next section in the manual, a description of number systems (decimal, binary) and data representation, presents an interesting challenge -- how to present mainly mathematical information in an interesting way to students whose mathematical ability may vary widely. Park and Hannafin's eighth principle, that learning improves as the amount of invested mental effort increases, may help on this point (Park and Hannafin, 1993:73). This principle implies that, in such situations, activities should be

used that cause learners to engage content to be learned in ways that are uniquely suited to each individual's prior knowledge and perceptions (Park and Hannafin, 1993:73). This principle could be applied by presenting the information on number systems accompanied by a series of mathematical exercises that start at a basic level and build up to a more complex level. The answers to each exercise would be provided before the student progressed to the next level. Figure 8 shows how this could be represented on the screen. The student has the choice of pressing the TEST button for further instruction. After completing the test exercises, the student would be returned to the original screen so that the session could resume.

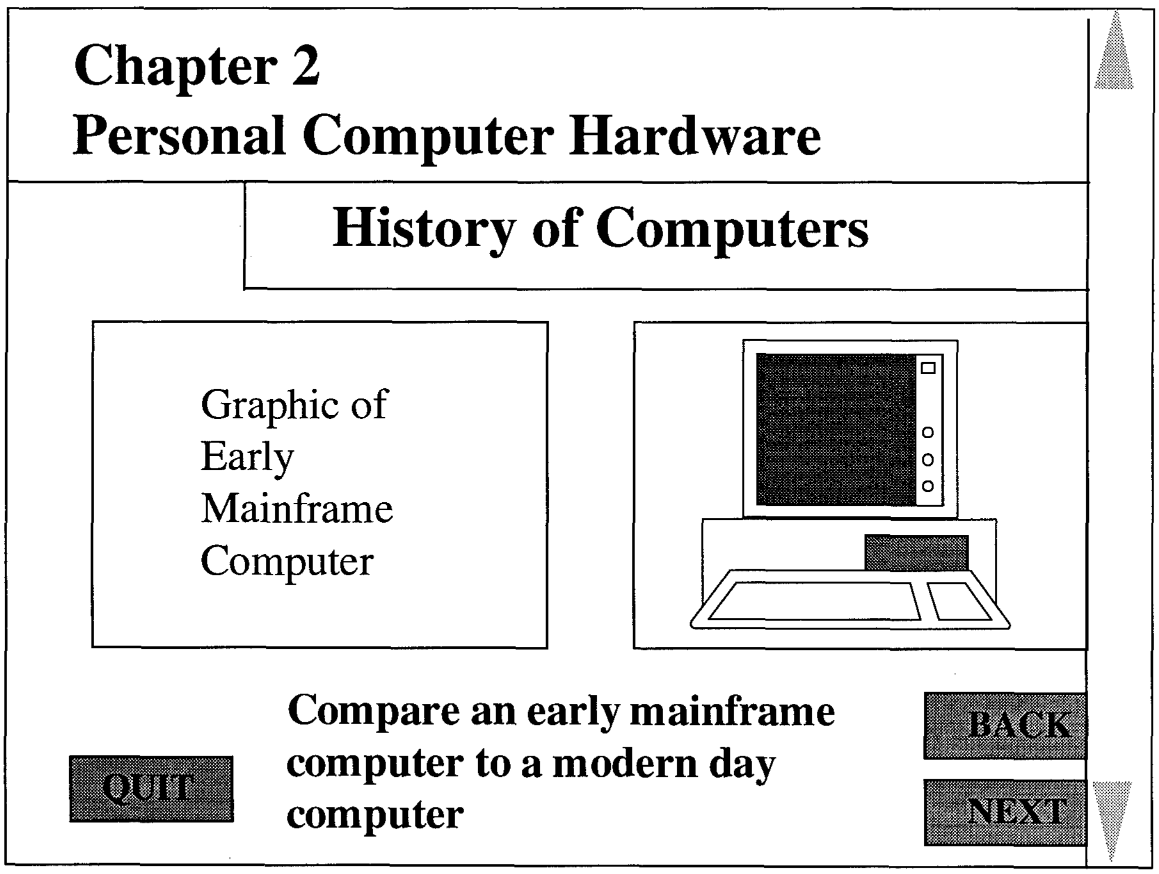


Figure 8. Sample Test Screen

Park and Hannafin's tenth principle could also be used to enhance the presentation of this information. This principle claims that transfer improves when knowledge is situated in authentic contexts (Park and Hannafin, 1993: 74). Students are often presented definitions isolated from the contexts of their natural use, and consequently, the terms lack natural meaning, which makes them difficult to understand (Park and Hannafin, 1993:72). The material on number systems and data representation should be anchored in a realistic context by providing real-life examples. The description of binary systems and data representation (bits and bytes) can be related to easier concepts for students, such as high school mathematics and perhaps even monetary examples.

At the conclusion of the section on "Number Systems", students are instructed to "Read Textbook: Introducing Computers p 30-32". Rather than requiring students to physically turn to a textbook and read a section, the textbook could be stored online and a hypertext "hot link" can be established between the CBI and the textbook, so that students can merely "click" to be instantly referred to the textbook material. By giving the student the opportunity to move to a different screen to read the textbook material, it is possible to take advantage of Park and Hannafin's 14th principle, which states that shifts in attention improve the learning of related concepts (Park and Hannafin, 1993:77). By shifting the student's attention to related concepts in the textbook material, improved learning may be possible. Figure 9 shows how a "hot link" can be included in the screen design. Students can click on the hypertext word "Information" to be transferred to a different screen containing the textbook material.

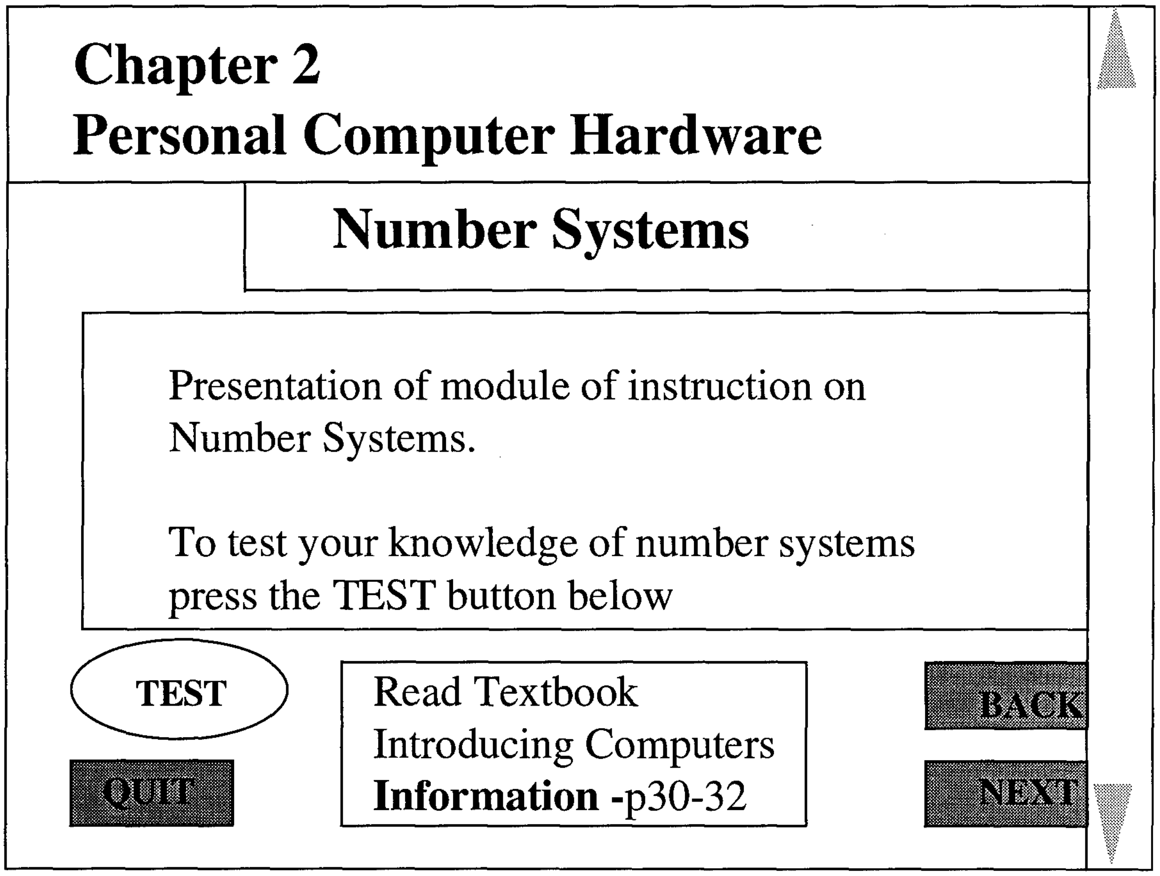


Figure 9. Sample "Hot Link" Screen

"Computer Functions, Hardware and Components". The manual then describes computer functions, hardware, and components. Four pages of text contain only one black and white graphic, representing an individual component of a computer, an ALU (Arithmetic Logic Unit). Not one graphic demonstrates how all the components fit together, despite the manual describing a digital computer being a system composed of five distinct elements. I think it is important to provide more visual interest to the student, particularly showing how components relate to each other. Park and Hannafin's 16th principle states that visual representations of lesson content and structure improve the learner's awareness of both the conceptual relationships and procedural requirements of a

learning system. Park and Hannafin are referring to both the requirement to provide visual aids to indicate the relationships among concepts (for example, computer components), and the requirement to provide the learner with "hypermaps" to indicate the location of the learner relative to other lesson segments.

The need to provide visual interest has been previously demonstrated. Figures 10 and 11 demonstrate a way in which a "hypermap" could be used in a CBI program. Figure 10 shows a simple screen, presenting a module of instruction, with a MAP button on the bottom of the screen. This MAP button could be shown on every screen. The student, by clicking this button, could be taken to a screen similar to Figure 11. This is a "hypermap" which shows where the student is in relative to other parts of the CBI program. Some form of programming would be required to enable the CBI program to pinpoint the student's exact location at any point in time.

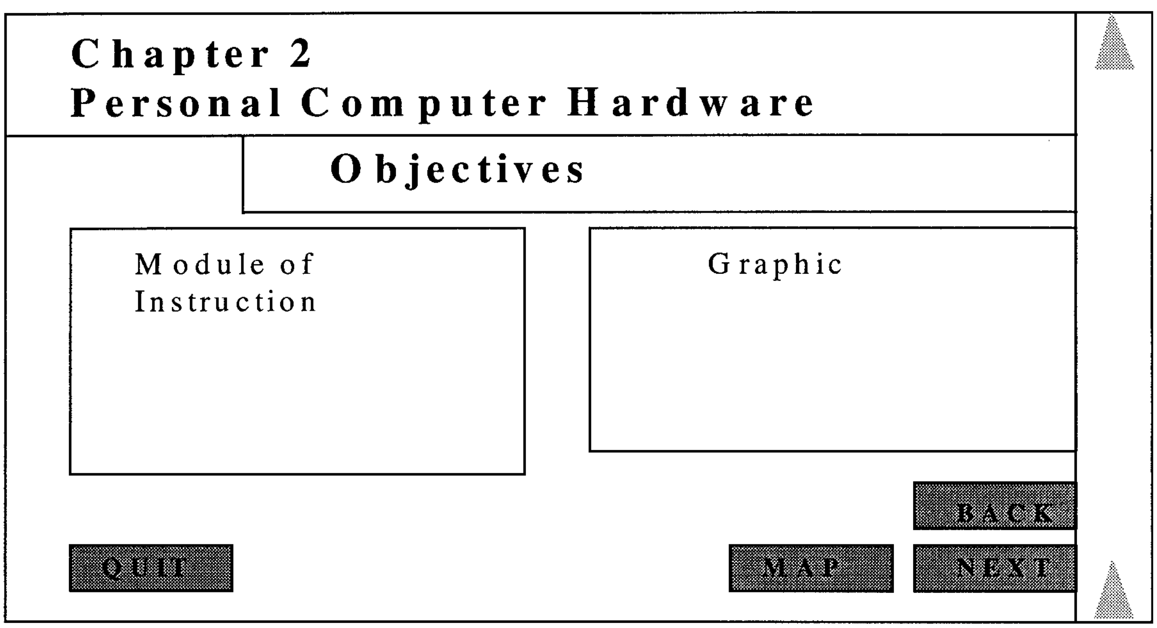


Figure 10. Sample Hypermap "From" Screen

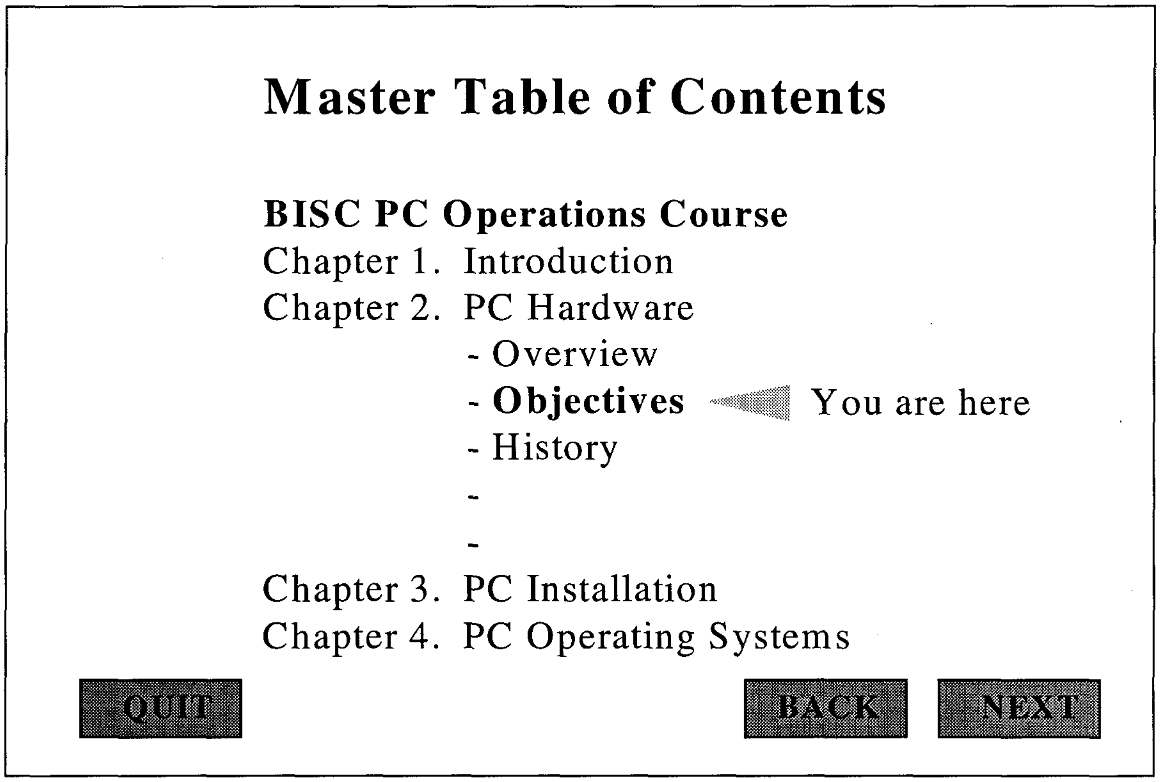


Figure 11. Sample Hypermap "To" Screen

"Communication Pathways". The next section in the manual, on Communication Pathways, describes the operation of data and address buses. The operation of data and address buses could be demonstrated more effectively using an animated graphic illustrating how an ordinary bus transport system works, stopping at bus stops and dropping off passengers. A bus on a computer works in much the same way. Figure 6 has already demonstrated how multimedia can be incorporated into screen design. Students could understand the concept of computer buses more easily by the use of this familiar metaphor. This is another example of Park and Hannafin's tenth principle -- to anchor knowledge in realistic context and settings (Park and Hannafin, 1993:74).

"Intel Microprocessors". The next section of the manual describes Intel Microprocessors. The discussion presents a short history of microprocessors, followed by a discussion of Computer Speed. A graphic shows racing cars depicting the relative speed of each microprocessor. This graphic presents the perfect opportunity to incorporate a highly appropriate animated graphic of racing cars flashing across the screen at different speeds to demonstrate the different speeds of microprocessors. Using animation is certain to provide visual interest and just a little bit of fun to lighten the lesson. The module of instruction on processor speed could first be presented as text, with students being asked to click a button to see a demonstration.

On a standard page in the manual, the racing cars look flat and uninteresting. On the screen, the powerful features of multimedia can be brought into play. The Gittelman and Park study found that animated visual displays are more effective than static displays, but only when they are used in congruence with the specific learning requirements of the given task (Gittelman, 1992:28). An animated graphic demonstrating computer speed is entirely appropriate and in keeping with Gittelman's findings.

"Computer Hardware". The next seven pages of the manual describe the different pieces of computer hardware -- data storage devices, main memory unit, secondary storage devices, input and output devices. Scattered throughout the discussion of these devices are many different definitions and acronyms -- like RAM, ROM, KB, WORM. These acronyms are explained the first time they are used in the manual. Hyper links could effectively connect these acronyms and their explanations. In that way, each time the acronym appears, which may be many times throughout the entire manual, the student

can just click on the word and immediately be shown its definition. Students could avoid having to scroll back through previous screens to find the definition of a word they have forgotten. The use of hyperlinks is illustrated in Figures 12 and 13.

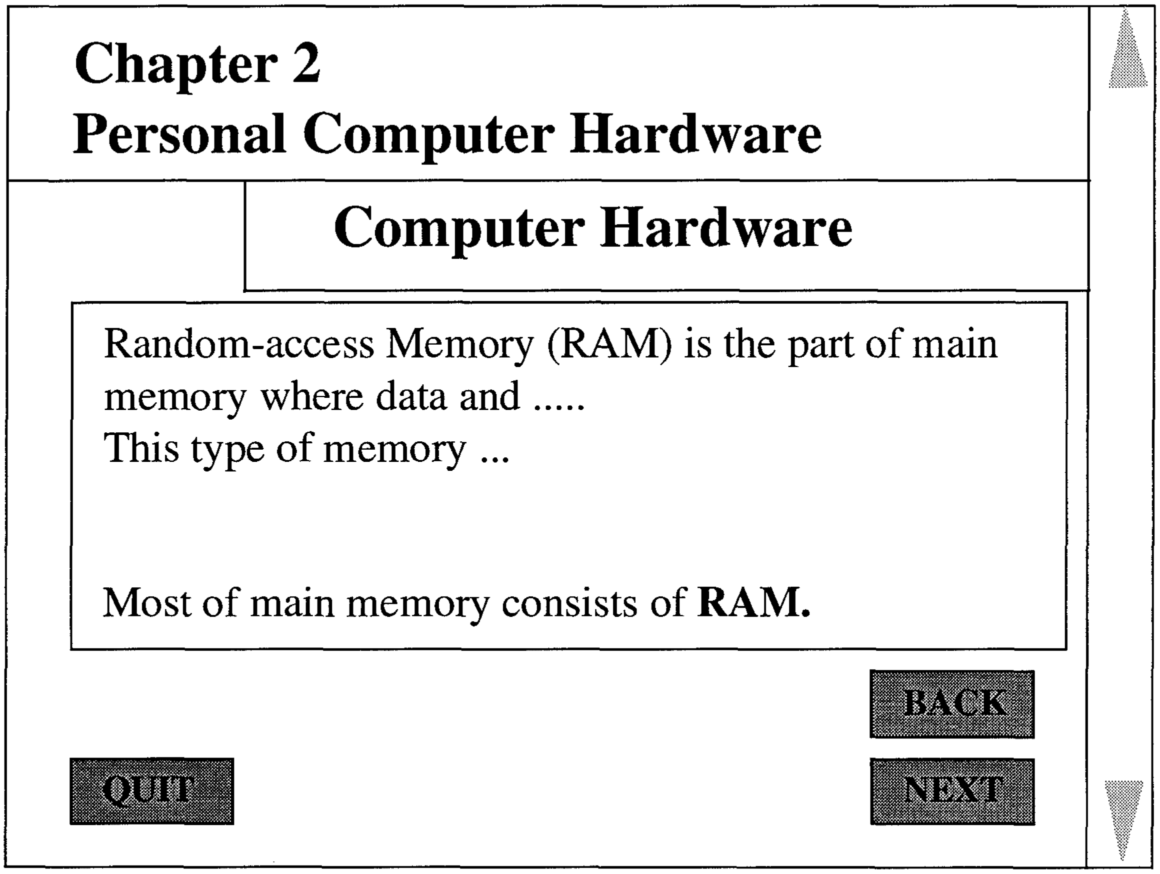


Figure 12. Sample Screen Showing Hyperlinks

In Figure 12, the use of boldface indicates that by clicking on the word (RAM, in this example), the student can be connected to another part of the program (such as the Definitions Screen of Figure 13) where the definitions of all technical words and acronyms can be stored.

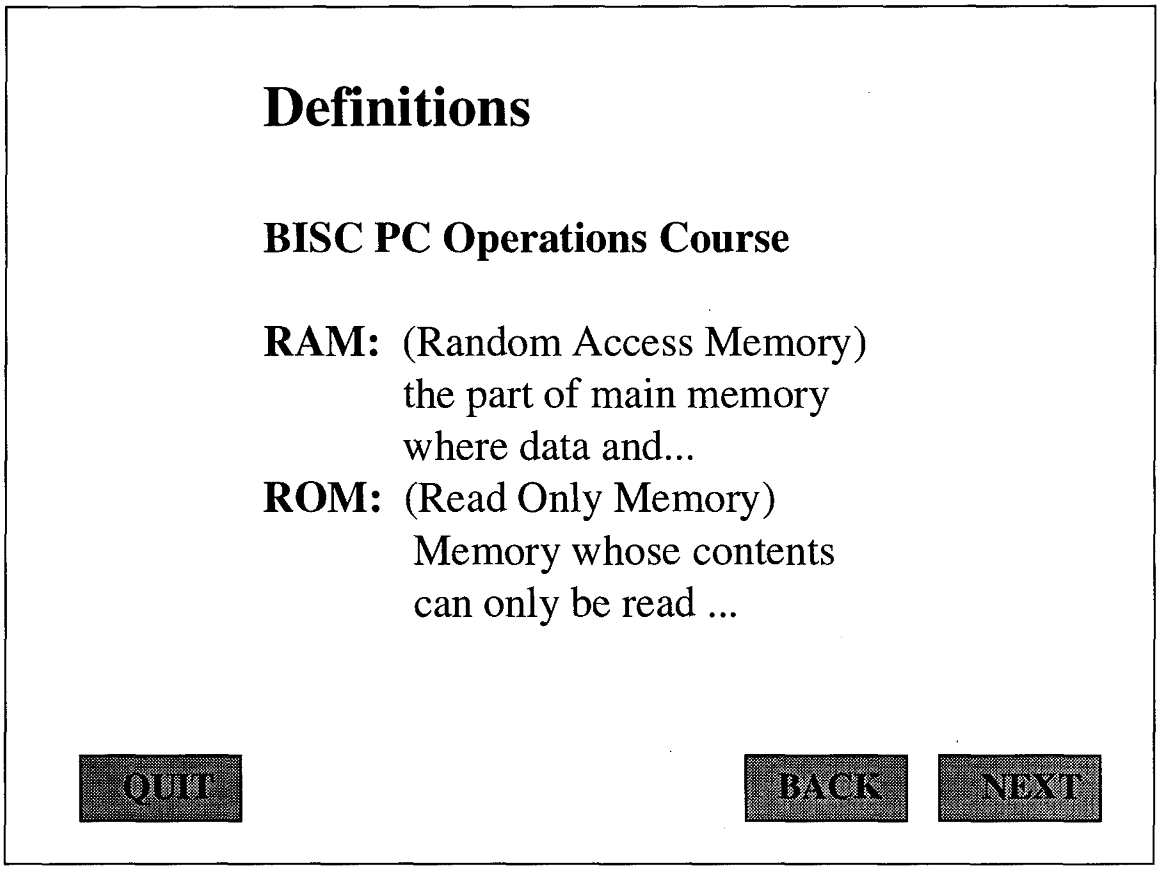


Figure 13. Sample Definitions Screen

The student could be linked to a separate Definitions Screen, or perhaps back to the place in the same document where the word was first defined. In this way, whenever students read the word RAM in any part of any lesson, they can always be referred back to its definition. Park and Hannafin's 11th principle requires the provision of methods that help learners acquire knowledge from multiple perspectives and cross-reference knowledge in multiple ways. By providing a source of definitions that can be accessed at any time during the lesson, the program delivers information from different perspectives and is able to refresh knowledge already learnt.

"Putting the Pieces Together". The final discussion section of Chapter 2 describes how all the components fit together, with a block diagram illustrating the relationship between these components. The graphic used in this section is highly appropriate.

"Summary". The chapter concludes with a short summary. This summary could be made more effective by allowing a student to use a hot link to click back to an earlier section. For example, the summary contains the sentence: " A PC consists of a Central Processing Unit (CPU), communications network, Input devices, output devices and memory storage devices." Each one of the main ideas in this sentence could be boldfaced and linked back to the original discussion. Figure 14 shows how the text box of the screen would look with the relevant words boldfaced.

> A PC consists of a **Central Processing Unit (CPU)**, communications **network, input** devices, **output** devices, and memory **storage** devices.

Figure 14. Sample Text Box

If the student wanted to review a particular section, it would be a simple task to click on the desired subject. Creating these "hot links" is not difficult using the sophisticated authoring packages and hypermedia development applications available today. Providing these links would also be in keeping with Park and Hannafin's 19th principle, which implies a learning program should provide prompts and self-check activities to aid the learner in monitoring comprehension and adapting individual learning

strategies (Park and Hannafin, 1993:80). Park and Hannafin's 17th principle is also relevant -- individuals vary widely in their need for guidance, so provide tactical, instructional, and procedural assistance (Park and Hannafin, 1993: 79). Provision of links back to earlier work for revision purposes would take account of the varying levels of guidance required by individual students.

"Review Exercise". The final section of the chapter is a Review Exercise. Including a review section in a CBI program of this course would enable the use of some of the advantages of CBI programs over traditional classroom teaching - summary of concepts, provision of feedback, periodic questioning. The student would answer the review questions, and based on the results, would either proceed or review the previous module. The program could be written so that either the student has the choice to proceed, regardless of results, or the computer controls the progression of the student. In either case, the provision of feedback will increase knowledge. Park and Hannafin's 13th principle states that feedback increases the likelihood of learning response-relevant lesson content (Park and Hannafin, 1993: 76). The Gittelman and Park study also supported the provision of feedback by stating that instructional strategies, such as feedback, should be applied selectively based on the specific learning requirements of a given task (Gittelman, 1992: 27).

Application of Principles to the Chapter in General

The previous discussion has shown the application of the multimedia design principles to specific sections of Chapter 2 of the *PC OPS Manual*. Other general design

principles also apply to Chapter 2 of the *PC OPS Manual* in its entirety. The relevance of each of these studies are summarised in the paragraphs below.

To overcome physical differences between page and screen, Humphreys suggests applying the principles of page design (Humphreys, 1994:623). He suggests using consistent screen design to delineate different types of screens. In our case, the introductory screen to Chapter 2 should be consistent with the introductory screen of all other chapters, but slightly different from the screens that present the learning material of Chapter 2. Delineation could be achieved quite simply by changing the background colour of the introductory screens. Humphreys points out that we should be careful in the use of colour and emphasis devices -- less is often more. It is not necessary to use bolding and italics everywhere -- controlled use of colour and a different size font could achieve the same effect.

To overcome the organisational differences between page and screen, Humphreys suggests retaining the navigational "buoys" that readers are familiar with -- page numbers and headings. Chapter 2 of the *PC OPS Manual* contains many different sections and would represent many screens of information. Plentiful headings (delineated by a slightly bigger font) and page numbers would greatly assist students.

One of Brooks' design tips was to provide help explaining or showing how the hypermedia publication functions as soon as the user opens the document (Brooks, 1993:426). This requirement implies that our CBI should have a short tutorial on how to use the program itself, before Chapter 1 presents learning material. The student should have the choice of skipping the tutorial if confident with using the package. Park and

Hannafin also expounded this principle, stating that learners become confused or disoriented when procedures are complex, insufficient, or inconsistent. Clearly defined procedures for navigating within the system and accessing online support must be provided (Park and Hannafin, 1993:68).

Another of Brooks' design tips relates to the economy of producing multimedia documents. He warns not to let available equipment, technology, or project managers determine the hypermedia design (Brooks, 1993:427). Extensive graphics, audio, and animation are complicated and time consuming to produce. Most multimedia documents should be kept simple to that they will not be difficult to update and maintain. Good design considers the appropriate level of expenditure for publishing a document as hypermedia (Brooks, 1993:426). In the hypermedia design of the *PC OPS Manual*, more complicated graphics and animation would do little to effectively present the information. I have pointed out where I consider use of graphics and animation would be appropriate. Additional graphics would incur more cost and add little to student learning.

The principles used by Jeff Carter in designing multimedia training packages are supported by the principles resulting from the published studies. Carter adds one principle to those already discussed: the importance of testing your package. Students have enough learning objectives with which to cope whilst doing a CBI program without software bugs disturbing their concentration. So to echo Jeff's words: "Test, test, test".

Chapter Summary

This chapter has shown, in a practical way, how the many principles of effective multimedia design can be applied to a specific CISCON course. The BISC PC Operations course was chosen as a sample course on which to demonstrate these design principles because of the relevance of this course to CISCON training needs. Chapter 2 of the manual was chosen as a representative sample of the chapters in the manual because of its mix of text, graphics, and practical examples. Each section of Chapter 2 of the *PC OPS Manual* was reviewed in order and the applicability of the multimedia design principles was discussed.

The application of CBI principles to Chapter 2 of the *PC OPS Manual* has revealed that most of the considerations in converting a paper-based course to CBI with multimedia capability come from the principles of print media. Application of principles specific to multimedia design in a step-by-step way to the learning objectives and material of a paper-based course, such as the BISC PC OPS Course, will produce a CBI program that is easy to use, effective, and relevant to the training need.

VI. Conclusions and Recommendations for Further Study

Chapter Overview

Past studies on the use of CBI in the training environments of a variety of corporations clearly support the hypothesis that CBI is an effective training tool. Past use of CBI in training has been misguided and inefficient, due, to some degree, to the lack of proven principles and guidelines in the use of the tool for converting traditional training courses to a computer format. Today, however, multimedia has the potential to add an exciting new dimension to CBI. An eclectic mix of sounds, graphics, and animation can enhance the student's learning experience dramatically. The designer must, however, apply the capabilities of the new technology to the training need in a way that suits the student, not the technology.

The RAAF has used traditional classroom teaching in the past to meet all of its training needs. With the current downsizing and rapid technological change, however, the RAAF is actively seeking new methods to perform all aspects of operations. New methods in training must also be sought. The formation of the new CISCON mustering in the RAAF and the concurrent formation of the BISCs on each RAAF base created a large training need that was not adequately met using the traditional RAAF training methods.

This thesis investigated the appropriateness of CBI to the CISCON training needs. The specific research problem was twofold:

1. how CBI, in general, could improve the training of CISCONs, and

2. how multimedia design principles could be applied against a specific CISCON training course.

The background to the problem was established through a survey conducted of all BISOs. This survey identified training gaps, discussed manning and experience levels of CISCONs, and gathered opinions from BISOs regarding the impact of these issues on the operation of their BISCs. The survey also provided data which answered the major research questions regarding the basic core of knowledge required by CISCONs, and the range of preparation among personnel employed at the BISCs.

The literature review provided extensive information and expert opinion on the development of the field of CBI and its impact on training. The general features of CBI that distinguish it from traditional classroom teaching were matched to the training requirements of CISCONs as identified in the survey. The resultant close matching showed that CBI, in general, could improve the training of CISCONs.

The literature review also summarised the results of numerous recent studies on the principles of hypermedia/multimedia design. By applying the relevant principles to a specific CISCON course, the BISC Personal Computer Operations Course, the potential for multimedia technologies in CISCON training was demonstrated. This demonstration, coupled with the matching of CISCON training needs to CBI features, provided the answer to the third major research question: Can a properly-designed CBI course, using a framework developed from existing guidelines and principles, meet these training needs? The demonstration highlighted the importance of a structured, principled approach when designing or converting training courses into electronic format.

In summary, this chapter presents conclusions drawn in previous chapters and outlines the potential applicability of the findings of this thesis to other RAAF training needs. The final conclusion for each research question will be stated and some recommendations for further research will also be proposed.

Conclusions

The research strongly supports the value of computers in training; more importantly, it emphatically supports the requirement to apply the technology appropriately to the training need, in accordance with the many principles that have been developed. This thesis has shown that the CISCON mustering in the RAAF has experienced training problems that were not sufficiently addressed by using traditional methods. Analysis of the survey data revealed many training gaps and a lack of confidence amongst CISCONs due, to large extent, to lack of experience and training. Past research has shown that computers in training can more rapidly respond to changing training needs, provided the technology is applied appropriately. CBI could have met the training challenges of the new CISCON mustering and the new BISCs in a more effective way than the traditional forms of training.

This thesis has provided answers to the three main research questions. The answers to these questions and the implications to the RAAF are summarised below:

Research Question #1. What basic core of knowledge do new BISC personnel need?

The survey data have shown that the basic core of knowledge required by CISCONs working at the BISCs relates to the skills required to manage the day-to-day operation of computer systems supported by the BISC. The survey revealed that these skills include knowledge of operating systems, networks, hardware and software, PC maintenance, and support.

The computer systems used by the RAAF at each RAAF base change very quickly. It is not practical for personnel at the BISCs to be absent from their primary place of duty for any period of time every time a new computer system is introduced. They need a fast way to update their skills, while still remaining on the job to perform their primary tasks: administration of the new system. The amount funds that are spent every year on new computing systems in the RAAF is considerable. Provision of funds to train the personnel to manage these systems, specifically the CISCONs at the BISCs, should be a high priority in the acquisition project. Training is usually overlooked in computer acquisition projects and the responsibility is left with the BISO to train his personnel on a wide variety of computer systems with a very small budget. CBI courses to train the systems administrators should be acquired or developed at the same time that the new computer hardware is being acquired.

The posting cycle in the RAAF also means that new personnel will arrive at a BISC on a regular basis. They need to update their skills quickly. A CBI course represents the opportunity for personnel to avoid the time wasting and expense of travelling away for a course, even permitting them to do the courses in their own time, if necessary.

Research Question #2. What is the range of preparation among personnel employed at the BISCs?

The range of preparation among personnel employed at the BISCs at the time of the survey was very narrow. BISOs identified many gaps in the current training, using traditional classroom methods, offered to CISCONs by the RAAF. Experience and confidence levels were generally low.

It is natural to expect that, on formation of the BISCs, personnel experience and preparation for their new jobs at the BISCs would be very limited. The BISCs were formed very quickly and were to be manned by personnel from a newly-created mustering. Some BISC personnel had never managed computer systems before, but had merely been passive users. The CISCON conversion course, which every COMMSOP and EDPOP completed before the mustering was formed, did an admirable job in cross-training the new CISCONs in their duties in Communications and EDP (duties from the old musterings). However, the course was not as successful in training the BISC personnel for their new duties. The conversion course was administered in the form of a course workbook. CBI could have improved the delivery of this course and may have permitted the inclusion of material more relevant to BISC training needs.

The BISC Personal Computer Operations Course, which was used as an example for the demonstration of multimedia principles, is only one of very few courses dedicated to training BISC personnel. Using CBI could improve the delivery of this course and

could permit the rapid development and delivery of more courses that could be tailored specifically to the needs of the CISCONs at the BISCs.

Research Question #3. Can a properly designed CBI course, using a framework developed from existing guidelines and principles, meet these training needs?

By matching the features of CBI to the training needs of CISCONs, it was shown that, in general, CBI techniques have applicability to CISCON training. The potential of multimedia technology was demonstrated more fully by the application of multimedia development principles to a specific CISCON training course -- the BISC PC Operations Course. This course was chosen because its CTOs (Course Terminal Objectives) represent the basic core of knowledge that a CISCON requires to perform the tasks required in a BISC.

There is no doubt that CBI can improve the training delivered and thus could have significantly increased the preparation of CISCONs who first manned the BISCs. The PC OPS course is one that is designed to introduce students to the basic operation of computing hardware and software. It is natural that such a subject should be taught with the use of a computer. Other, less obvious subjects can be taught with CBI with equal success, provided the learning objectives of the course are kept in mind when the design is being undertaken. The demonstration of the application of the multimedia principles to a specific CISCON course brought out the importance of applying these principles in the proper way.

The answers to these research questions have many implications to the RAAF. Traditional teaching methods, requiring students to attend classes away from their primary place of work, cannot meet the training needs that arise when a new mustering, such as the CISCON mustering, is formed, or when a new operational capability, such as the BISCs, is required. The enormity of the training need in this case was compounded by the fact that the two events, formation of the CISCON mustering and establishment of the BISCs, were concurrent. The survey identified that the personnel manning the BISCs in April, 1994 (just over a year after formation) still lacked adequate skills and training to successfully perform their duties. RAAF educators should take note of the advances in CBI (multimedia and hypermedia) and the experiences of the CISCON mustering to plan for changes to RAAF training in the future. This thesis has shown that CBI offers an effective alternative to traditional teaching methods, and has demonstrated a practical way of using CBI.

Recommendations for Future Research

The RAAF has already lost responsibility for some of its training to civilian institutions. Following evaluation of certain training activities under the RAAF Commercial Support Program (CSP), the NSW TAFE Commission was awarded the contract to provide training for aerospace systems, aircraft and avionics fitter courses, and a range of general trade training courses at RAAFSTT (RAAF News, 1994:1). CBI represents an alternative that the RAAF could consider if it wishes to retain responsibility for training its own personnel.

The very important consideration of cost was not addressed in this thesis. To be successful, CBI would have to incorporate relatively expensive hardware and software components, including authoring systems, audio and video systems, CD-ROM drives, colours screens, laserdisc players. If the RAAF were to seriously consider adopting CBI as a major facet of its training operations, an extensive cost/benefit analysis would have to be performed.

Cost and time are two of the most important decision factors in a modern corporation. There is no doubt that producing CBI programs involves a very large up-front cost and involves a great amount of time. However, opponents of CBI can point to costs that are easily quantifiable; costs of hardware, software, hours of development time. To counter this, other experts report that the option of instructor-led training is generally even more costly and not completely satisfactory either. The costs in instructor-led training are not as easy to quantify to enable an easy comparison to CBI - for example, how do you quantify the cost of loss of productive work time while a student attends a course? While instructors can create classroom courses for less money than CBI programs, there is a growing belief among CBI advocates that the cost of training geographically dispersed users wipes out any advantage of instructor-led training. The RAAF needs to train personnel who work in a widely-dispersed geographic area. It is simply not cost-effective to bring students to training; the training must go to the students. CBI is more expensive to develop, yet it is more cost effective to reproduce and distribute. In the long run, CBI is easier to update when training needs change.

When the up-front costs are spread over the expected life of CBI courses, these costs are not as significant.

Thus, a more extensive cost/benefit analysis must be done to investigate the proper costs and benefits involved in each proposal. This analysis could show that the long-term cost-effectiveness of CBI outweighs that of instructor-led training. All relevant costs, including instructor salaries, travelling costs, salaries of students whilst on course, and other allowances, would have to be considered. This cost/benefit analysis would be a logical follow on to the research presented in this thesis.

Another follow-up research option would be the demonstration of the principles of multimedia design in the actual production of a CBI program using an authoring tool. The actual production of a CBI program involves many more issues than I have addressed in my thesis, including copyright, choice of software, hardware processing issues. An investigation of the issues involved in actually converting a RAAF training course to multimedia format would be a useful follow-on to my research.

Conclusion

The RAAF needs to update its training methods from the traditional instructor-led style to a style more in keeping with technological change. This change is required for many reasons: to retain responsibility for training its own personnel, to be able to respond more quickly to changes in training needs, to reduce training costs. Consideration of CBI represents the first step in this process of updating training methods and multimedia is an extension of it.

The course of action for the RAAF presented in this thesis is clear: use the example of the CISCON mustering to plan for the future of RAAF training; put training of system administration personnel at a higher priority in the acquisition of new computer systems; and investigate CBI as a replacement for traditional RAAF training methods due to its superiority in delivery of instruction. The RAAF must face the reality that it risks losing responsibility for all of its training to commercial educational institutions and will face serious training gaps, similar to those experienced by the CISCONs, unless it can update the method, effectiveness, and timing of instruction. CBI, and the possibilities of multimedia and hypermedia, offer a viable alternative.

While the research presented in this thesis is preliminary, it reveals that we cannot ignore the possibilities of Computer-Based Instruction in RAAF training. As with any new technology, the costs of multimedia are not completely firm as yet, but the need for faster, more effective training, delivered at the time and place required by the students, in a format designed to stimulate interest and learning, make the traditional methods of training in the RAAF obsolete. This thesis has shown that CBI is a viable alternative.

Appendix A: Explanation of Acronyms

AC: Aircraftsman

ADFA: Australian Defence Force Academy

AHQ: Air Headquarters

BISC: Base Information Systems Centre

CAI: Computer-Assisted Instruction

CAMM: Computer-Aided Maintenance Management

CE: Constrained Establishment

CBI: Computer Based Instruction

CD-ROM: Compact Disc - Read Only Memory; a high capacity method of storing information for use on a computer.

CIS: Communications and Information Systems

CISCON: Communications and Information Systems Controller

CMI: Computer-Managed Instruction

COMMSOP: Communications Operator

CPL: Corporal

CTO: Course Terminal Objective

CSP: Commercial Support Program

DCIS: Directorate of Communications and Information Systems

DFASS: Defence Force Assisted Study Scheme

DRS: Data Reporting Sections

DSRMS: Defence Supply Retail Minicomputer System

EDPOP: Electronic Data Processing Operator

ETR: Excess Tasking Report

FLTLT: Flight Lieutenant

FSGT: Flight Sergeant

HQTC: Headquarters Training Command

IS: Information Systems

ISA: Information Systems Agency

ISSOR: Information Systems Statement of Requirement

LAC: Leading Aircraftsman

LACW: Leading Aircraftswoman

LAN: Local Area Network

NCO: Non-Commissioned Officer

OJT: On-the-Job Training

PC: Personal Computer

PIR: Post-Implementation Review

RAAF: Royal Australian Air Force

RAAFACE: RAAF Automated Computing Environment

RAAFSTT: RAAF School of Technical Training

RABS: Review of Air Base Support

RODNET: RAAF On-Base Digital Network

RSCST: RAAF School of Clerical and Supply Training

RSWAPS: RAAF Standard Word and Administrative Processing Systems

SCPE: Short Course at Public Expense

SDSS: Standard Defence Supply System

SGT: Sergeant

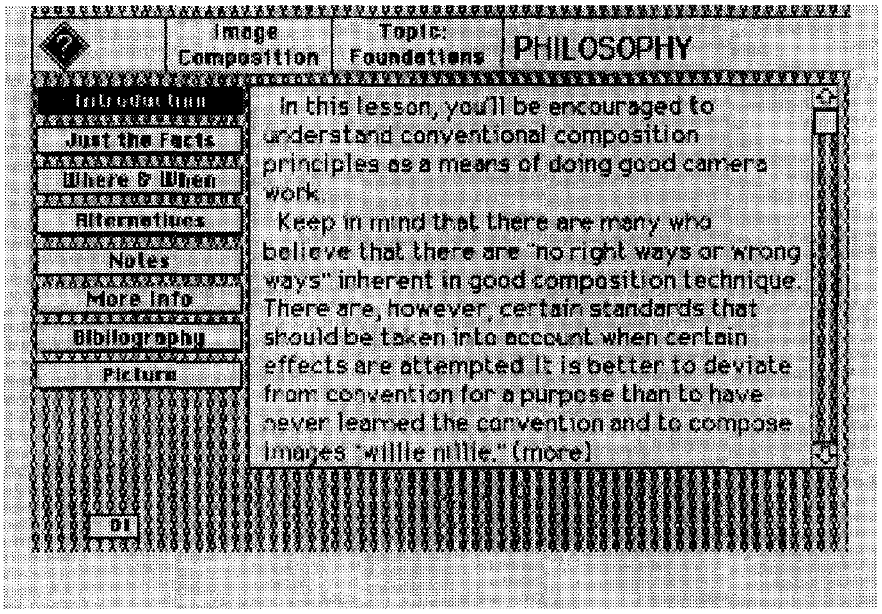
SNCO: Senior Non-commissioned Officer

SOP: Standard Operating Procedure

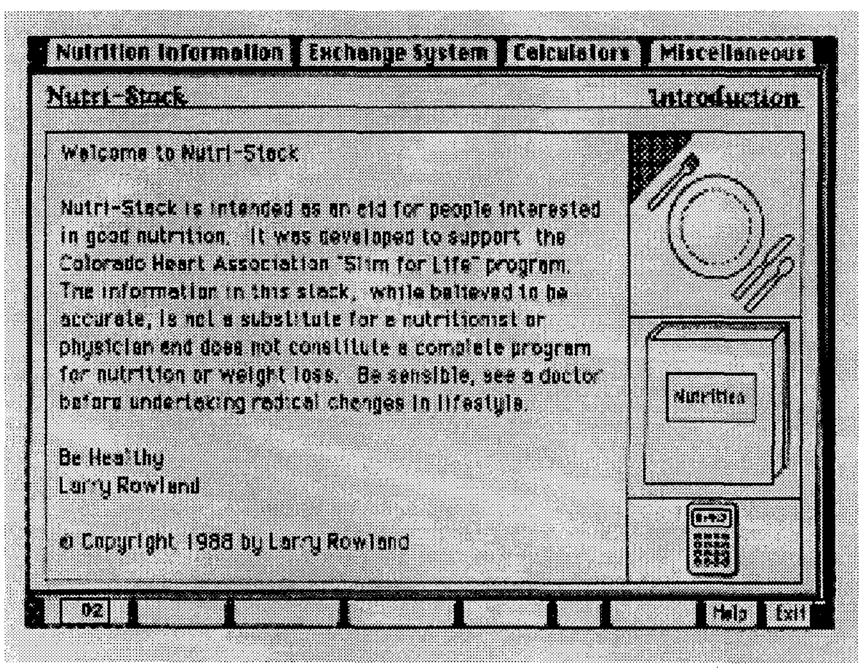
TAFE: Technical and Further Education

WOFF: Warrant Officer

Appendix B: Examples of Screen Design



Screen 1 (Ranking: 8)



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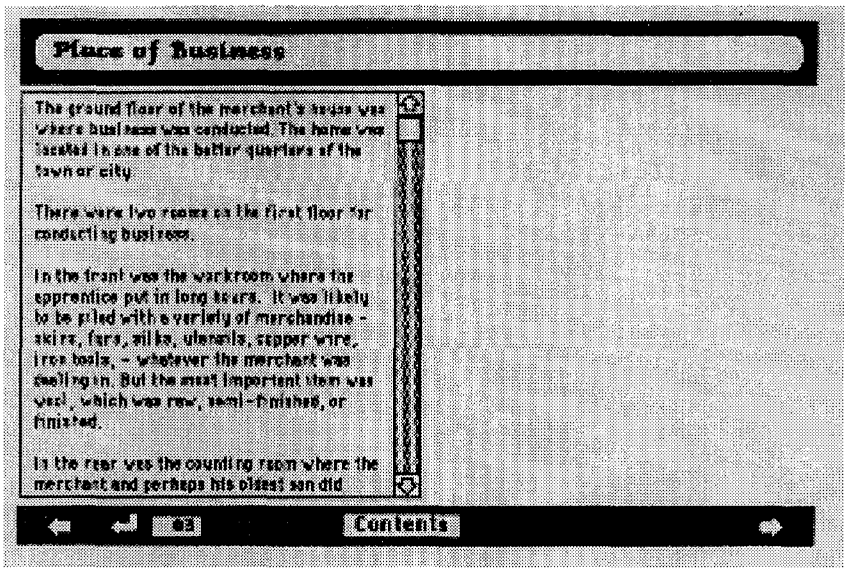

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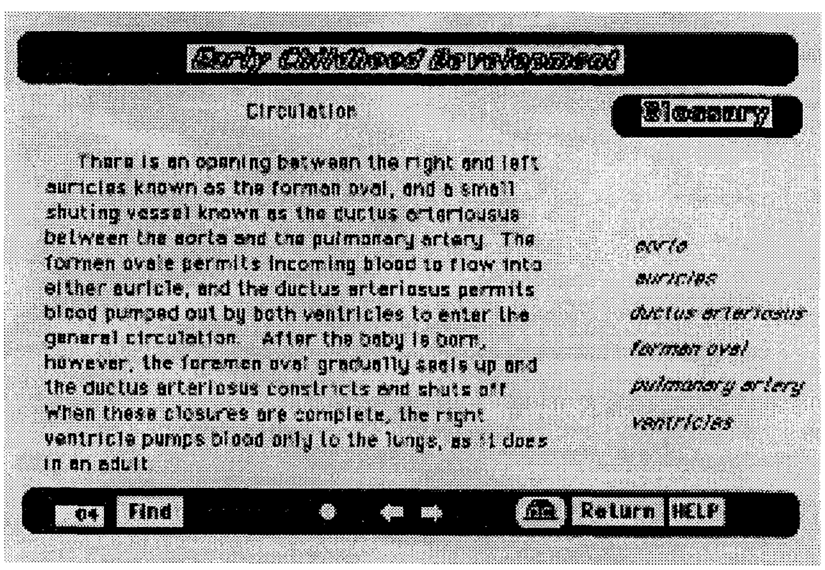

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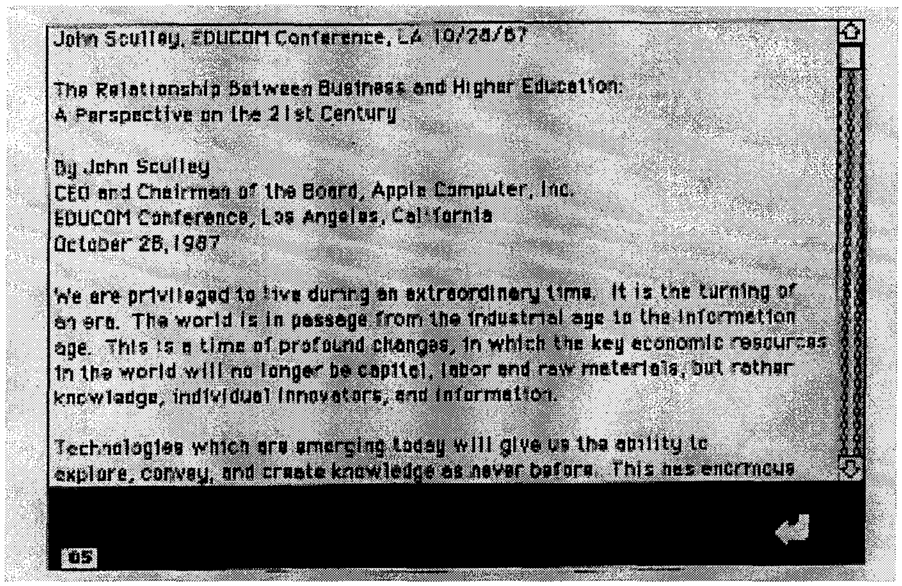

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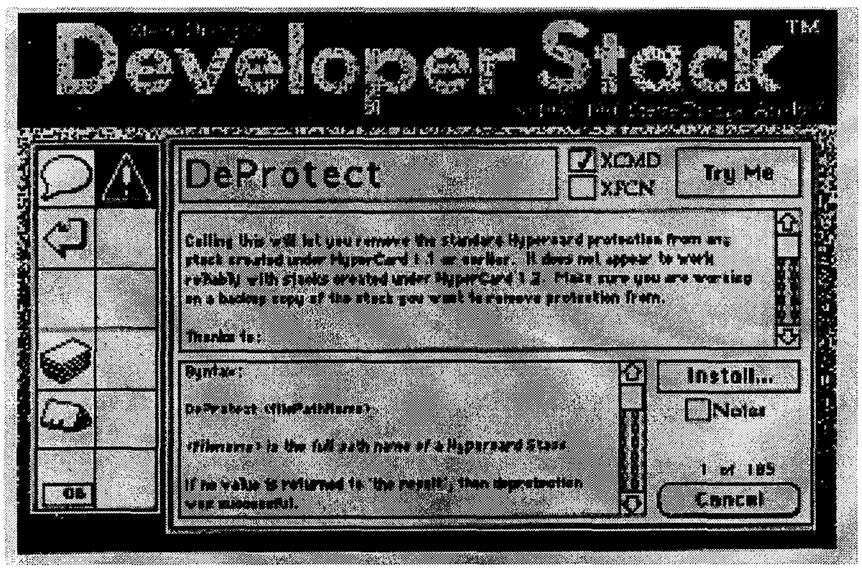

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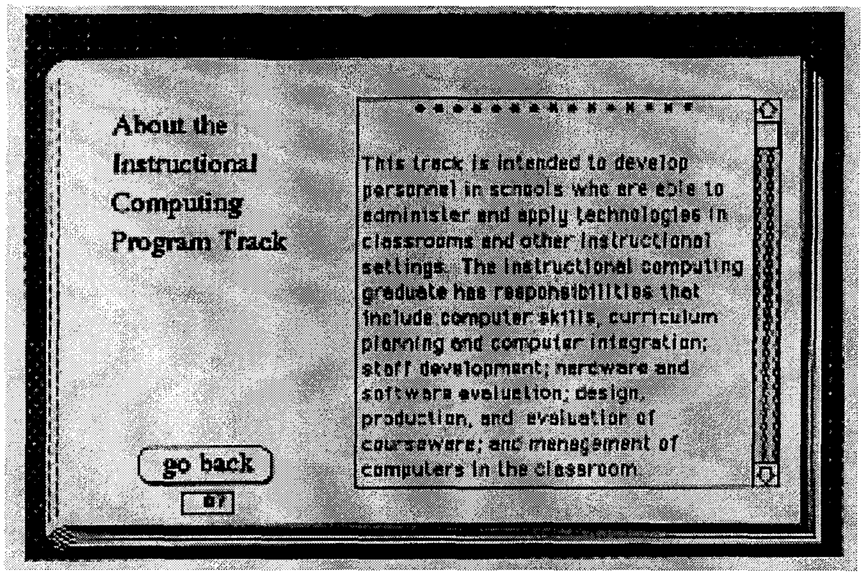

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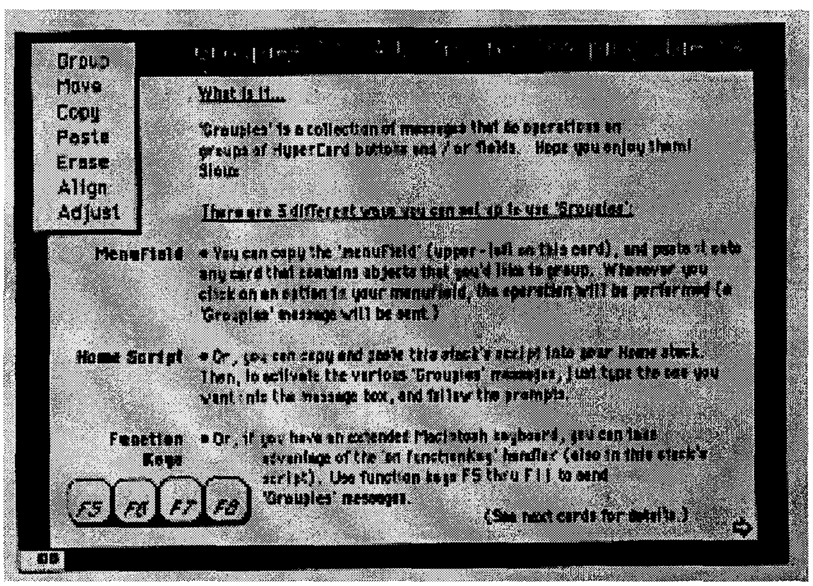

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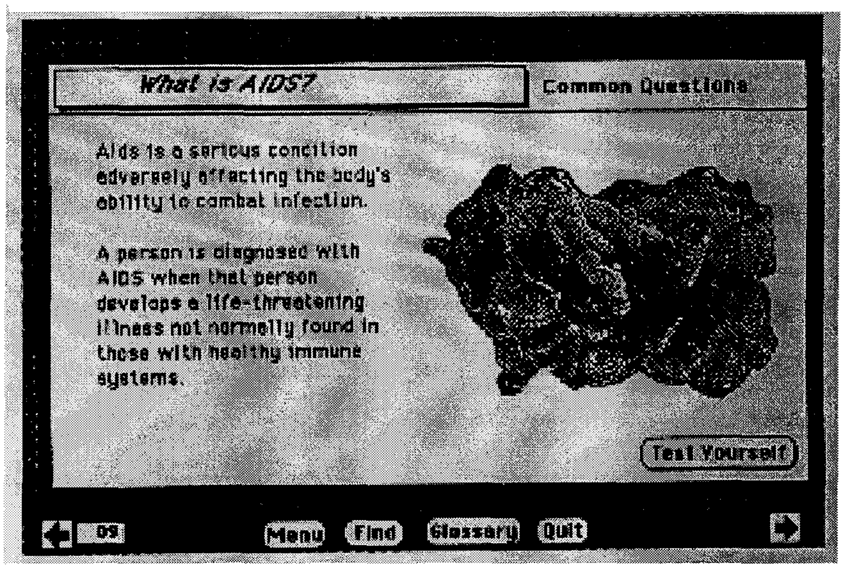

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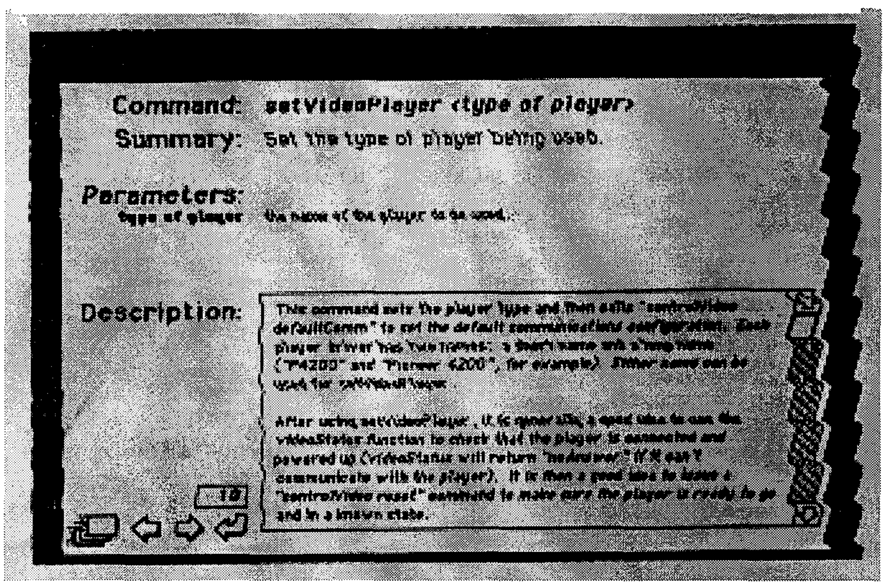

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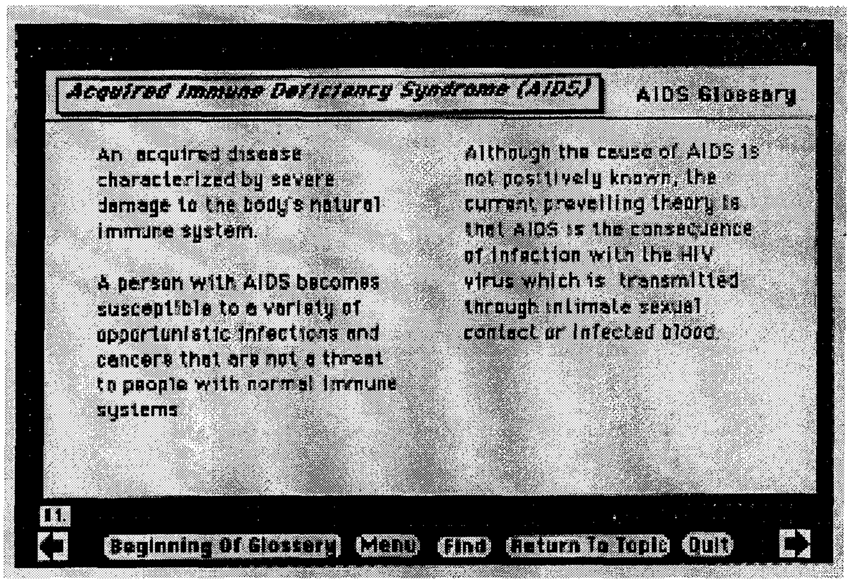

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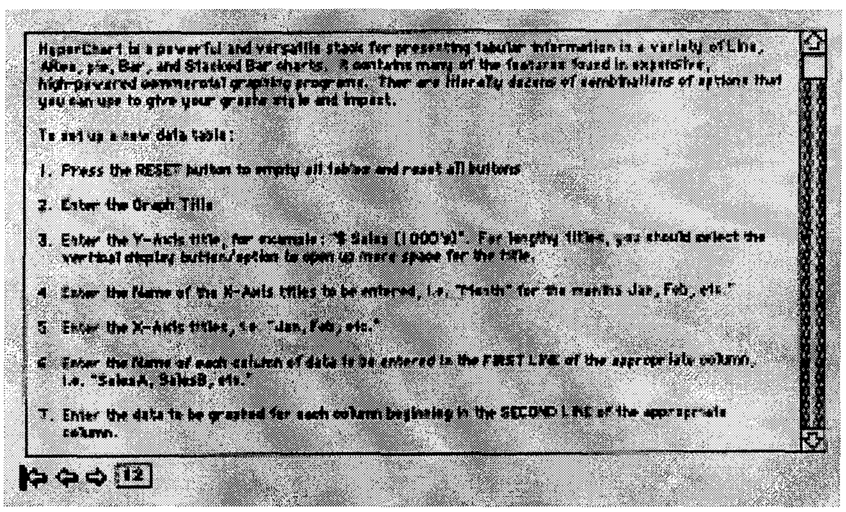

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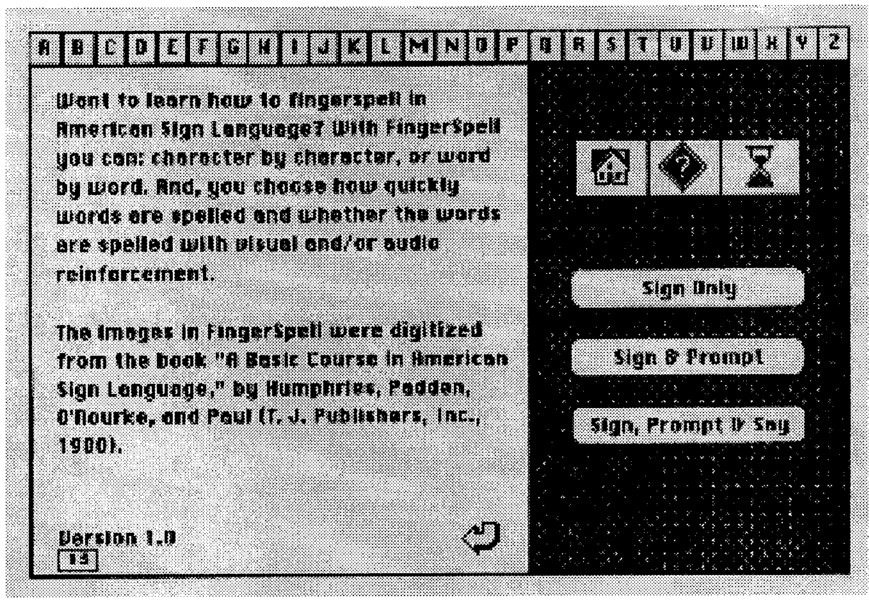

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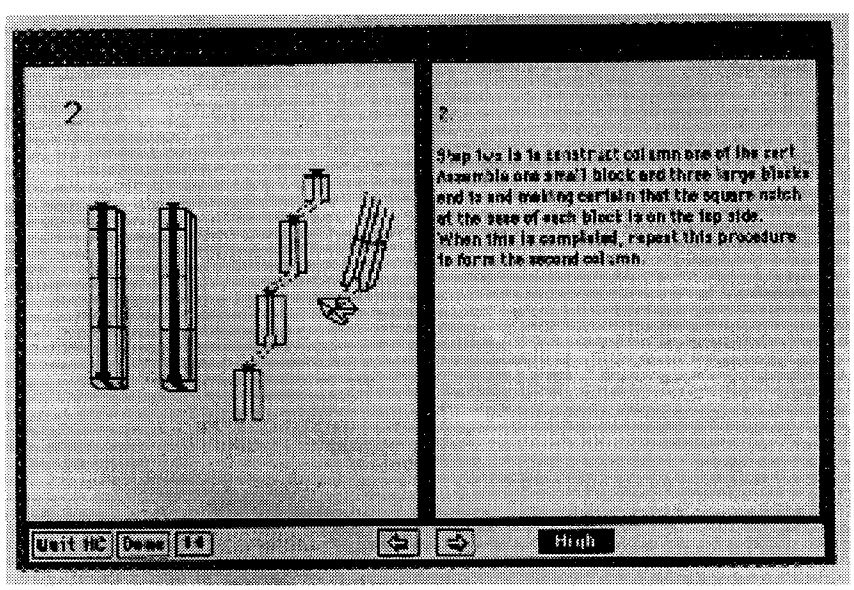

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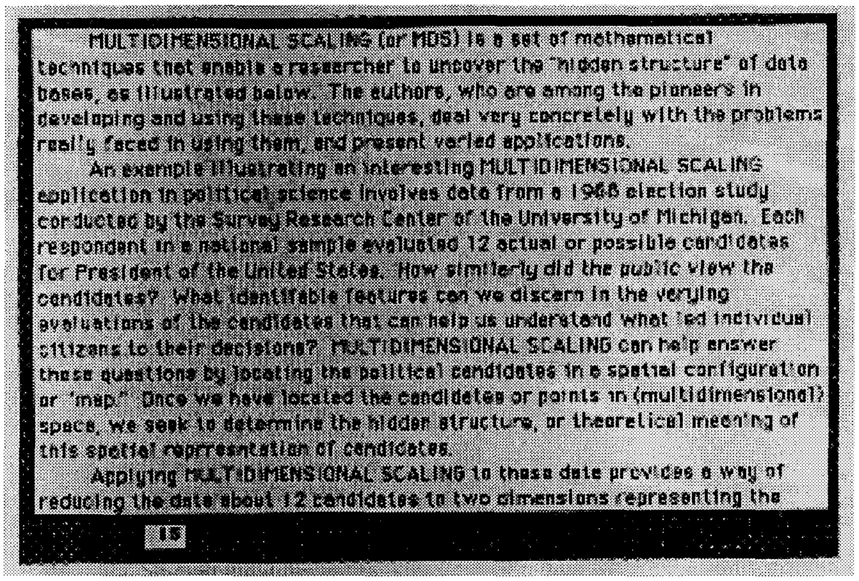


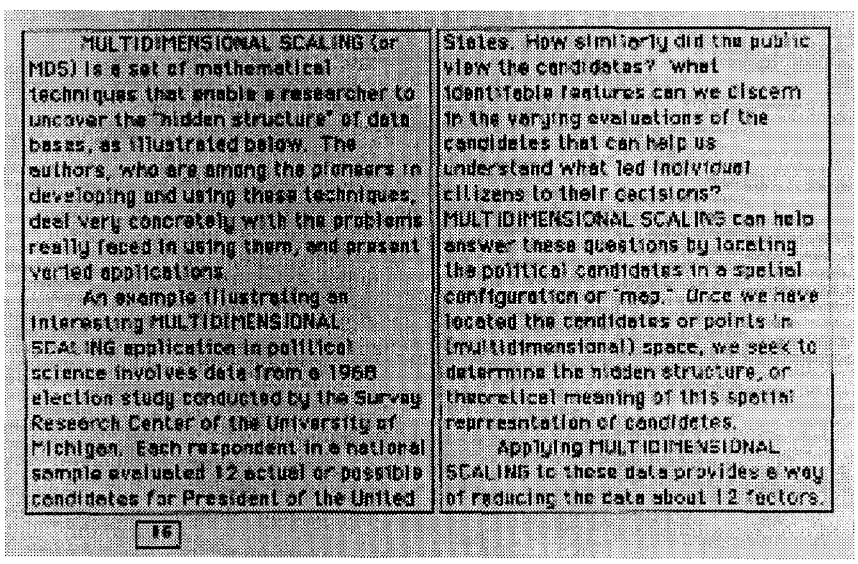
MULTIDIMENSIONAL SCALING (or MDS) is a set of mathematical techniques that enable a researcher to uncover the "hidden structure" of data bases, as illustrated below. The authors, who are among the pioneers in developing and using these techniques, deal very concretely with the problems really faced in using them, and present varied applications.

An example illustrating an interesting MULTIDIMENSIONAL SCALING application in political science involves data from a 1968 election study conducted by the Survey Research Center of the University of Michigan. Each respondent in a national sample evaluated 12 actual or possible candidates for President of the United States. How similarly did the public view the candidates? What identifiable features can we discern in the varying evaluations of the candidates that can help us understand what led individual citizens to their decisions? MULTIDIMENSIONAL SCALING can help answer these questions by locating the political candidates in a spatial configuration or "map." Once we have located the candidates or points in (multidimensional) space, we seek to determine the hidden structure, or theoretical meaning of this spatial representation of candidates.

Applying MULTIDIMENSIONAL SCALING to these data provides a way of reducing the data about 12 candidates to two dimensions representing the

15

Screen 15 (Ranking: 20)



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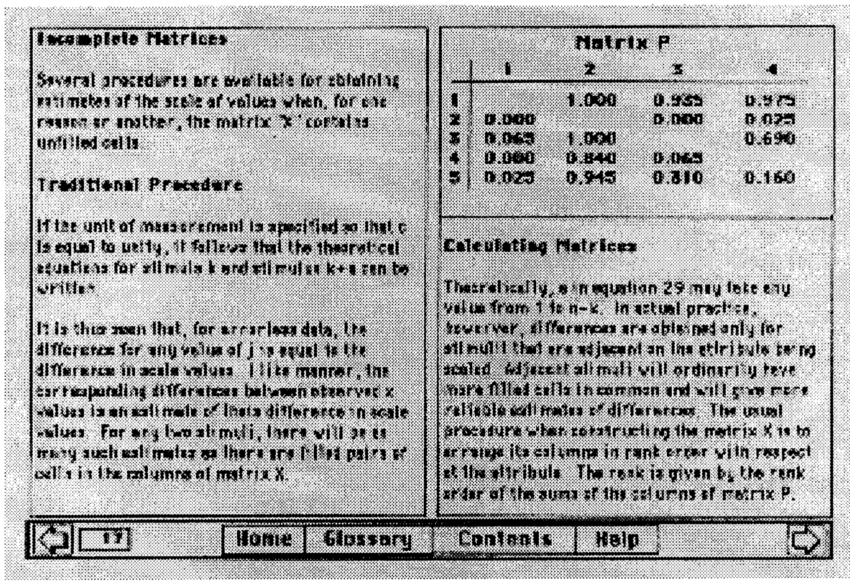
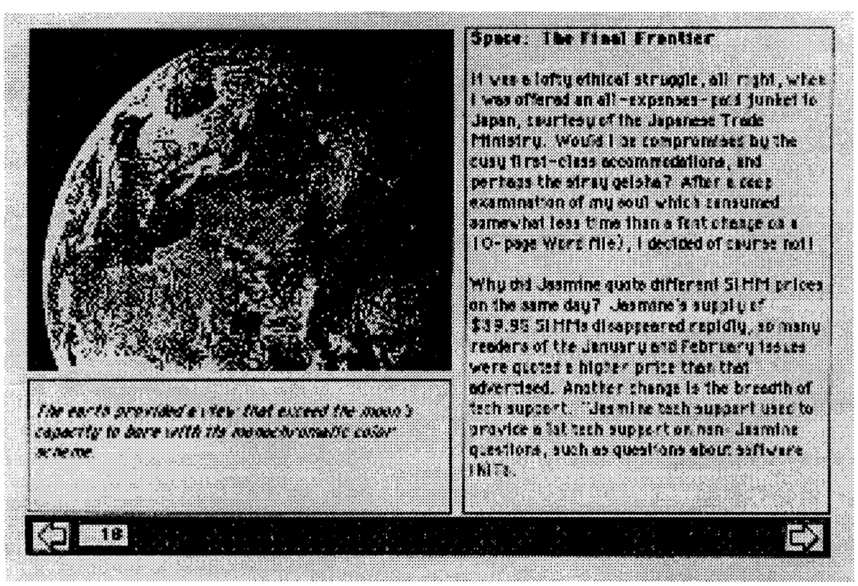
Applying MULTIDIMENSIONAL SCALING to these data provides a way of reducing the data about 12 factors.

16

Screen 16 (Ranking: 18)



Screen 17 (Ranking: 16)



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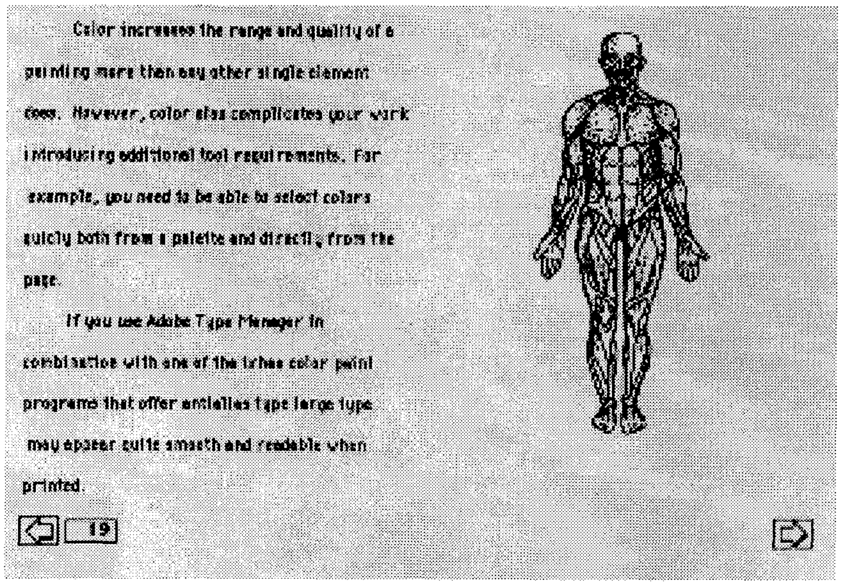

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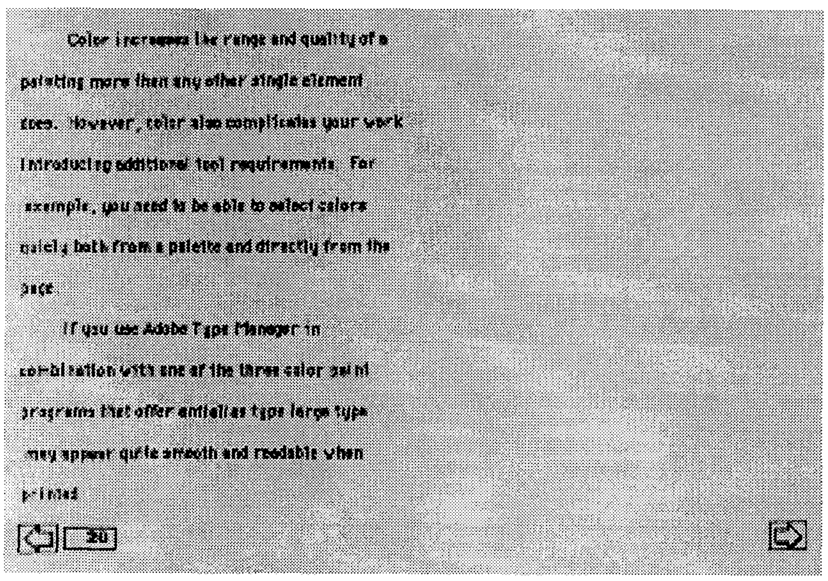


Screen 20 (Ranking: 17)

Appendix C: BISC Questionnaire

NAME:

The purpose of this questionnaire is to gather information on the current state of operations at each BISC for potential use in a thesis study at the USAF Institute of Technology. Please answer the questions as fully as your knowledge and time permits. Your assistance in completing this questionnaire is appreciated.

(Please note: in the original questionnaire, space was left below each question for respondents' answers).

PERSONAL EXPERIENCE/QUALIFICATIONS

1. Civilian Qualifications.

(Please give information on type of qualification; e.g. degree, TAFE certificate, grad dip; institution at which gained; types of subjects [no need to list them all] and whether the qualification had a technical or management slant towards IS).

2. Civilian Experience.

(Please give details of any civilian experience in IS before joining the RAAF or any part-time work currently being performed).

3. RAAF Qualifications.

(Include any ADFA courses and short courses conducted by RAAF e.g. CAMM Managers Course).

4. RAAF Experience. Have you been posted to IS positions previously? Please describe.

5. Do you have a computer at home? Please describe it.

DESCRIPTION OF CURRENT POSITION

6. Established Rank and Category of Position.

(Please attach a copy of your CE diagram and Duty Statements (if held).

7. Essential Qualifications/Experience Annotated against Position.
8. Your Category and Rank.

9. Length of Time in Current Position.
10. Do you have a computer on your desk? Please describe.

PERSONNEL AND TRAINING ISSUES

Experience Levels

11. Please describe the experience level of CISCONs in your BISC.
12. What backgrounds do they have (e.g. COMMSOP or EDPOP).

Training

13. What training courses have your subordinates completed? (e.g. Conversion courses, CISCON advanced courses).
14. What is the confidence level of your subordinates in their own abilities to do the BISC tasks?
15. Can you identify any gaps in training for CISCONs?
16. Please provide details of the progress of training in Office Automation software on your base.

Manning

17. Has CE been transferred from other areas of the base to your BISC in accordance with OPS 8-31?
18. At what level are you currently manned?
19. Please provide details of some of the tasks (most important ones) that your manning does not permit.
20. Please detail what effect RABS has had (if any) on your manning situation.
21. Please make other general comments on training/personnel issues at your BISC.

SYSTEMS SUPPORTED BY YOUR BISC

22. Please describe the different systems supported by your BISC. Include a brief description of hardware types, operating system, software packages available on the system, performance track record. A table has been provided at Annex A (not reproduced for the purposes of this thesis) for your convenience. This table is based on that provided by FLTLT M. Hewson, BISO AMB, in his paper "RAAF Amberley BISC Implementation Plan".

23. A representative from DCIS visited all bases during 1992 to identify IS "hurt" areas. A number of recommendations were made to DCIS about providing additional IS support. As far as you are aware, did this support materialise?

PROJECTS & OTHER INITIATIVES

24. Please provide short details of the status of certain projects on your base. These include SDSS, RODNET, RAAFACE, withdrawal of RSWAPS, among others.

OPINIONS

This section is entirely voluntary; however I am keen to learn your opinions on various "knotty" issues. These opinions will be kept entirely confidential and will go no further than me, but may form the basis for general theories and opinions in my thesis work.

25. What category of RAAF Officers is most suited to BISO type jobs? (Feel free to mention more than one category).

26. What category of officer, qualifications and experience do you think are required for **your** BISO position?

27. Do you believe the RAAF needs a specialist IS category?

28. Does the training that you have help in your current position?

29. Do you think RAAF training is adequate to prepare you for the rigours of BISO life?

30. How can the training be improved?

31. What is your opinion on the amalgamation of the EDPOPs and COMMSOPs? Please make any comments you like on issues such as training, success of the amalgamation, experience levels etc.

32. What level of support are you receiving from DCIS? Please detail areas of improvement.

33. What level of support are you receiving from your Command ISA? Please details things like satisfaction of ISSORs, information flow, etc.

34. What level of support are you receiving from your Base Commanders?

35. What is your opinion on the placement of the BISC on your base (in terms of command chain and who you are responsible to).

GENERAL

36. Please make any general comments.

ATTACHMENTS

As requested in question 6, please attach a copy of your CE diagram which shows the placement of your BISC within the organisation on your base. In addition, if a duty statement exists for your BISO position, please provide a copy.

ACKNOWLEDGMENTS

Thank you for your assistance in completing this questionnaire. The information gathered from it may be used as data in a research thesis to be done at USAFIT. All responses will be treated with the strictest confidentiality. If you have any questions or more information you would like to impart, please don't hesitate to contact me. Thank you to FLTLT Hewson from BISC AMB for allowing me to use the format of his tables from his BISC Implementation Plan.

Appendix D: Complete Responses to Relevant Questions (Raw Data)

Question 11. Please describe the experience level of CISCONs in your BISC.
Responses:

1. 1 x FSGT doing Bachelor's Degree DFASS very experienced
   1 x CPL doing Assoc Dip DFASS experienced
   1 x LAC/W experienced DRS only
2. Amalgamation of Question 11 and 12.
   Have 13 staff so it will be brief!
   SNCO FSGT Ex COMMSOP 21 years RAAF experience, no formal IS training
   SNCO SGT Ex EDPOP 13 years RAAF, no formal IS training
   SNCO SGT Ex COMMSOP 13 years RAAF, no formal IS training
   NCO CPL Ex EDPOP 10 years, no formal IS training
   NCO CPL Ex COMMSOP 9 year, nearly finished Ass Dip IS
   LAC Ex COMMSOP 4 years, nearly finished Ass Dip IS
   LACW Ex COMMSOP 2.5 years, first year Ass Dip IS
   LAC Ex EDPOP 4 years, first year Business Studies degree (major in Computing)
   LAC Ex COMMSOP x 2, 4 and 6 years, no formal training
   LAC Ex EDPOP x 3, 4,5,4 years, no formal training
3. Varied experience mainly due to personal dealings with PCs. Not all CISCON members have PCs at home and have only recently been provided adequate availability to PCs at work. Training for software packages has begun and more courses are planned for year ahead. In the areas of traditional jobs such as EDP and Communications, members are obviously competent in one and rapidly gaining experience in the other through the use of rotating shifts.
4. Three CISCONs (formerly EDPOPs) are all fully conversant with EDP duties. Two have been trained in the Microsoft Office Automation Software and two also in OS/2 (DEFMIS). Valuable experience is gained through Help Desk functions and information and guidance from a SGT CETECH employed within the section.
5. Extensive experience on mainframe RAAF systems in the CPL and SGT with very little experience on PCs and networks. One LAC has done an OS/2 training course and has a fair personal knowledge of PCs.
6. SGT ex EDPOP no IS qualifications
   CPLs - limited PC skills, OJT
   LAC/W - as for CPL
7. NIL experience in IS. Personnel are EDPOPs who are data processors. Could not load Windows until shown by BISO. Lack of IS expertise in BISC is our greatest problem.
8. SNCOIC 10 years EDP, 5 years RSWAPS, 5 years PC (concurrently)
   CPL 7 years EDP, 1 year RSWAPS (concurrently)
   LACW 4 years EDP
   LACW 3 years EDP, 2 years RSWAPS, 1 year PC (concurrently)
   LACW 3 months - CISCON (COMMSOP from Comcen)

Question 11 (continued)

9. One CISCON has CNE qualifications. He is very helpful with technical issues. Others only have a basic computer understanding.
10. No CISCON who has been employed in the BISC since its introduction in Aug 93 has had any previous experience in using either PCs or RSWAPS.
11. Very limited. Most experience has been OJT with my FSGT and 2 CPLs undertaking TAFE courses part time. One has a PC at home and is definitely a "hacker". He was the most IS literate of my staff.
12. They are all competent in their parent trades ie. EDPOP or COMMSOP. They are continually on a switch roster and are almost completely cross-trained. We run as a BISC only, not a Commcen and BISC.

Question 12. What backgrounds do they have (e.g. COMMSOP or EDPOP)
Responses (tabulated for ease of reference):

All former EDPOPs: 4 BISCs
All former COMMSOPs: 0
Mixture of EDPOPs and COMMSOPs only: 7
Mixture of EDPOPs, COMMSOPs and others (CETECHs, other musterings): 1

Question 13. What training courses have your subordinates completed? (e.g. Conversions courses, CISCON advanced courses)
Responses (summarised):

As of April 1994, all personnel working in all BISCs had completed the CISCON conversion course, except for two personnel who were unable to complete the course due to medical reasons. This course was intended to train EDPOPs in the basics of Communications, and COMMSOPs in the basics of EDP.

In addition, some personnel had done additional courses, mainly through the initiative of the BISO in finding available training funds and suitable courses in the local area. These courses included:

Office Automation Applications
DOS
Windows
Windows For Workgroups
Corporate Software Training
LAN Awareness course
Software Evaluation
OS/2
Access software package
Introduction to UNIX
UNIX Administration
Introduction to computing
Maintaining and Supporting Hardware

The RAAF-conducted courses that had been completed, in addition to the CISCON conversion course, included RSWAPS System Manager course, the Advanced

EDP course and the DEFMIS course (the computerised pay system). No personnel had completed the CISCON advanced course.

Question 14. What is the confidence level of your subordinates in their own abilities to do the BISC tasks?

Responses:

1. Except for FSGT and CPL, very low. The BISC task is moving away from DRS data entry as CAMM2 replaces CAMM, SDSS replaces DSRMS and AFFERM replaces AFMAN) to system administration of RSWAPS systems and NOVELL networks, Workgroups, and peer-to-peer LANs and PCs. They have had no training.
2. Varies between high and non-existent between personnel. The members that have had training/education/prior experience are reasonably confident. Those who are new to the job have very little or no confidence and require constant supervision.
3. Once again, confidence is varied however as they deal with these tasks more frequently their confidence is growing.
4. On training aspects of software and minor Help Desk functions - good. Configuration and Hardware - little confidence.
5. Confidence is growing as the hands-on learning curve increases. No courses are available as yet.
6. Very confident
7. For EDP tasks - good. For other IS tasks - low.
8. SNCO - high EDP/high BISC
CPL - high/lower
LACW x 2 - high/lower
LACW - medium/lower
9. SGT/LAC very confident. CPL needs some direction but performs tasks adequately.
10. The confidence level is minimal at best. However, as the CISCONs gain experience their confidence and competence is improving albeit slowly.
11. Very low - all feel they need at least <u>some</u> training in order to understand the tasks required of them.
12. Very low, however most are taking notes and assisting with basic tasks ie. disk copies, software and hardware registration.

Question 15. Can you identify any gaps in training for CISCONs?

Responses:

1. Basic CISCON training (and catch-up for CISCONs in the field currently) needs to cover:

DOS	Windows for Workgroups
Windows	NOVELL (to CNA level)
OS/2	UNIX
Data communications basics	PC and peripherals basic hardware

Very soon all CISCONs will be working in this area and yet no training is offered. I have attempted to train my staff using SCPE but shift work, other BISC loads and lack of funds has meant only a piecemeal approach.

2. Yes! Training in most aspects of IS is required from PC hardware fundamentals, DOS, OS/2, Novell, UNIX to applications e.g. Word, Powerpoint, Excel, Access, PCTools, Norton Utilities, Database Management, minor maintenance, cabling standards.
3. In a new environment such as this, it is inevitable for gaps in training to occur, however as they are being realised we are moving to correct these deficiencies accordingly. My belief is that CISCONs need to be trained in LANs and PC hardware. LANs because of the increasing use on bases with RAAFACE, RODNET and PC hardware because at present we need to bring in techs to install LAN cards etc.
4. Technical support skills, computer configuration skills
5. Currently, CISCONs do not exist - there are only COMMSOPs and EDPOPs by a different name. When the first people come out of CISCON training, this may change.
6. IS training, basic computing, anything to allow CISCONs to carry out their tasks such as Help Desk, Basic computer fault finding, Basic database design.
7. No formal and only "as available" OJT for ex EDP CISCONs in most aspects of IT management. CISCONs have not been trained for BISC role and will not develop expertise for some time. All ex EDPOPs are capable for EDP functions.
8. PC use.
9. There is currently no formal CISCON training in the use and maintenance of PCs and PC peripherals, although I believe that training in these areas will be provided for new CISCONs at RSCST Wagga. This training should be extended to include current CISCONs.
10. To date, my CISCONs have had <u>no</u> IS training - major gap. With the $s freeing up as the FY ends, am hopeful I can get some training going.
11. Most definitely - until real training commences (RAAF). We do not have the numbers to release staff for civilian courses.

Question 17. Has CE been transferred from other areas of the base to your BISC in accordance with OPS 8-31?

Responses:

1. No! But I'm working on it. Refer to the BISC Implementation Plan (BIP) which you have seen. The BIP relies on transfer of 4 TELSFLT (2 Commcen and 2 GTEMS) staff into the BISC and 12 personnel to be gained from units IAW OPERATIONS 8-31. Both are going to be tough to achieve. However, if this CE does not work then the BISC will be overrun. As mentioned, IT is arriving at a great rate of knots - the expected pace before EOY include: CAMM2, SDSS, AFFERM, RODNET, RAAFACE, lots of ISSORs, replacements, including several CSP complete LANs.

2. Almost. Nearly finished negotiation. Have had 8 ex-COMMSOPs transferred to BISC.
3. No, areas that run IS have their own managers. I liaise with them when I need information and vice versa.
4. No CE transferred, however I SGT CETECH provided from within TELSFLT and 1 LAC CETECH "borrowed" for 6 months.
5. No
6. No. We were waiting to have the CE transferred under RABS.
7. We were told that should personnel be transferred under RABS we could then lose these personnel to a base with greater needs - so we are operating with 7 personnel.
8. No. Under the RABS submission, our base identified the Stock Control Officer as an offset for the BISO (which doesn't exist here, but not yet approved/endorsed by AHQ). CETECH manning has also been identified, and offsets provided, but acceptance by RABS is as yet unknown.
9. No.
10. No.
11. No.
12. Not yet. We have an ETR being progressed for a CPL CETECH. We also have an ETR pending for a CPL CISCON as a Systems Administrator.

Question 18. At what level are you currently manned?
Responses:
1. Fully according to former EDP CE. The BIP tells the remaining story!
2. 13 CE (if RABS allows it) and 1 on attachment from other unit. This leaves me 5 short of my ETR. Note: current CE is still 6 - BISO + 5.
3. up to CE with 2 extra awaiting remuster.
4. BISC is manned with the 3 EDPOPs and 2 CETECHs (CE reflects 3 CISCONs).
5. To CE, 1 x SGT, 1 x CPL, 2 x LAC (all CISCONs), 2 x LAC, 1 x LAC CETECH from Radio Workshops.
6. 1 SGT, 2 CPLs, 4 LACs, 1 additional LAC is employed in the Commcen
7. 1 FLTLT, 1 SNCO, 2 CPLs (though one is on Maternity leave), 3 LACs, have borrowed unofficially 2 CISCONs and 1 CETECH.
8. 5 x CISCON (implemented in anticipation of RABS)
   1 x SGT CETECH } CETECHS tend to undertake most of the IT BISC
   1 x CPL CETECH } activities, although CISCONs are regularly encouraged
   1 x LAC CETECH } to participate
9. FLTLT, SGT, CPL, AC
10. 1 x SGT CISCON, 2 x LAC/LACW CISCON. The manning for the BISC has been drawn from within the Flight.
11. Even CE/Strength.
12. 2 x SGT CISCON
    2 x CPL CISCON
    2 x LAC CISCON

1 x supernumerary officer

Question 19. Please provide details of some of the tasks (most important ones) that your manning does not permit.

Responses:

The following list summarises the tasks that each BISC currently cannot perform. Where more than one BISC mentioned the task, a number in parentheses appears after the list entry, indicating the number of BISCs who have stated they cannot perform this task.

RODNET management
Connecting LANs (for RODNET connection)
System Administration roles across nearly all the systems (2)
Consolidating unit IT use - improvements to infrastructures
Systems Analysis of current systems - database and spreadsheet development (2)
Software audits/unit visits (checking backup routines for instance) (2)
Preventive maintenance of hardware (3)
Timely response to problem resolution (2)
Database configuration
Contingency planning (3)
Strategic planning (4)
Application configuration
Security procedure writing and overseeing (3)
Timely response to customer enquiries (2)
Accreditation and Evaluation
Help Desk management (2)
Immediate action to fault reports
Network planning
Monitoring workload and practices
Constant monitoring for illegal software and virus detection
Classification checking of documents held on hard disk
Adequate end-user training
More involvement of CISCONs in IT aspects
More consultation and assistance with customers identifying IT needs
Full asset register
Optimising the setup/performance of systems
Development of SOPs
Managing Telephones and Landlines
Maintaining current versions of software on distributed stand-alone PCs
Regular hardware audits

Question 21. Please make any other general comments on training/personnel issues at your BISC?

Responses:

1. Covered fairly much as above and particularly in the BIP (BISC Implementation Plan). I wish there was money for seminars ie. "demystifying LANs" etc.

Question 21 (continued)

2. Without an organised and structured training program that is implemented RAAF-wide for CISCONs, BISOs are going to have to try and train their staff using SCPE funds as best they can. This will result in a haphazard, inconsistent training regime for CISCONs that will not best serve the RAAF's interests and further compound the poor morale that exists in the rank and file at present.
3. BISO, though well-versed in communications and IS, has no tertiary background. The technical knowledge via the CETECHs helps to cover this deficiency. In addition the Base has seen fit to have the SGT CETECH CNE trained which is and has already proved a bonus. As stated previously, CISCONs should received some form of intermediate technical training.
4. Unlike other bases, we do not need 18 -24 personnel. We can provide an excellent service to our customers (the rest of the base) with 10 - 11 personnel. However, these personnel MUST be trained in IS and able to carry out their duties. For the first year, the BISO was (aside from my normal duties), the Help Desk, the technical expert, installed hardware and software, trained users. This was due to no IS knowledge in the BISC.
5. Integration between CISCONs and CETECHs has not occurred. Although SNCOIC (SGT) believes he has a high confidence level in his ability to undertake BISC/IT functions, I do not agree with his assessment. CISCONs do not yet have the experience to fulfill most of the more technical aspects of BISC operation. It will take a long time before CISCONs can fully run a fully-fledged BISC, unless significant training effort is expended.
6. BISC personnel have had some Office Automation training. Most experience is gained through OJT.
7. The troops are hesitant when advised of their rotation into IS support - purely because of lack of training. Once they realise that I don't expect "instant gurus", they are at least willing to give the job a shot. I am pleased with the progress to date.

Question 31. What is your opinion of the amalgamation of the EDPOPs and the COMMSOPs? Please make any comments you like on issues such as training, success of the amalgamation, experience levels, etc.

Responses:

1. The amalgamation should work well, obviously IT and communications work hand in hand. The bearer and the equipment are more and more integrated. The ex COMMSOPs coming into the BISC are proving no problem so long as they are keen to learn (which is no different from any other change in the work place). The ex EDPOPs need training to cope with their new role and are thus in the same boat. So the amalgamation should prove no problem - the training commitment however is an ongoing challenge.

2. The experience level is zero at present. Luck has been on our side, in that there are some staff who had a prior interest and non-RAAF training; but this is strictly LUCK.

Question 31 (continued)

CISCONs are keen to get into their new roles; there is no training and without it they are close to useless - I have to constantly monitor and supervise. The amalgamation has been successful though - I think it was a good decision.

3. I believe that this is a step in the right direction and can see the Communications areas and BISC becoming increasingly to be seen as a single entity.
4. Obviously, experience levels are presently low. This section (Comcen) recently lost two experienced CISCONs (COMMSOPs) to be replaced with 2 inexperienced CISCONs (EDPOPs). With manning cut to the bone, signs of hurt and stress were evident at this time. Nevertheless, time will tell. Additionally, because the EDP functions still exist in the BISC and manning is so short as to negate cross-training, I'm currently unable to employ ex-COMMSOPs in the BISC.
5. True cross-training was not done, it was only token, despite this, if CISCONs are posted between streams they can be cross-trained on the job. Also, within the BISC, the CISCONs have only EDPOP experience but are now expected to know all about PCs.
6. Excellent concept. Training has been addressed on all primary tasks except IS ie. the new part of the BISC.
7. At our base, the amalgamation has been smooth. Cross training has been successful across the ranks.
8. A lot of resistance from SNCO level (or so it appears). Our two FSGTs are very supportive, but I don't believe that this is the norm. I think given time and (and the discharge of certain dinosaurs), things will iron out.
9. Great. However, I get the impression that there are too many old dogs that either can't or won't learn new skills.

Question 36. Please make any general comments.
Responses:

1. In order for the BISCs to be able to function we must have more than "support in spirit" from areas such as AHQ and DCIS. We must have manning and training.
2. It is early days yet and the experience in this BISC is growing at a steady pace hampered only by the introduction of new equipment (this is not a bad thing). When the current replacement program is complete and the OA training arranged by this section ended or taken over by Base Training, the BISC will be able to concentrate on the day-to-day running of the BISC proper.
3. The job has a lot of potential, but is extremely frustrating because of:
   (1) lack of $
   (2) lack of resources
   (3) lack of training

4. (1) Problems abound through lack of manpower and training.
   (2) Too many reviews and audits required by DCIS and ISAs (we realise there is a need). **END OF DATA**

END OF DATA

<u>Appendix E: Syllabus Objectives of the BISC PC OPS course</u>

PC HARDWARE

1. Describe the basic functions of a personal computer.
2. Describe the main components of a personal computer, including:
   (1) CPU
   (2) Input and Output devices
   (3) Memory Devices.
3. Describe the function of the components listed above.
4. Explain to block diagram level the relationship between the components listed above.
5. Explain the operation and connection of the components listed above.

PC INSTALLATION

Electrical Safety

1. Describe the symptoms of electrical shock.
2. Describe the procedures to be followed when a fellow worker is electrocuted.
3. Identify the areas in a personal computer which may cause electrical shock.
4. Describe the damage that may occur to computer components due to inappropriate electrostatic avoidance procedures.
5. Describe the RAAF approved work practices which minimise the chance of:
   (1) Electrical shock, and
   (2) Electrostatic damage to equipment.

Personal Computer (PC) Installation

1. Describe the procedures to be followed when packing and unpacking PCs and peripherals.
2. Describe the procedures used to assemble and install a PC.
3. Assemble and install a stand alone PC.
4. Describe procedures used to test the installation of a stand alone PC, including those for:
   (1) boot up and shut down, and
   (2) check system settings.

5. Test the installation of a stand alone PC using procedures described above.
6. Describe the physical connection of a PC to a computer network.
7. Describe the methods used to test the physical connection of a PC to a computer network.
8. Test the installation of a PC to a computer network.

Peripheral Connection

1. Describe common PC peripheral devices used in RAAF workplaces, including:
   (1) Printers,
   (2) Modems,
   (3) Image projection devices,
   (4) CD ROMs, and
   (5) Scanners.
2. Explain the principles behind the connection of peripheral devices to a PC.
3. Identify the connection ports which are seen on a typical PC.
4. Distinguish between the connection ports seen on a typical PC on functional and appearance grounds.
5. Connect common peripherals using manufacturer's manuals, installing appropriate cards where required including:
   (1) printers, and
   (2) CD ROMs.
6. Describe the methods used to test the connection of peripherals.
7. Test for the correct installation of the peripheral devices described above.

System Upgrades

1. Describe the range of possible system upgrades available for a PC.
2. Describe the possible methods of upgrading Pcs using the following:
   (1) Sound cards and speakers,
   (2) Video cards,
   (3) RAM upgrades, and
   (4) Data storage devices.

PC OPERATING SYSTEMS

Function of the Operating System

1. Explain the function of a computer operating system.
2. Explain the interface between operating systems and applications (including protocols).

Common Operating Systems

1. Describe common operating systems used by the RAAF, including:
   (1) UNIX

(2) DOS/WINDOWS
(3) MINEX, and
(4) OS/2.

Using Microsoft Disk Operating System (MS-DOS)

1. Describe the effect of common MS-DOS commands.
2. Apply common MS-DOS commands.
3. Describe MS-DOS utilities.
4. Use MS-DOS utilities.
5. Determine the system configuration and memory allocations for a PC.
6. Describe the functions of the AUTOEXEC.BAT and CONFIG.SYS files in a PC.
7. Describe utility programs available in Windows.
8. Use these Windows utilities.
9. Describe the function of WIN.INI and SYS.INI files.

PC SOFTWARE INSTALLATION

Software Standards

1. Explain the need for the standardisation of software packages used by the RAAF.
2. Describe the dangers of using unauthorised software on RAAF computer systems.
3. Locate the Defence Instructions governing software use in the RAAF.
4. Interpret the Defence Instructions governing software use in the RAAF.
5. Describe the software packages used by the RAAF as standards in the following situations:
   (1) Operating environment,
   (2) Word processing,
   (3) Spreadsheet,
   (4) Presentation graphics,
   (5) CAD/CAM, and
   (6) EMAIL/Scheduling.

Installing Software

1. Determine procedures for installing RAAF standard software packages onto a PC by using manufacturer's manuals.
2. Install four RAAF standard packages onto a PC to the software manufacturer's specification.
3. Test for correct installation of standard software by reference to manufacturer's manuals.

Virus Protection

1. Explain the behaviour and consequences of computer virus infection of personal computers and networks.
2. Describe the use of anti-virus software.
3. Describe the RAAF standard anti-virus software.
4. Use RAAF standard virus detection and elimination software.

Data Backup and Recovery

1. Describe the necessity for data backup and recovery procedures in PCs and PC networks.
2. Describe the criteria used to select data to be backed up.
3. Describe backup procedures.
4. Describe procedures used to evaluate recovered data for errors.
5. Select and backup data.
6. Recover data which has been backed up.
7. Evaluate recovered data for errors.

OPTIMISING SYSTEM RESOURCES

Optimising System Resources

1. Describe the requirement to optimise system hardware and software.
2. Use manufacturer's manuals to physically adjust hardware to optimise performance.
3. Alter operating system parameters to optimise system performance.
4. Use manuals to configure RAAF standard software packages to optimise performance, including:
   - (1) Word processing,
   - (2) Spreadsheet,
   - (3) Database, and
   - (4) Windows.
5. Alter the AUTOEXEC.BAT, CONFIG.SYS, WIN.INI and SYS.INI files to optimise the configuration of a PC.

PC NETWORKS

Data Communications

1. Describe the role of a computer network.
2. Describe the features which distinguish between the common types of computer networks.
3. Describe the importance of the following in setting up and operating computer networks:

(1) Circuit and packet switching,
(2) Channel type,
(3) Channel capacity,
(4) Bandwidth,
(5) Data compression, and
(6) Multiplexing.

4. Describe the protocols used for networking computers.
5. Describe RAAF standard PC networking software packages.

Electronic Mail (EMAIL)

1. Define EMAIL.
2. Describe the role of EMAIL within the RAAF.

Network Connections

1. Describe the installation of network hardware and software into a PC.
2. Install network hardware into a PC.
3. Install network software into a PC.
4. Install a PC into a computer network.
5. Describe the role of network tuning.

Modem Communication

1. Explain how modems are used to communicate between PCs.
2. Describe the protocols used for PC communications by modem.
3. List the characteristics of a provided modem by reference to manufacturer's manuals.
4. Describe the procedures used to install a modem to a PC by reference to manufacturer's manuals.
5. Install a modem to a PC to manufacturer's specifications.
6. Describe the methods used to test the operation of an installed modem.
7. Test the operation of an installed modem.
8. Describe the security implications of using modems.
9. Operate a PC and modem to access:
   (1) a Bulletin Board Service, and
   (2) a remote PC and modem.
10. Upload and download files to and from:
    (1) a Bulletin Board Service, and
    (2) a remote PC and modem.

TROUBLESHOOTING HARDWARE AND SOFTWARE

Identifying Symptoms

1. Identify unusual PC system behaviour.
2. Evaluate unusual system behaviour to determine if it represents a fault.

3. Describe common faults occurring in PCs.
4. Describe the exact nature of a fault.

Fault Diagnosis

1. Describe the range of diagnostics and utilities available to diagnose common faults.
2. Select an appropriate diagnostic or utility for a fault.
3. Diagnose at least the following PC faults using appropriate diagnostic programs or utilities:
   (1) cabling combinations,
   (2) card settings,
   (3) DIP switch faults,
   (4) jumper errors,
   (5) connector integrity faults, and
   (6) memory conflicts.

Fault Rectification

1. Determine the options available to rectify the above faults.
2. Apply these options in order of predicted effectiveness to rectify faults.

BISC PROCEDURES

BISC Roles

1. Describe the role of BISC personnel in the management of PCs and PC networks on a base.

Customer Requirements Analysis

1. Describe the procedures used by RAAF elements to acquire computer resources.
2. Assess the suitability of workplace sites for IS asset placement.
3. Interview customers to determine their perceived IS requirements.
4. Analyse customer requirements and workplace suitability to determine options available to satisfy a customer's actual needs.

IS Asset Registration

1. Explain the need for IS Asset Registration within RAAF workplaces.
2. Identify Defence Instructions which relate to holding of information systems assets.
3. Interpret Defence Instructions which relate to RAAF IS asset registers.

Using an IS Asset Register

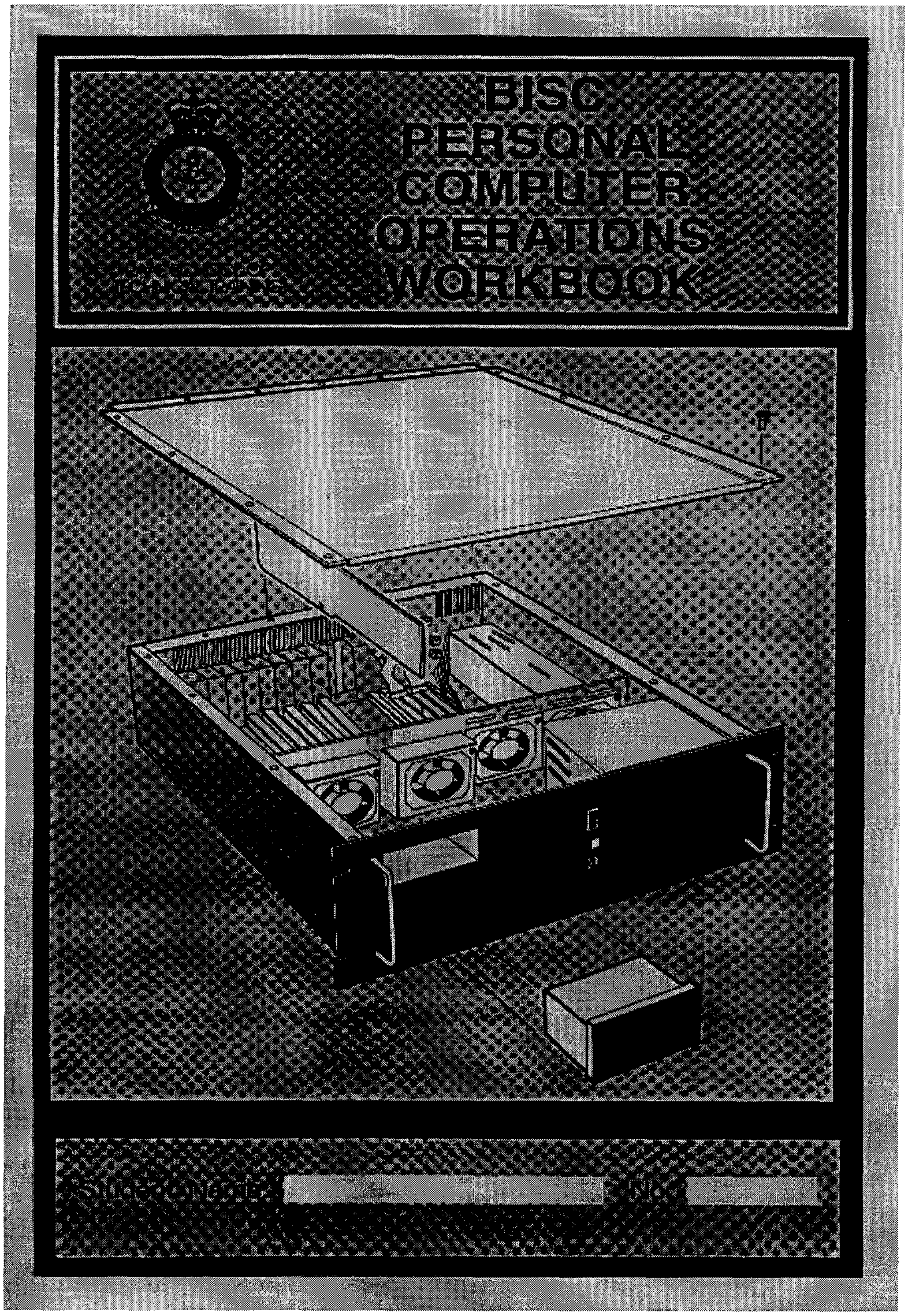
1. Describe IS asset register procedures used at RAAF installations.

2. Describe the principles of input and extraction of information to and from an IS asset register.
3. Input and retrieve information to and from an IS asset register.
4. Describe IS asset audit procedures used at RAAF installations.
5. Describe the action taken when unauthorised hardware and software configurations are detected during a RAAF IS asset audit.
6. Inspect RAAF installations to confirm that hardware and software configurations are in accordance with the local asset register.

Help Desk Skills

1. Explain the role of the BISC help desk.
2. Describe the use of checklists in recording help desk information correctly.
3. Describe electronic fault logging applications used in the RAAF.
4. Use electronic fault logging applications.
5. Explain how a telephone conversation may be used to extract and record information relating to a customer's perceived needs.
6. Explain how to best communicate with customers in a face-to-face situation, extracting and recording information dealing with their perceived needs.
7. Perform face-to-face and telephone interviews with customers to:
   (1) dispense advice on BISC matters, and
   (2) extract and record information relating to customer requirements.

Appendix F: Sample Chapter from PC OPS Manual



Chapter 2

Personal Computer Hardware

Overview

A Computer is a mechanical or electronic device that can receive a set of instructions or a program, and then carry out this program by performing calculations on numerical data or by organising other forms of information.

The modern world of high technology could not have come about except for the development of the computer. Different types and sizes of computers find uses throughout society in the storage and handling of data, from secret governmental files to banking transactions to private household accounts. Computers have opened up a new era in manufacturing through the techniques of automation, and they have enhanced modern communication systems. They are essential tools in almost every field of research and applied technology, from constructing models of the universe to producing tomorrow's weather reports. There is not one day in our lives when computers do not exert some influence.

WELL THIS HAS SURE TURNED OUT TO BE A MICKEY MOUSE SYSTEM

In this topic we will discuss Hardware, the basic building blocks to the personal computer (PC).

Objectives

PC Hardware

- Describe the basic functions of a personal computer.
- Describe the main components of a personal computer, including:

  (1) CPU
  (2) Input and Output devices
  (3) Memory Devices

- Describe the function of the components listed above.
- Explain to block diagram level the relationship between the components listed above.
- Describe common input/output devices.
- Draw the block diagram of a personal computer.
- Explain the role of personal computer components in carrying out common computing practices.

History

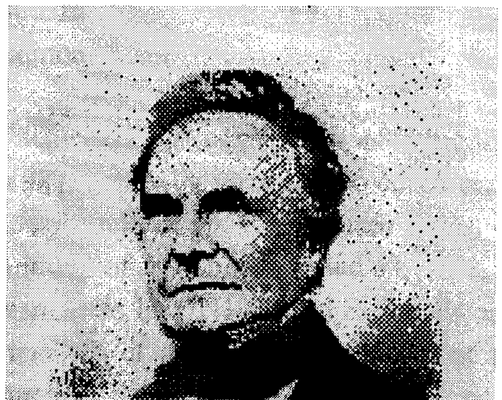
The first adding machine, a precursor of the digital computer, was devised in 1642 by the French philosopher Blaise Pascal. This device employed a series of ten-toothed wheels, each tooth representing a digit from 0 to 9. The wheels were connected so that numbers could be added to each other by advancing the wheels by a correct number of teeth. In the 1670s the German philosopher and mathematician Gottfried Wilhelm von Leibniz improved on this machine by devising one that could also multiply.

The French inventor Joseph Marie Jacquard (1752-1834), in designing an automatic loom, used thin perforated wooden boards to control the weaving of complicated designs. During the 1880s the American statistician Herman Hollerith (1860-1929) conceived the idea of using perforated cards, similar to Jacquard's boards, for processing data.

Employing a system that passed punched cards over electrical contacts, he was able to compile statistical information for the 1890 U.S. census.

The Analytical Engine

Also in the 19th century, the British mathematician and inventor Charles Babbage worked out the principles of the modern digital computer. He conceived a number of machines, such as the Difference Engine, that were designed to handle complicated mathematical problems. Many historians consider Babbage and his associate, the British mathematician Augusta Ada Byron, the daughter of the English poet Lord Byron, the true inventors of the modern digital computer. The technology of their time was not capable of translating their sound concepts into practice; but one of their inventions, the Analytical Engine, had many features of a modern computer. It had an input stream in the form of a deck of punched cards, a "store" for saving data, a "mill" for arithmetic operations, and a printer that made a permanent record.



• Charles Babbage

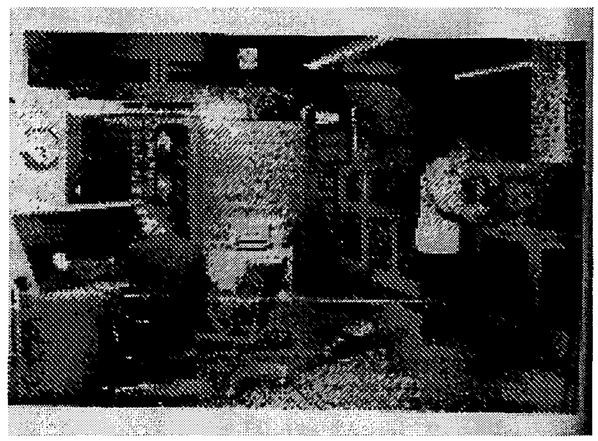
Early Computers

Analog computers began to be built at the start of the 20th century. Early models calculated by means of rotating shafts and gears. Numerical approximations of equations too difficult to solve in any other way were evaluated with such machines. During both world wars, mechanical and, later, electrical analog computing systems were used as torpedo course predictors in submarines and as bombsight controllers in aircraft. Another system was designed to predict spring floods in the Mississippi River Basin.

In the 1940s, Howard Aiken (1900-73), a Harvard University mathematician, created what is usually considered the first digital computer. This machine was constructed from mechanical adding machine parts. The instruction sequence to be used to solve a problem was fed into the machine on a roll of punched paper tape, rather than being stored in the computer. In 1945, however, a computer with program storage was built, based on the concepts of the Hungarian-American mathematician John von Neumann. The instructions were stored within a so-called memory, freeing the computer from the speed limitations of the paper tape reader during execution and permitting problems to be solved without rewiring the computer.

Electronic Computers

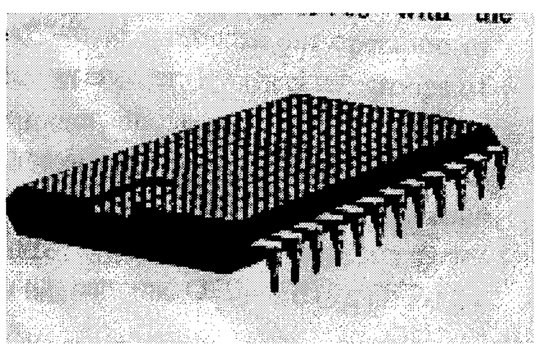
The rapidly advancing field of electronics led to construction of the first all-electronic computer in 1946 at the University of Pennsylvania by the American engineer John Presper Eckert, Jr. (1919- ?) and the American physicist John William Mauchly (1907-80). (Another American physicist, John Vincent Atanasoff, later successfully claimed that certain basic techniques he had developed were used in this computer). Called ENIAC, for Electronic Numerical Integrator And Computer, the device contained 18,000 vacuum tubes and had a speed of several hundred multiplications per minute. Its program was wired into the processor and had to be manually altered.



The use of the transistor in computers in the late 1950s marked the advent of smaller, faster, and more versatile logical elements than were possible with vacuum-tube machines. Because transistors use much less power and have a much longer life, this development alone was responsible for the improved machines called second-generation computers. Components became smaller and the system became much less expensive to build.

Integrated Circuits

Late in the 1960s the integrated circuit, or IC, was introduced, making it possible for many transistors to be fabricated on one silicon substrate, with inter-connecting wires plated in place. The IC resulted in a further reduction in price, size, and failure rate. The microprocessor became a reality in the mid-1970s with the introduction of the large scale integrated (LSI) circuit and, later, the very large scale integrated (VLSI) circuit, with many thousands of interconnected transistors etched into a single silicon substrate.



To return, then, to the "switch-checking" capabilities of a modern computer: computers in the 1970s generally were able to check eight switches at a time. That is, they could check eight binary digits, or bits of data, at every cycle. A group of eight bits is called a byte, each byte containing 256 possible patterns of ONs and OFFs (or l's and 0's). Each pattern is the equivalent of an instruction, a part of an instruction, or a particular type of

datum such as a number or a character or a graphics symbol. The pattern 11010010, for example, might be binary data--in this case, the decimal number 210 or it might tell the computer to compare data stored in its switches to data stored in a certain memory-chip location.

The development of processors that can handle 16, 32, and 64 bits of data at a time has increased the speed of computers. The complete collection of recognisable patterns--the total list of operations--of which a computer is capable is called its instruction set. Both factors--number of bits at a time, and size of instruction sets-- continue to increase with the ongoing development of modern digital computers.

Types of Computers

Two main types of computers are in use today: analog and digital, although the term computer is often used to mean only the digital type. Analog computers perform calculations on continuous signals, e.g. a speedometer converts the continuous rotary motion of the driveshaft into a numerical value. Digital computers in comparison solve problems by performing sums and by dealing with each number digit by digit.

Installations that contain elements of both digital and analog computers are called hybrid computers. They are usually used for problems in which large numbers of complex equations, known as time integrals, are to be computed. Data in analog form can also be fed into a digital computer by means of an analog-to-digital converter, and the same is true of the reverse situation.

Analog Computers

The analog computer is an electronic or hydraulic device that is designed to handle input in terms of, for example, voltage levels or hydraulic pressures, rather than numerical data. The simplest analog calculating device is the slide rule, which employs lengths of specially calibrated scales to facilitate multiplication, division, and other functions. In a typical electronic analog computer, the inputs are converted into voltages that may be added or multiplied using specially designed circuit elements. The answers are continuously generated for display or for conversion to another desired form.

Digital Computers

Everything that a digital computer does is based on one operation: the ability to determine if a switch, or "gate," is open or closed. That is, the computer can recognise only two states in any of its microscopic circuits: on or off, high voltage or low voltage, or--in the case of numbers--0 or 1. The speed at which the computer performs this simple

act, however, is what makes it a marvel of modern technology. Computer speeds are measured in megaHertz, or millions of cycles per second. A computer with a "clock speed" of 33 MHz--a fairly representative speed for a microcomputer--is capable of executing 33 million discrete operations each second. Supercomputers used in research and defence applications attain speeds of billions of cycles per second.

Digital computer speed and calculating power are further enhanced by the amount of data handled during each cycle. If a computer checks only one switch at a time, that switch can represent only two commands or numbers; thus ON would symbolise one operation or number, and OFF would symbolise another. By checking groups of switches linked as a unit, however, the computer increases the number of operations it can recognise at each cycle. For example, a computer that checks two switches at one time can represent four numbers (0 to 3) or can execute one of four instructions at each cycle, one for each of the following switch patterns: OFF-OFF (0); OFF-ON (l); ON-OFF (2); or ON-ON (3).

Number Systems

A number system is defined by the base it uses, the base being the number of different symbols required by the system to represent any of the infinite series of numbers.

Decimal Number System

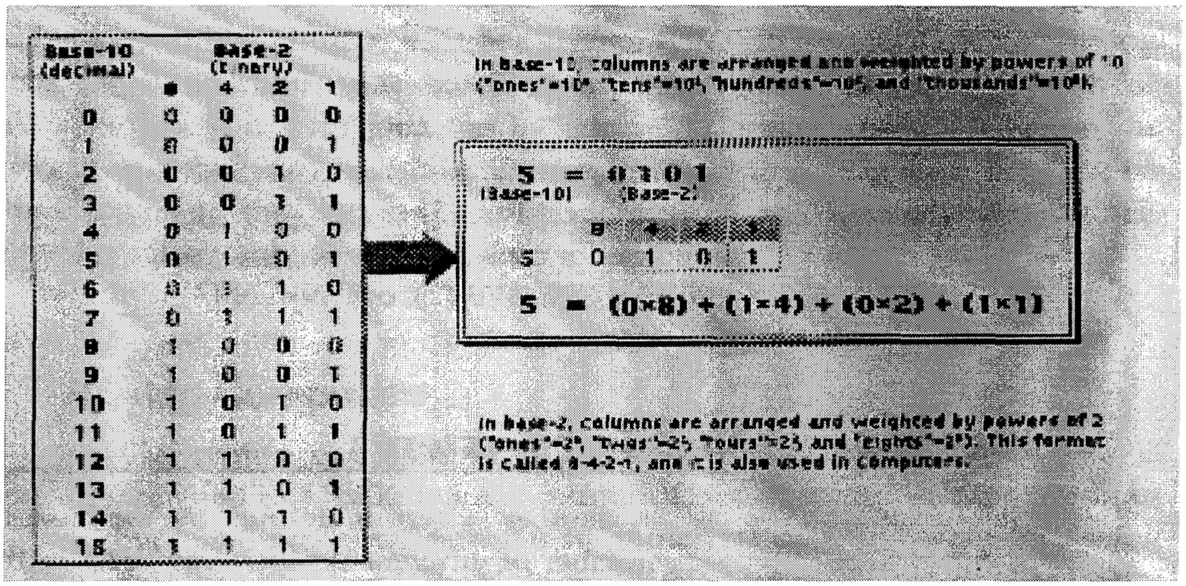
The decimal system in universal use today (except for computer application) requires ten different symbols, or digits, to represent numbers and is therefore a base-10 system. The position of a symbol in a base-l0 number denotes the value of that symbol in terms of exponential values of the base. That is, in the decimal system the quantity represented by any of the ten symbols used--0, 1, 2, 3, 4, 5, 6, 7, 8, and 9--depends on its position in the number. Thus, the number 3,098,323 is an abbreviation for $(3 \times 10^6) + (0 \times 10^5) + (9 \times 10^4) + (8 \times 10^3) + (3 \times 10^2) + (2 \times 10^1) + (3 \times 10^0$, or $3 \times 1)$. The first "3" (reading from right to left) represents 3 units; the second "3," 300 units; and the third "3," 3 million units. In this system the zero plays a double role; it represents naught, and it also serves to indicate the multiples of the base 10: 100, 1000, 10,000, and so on.

Binary Number System

The binary number system plays an important part in computer operations, consisting of only two numerals (0 & 1). It is ideal for the representation of the ON and OFF states a switch or switches may assume.

The first 20 numbers in the binary notation are 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111, 10000, 10001, 10010, 100111, 10100. The zero here

has the role of place marker, as in the decimal system. Any decimal number can be expressed in the binary system by the sum of different powers of two. For example, starting from the right, 10101101 represents $(1 \times 2^0) + (0 \times 2^1) + (1 \times 2^2) + (1 \times 2^3) + (0 \times 2^4) + (1 \times 2^5) + (0 \times 2^6) + (1 \times 2^7) = 173$. This example can be used for the conversion of binary numbers into decimal numbers.



Because only two digits (or bits) are involved, the binary system is used in computers, since any binary number can be represented by, for example, the positions of a series of on-off switches. The "on" position corresponds to a 1, and the "off" position to a 0. Instead of switches, magnetized dots on a magnetic tape or disk also can be used to represent binary numbers: a magnetized dot stands for the digit 1, and the absence of a magnetized dot is the digit 0. Flip-flops (electronic devices that can only carry two distinct voltages at their outputs and that can be switched from one state to the other state by an impulse) can also be used to represent binary numbers; the two voltages correspond to the two digits. Logic circuits in computers carry out the different arithmetic operations of binary numbers; the conversion of decimal numbers to binary numbers for processing, and of binary numbers to decimal numbers for the readout, is done electronically.

Data Representation

Computers identify only signals in the form of digital pulses that represent either a high-voltage state (on) or a low-voltage state (off). The on and off conditions are commonly labelled with the numbers 1 and 0, respectively. The number system using only 1s and 0s is called the binary system. Various combinations of 1s and 0s represent all of the numbers, letters, and symbols that can be entered into a computer. While you see numbers, letters, and symbols assembled to form English words and phrases, the

computer sees things totally differently. For example, the uppercase letter D is represented by the binary sequence 11000100.

Because the language of the computer, machine language, is based on the binary system, data entered into a computer must be interpreted into binary code before they can be used by the computer. Programs take care of this conversion.

Bits and Bytes

The smallest piece of data that can be recognised and used by a computer is the bit, a binary digit. A bit is a single binary value, either a 1 or a 0. A grouping of eight bits is a byte. The term nibble, which is half of a byte (four bits), is used occasionally. The byte is the basic unit for measuring the size of memory. However, with today's memory sizes, it is more common to hear the term kilobyte (K or KB) or megabyte (MB). To give you an idea of how many English words are in a kilobyte, the text material in this chapter is approximately 60,000 bytes, or 60 kilobytes (60K).

There is some confusion over the prefixes kilo- and mega-. In strict scientific notation, kilo- means 1,000 and mega- means 1,000,000. However. in the language of computers, kilo- actually is 1,024 and mega- is 1,048,576. The disparity occurs because computers are binary machines, that is, machines based on the powers of 2. If 2 is raised to the 10th power, the decimal number is 1,024. Since this is very near 1,000, the prefix kilo- was adopted for computer use. The same reasoning is behind the prefixes mega- and giga- (1 billion).

Before long, memory capacities in the terabytes (1 trillion bytes) may be common in some of the largest computer systems.

Computer Words

A computer word is the number of adjacent bits that can be stored and manipulated as a unit. Just as English vocabulary words are of varying lengths, so are computer words. Many personal computers have the ability to manipulate a 32-bit word, while some models have word lengths of 8 and 16 bits.

Read Textbook: Introducing Computers
Information - p30-32.

Computer Functions

Computers perform three basic tasks:

1. Perform arithmetic functions on numeric data (adding, subtracting, multiplying and dividing),

2. Test relationships between data items by comparing values, and

3. Store and retrieve data.

These tasks are no more than people do but computers can accomplish the tasks faster. more accurately and more reliably.

Hardware

Modern digital computers are all conceptually similar, regardless of size. Nevertheless, they can be divided into several categories on the basis of cost and performance: the personal or microcomputer, a relatively low-cost machine usually of desk-top size (some, called laptops, are small enough to fit in a briefcase); the workstation, a microcomputer with enhanced graphics and communications capabilities that make it especially useful for office work; the minicomputer, an appliance-sized computer, generally too expensive for personal use, with capabilities suited to a business, school, or laboratory: and the mainframe computer, a large expensive machine with the capability of serving the needs of major business enterprises, government departments, scientific research establishments, or the like (the largest and fastest of these are called supercomputers).

Components

A digital computer is not actually a single machine, in the sense that most people think of computers. Instead it is a system composed of five distinct elements:

- Central Processing Unit;
- Input Devices:
- Memory Storage Devices;

- Output Devices; and

- A Communications Network, called a bus, that links all the elements of the system and connects the system to the external world.

Central Processing Unit (CPU)

Microprocessors (CPU) made possible the rapid development of personal computers. You may hear someone refer to a computer as, for example, a "386 machine". What the person is referring to is the microprocessor, in this case the Intel 80386. Many times, you will hear a computer described by its processor rather than its brand name. In a personal computer, the microprocessor and other support chips are mounted on the main circuit board, often called the motherboard or system board.

The CPU may be a single chip or a series of chips that perform arithmetic and logical calculations and that time and control the operations of the other elements of the system. Miniaturisation and integration techniques made possible the development of a CPU chip called a microprocessor. which incorporates additional circuitry and memory. The result is smaller computers and reduced support circuitry.

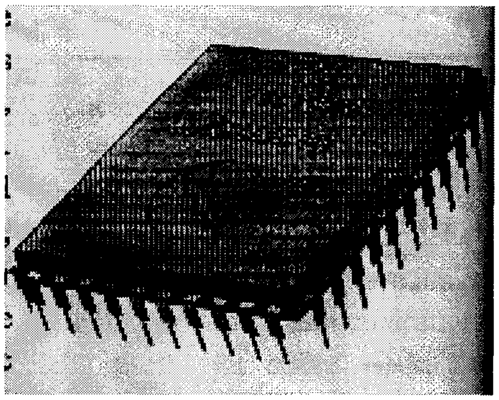
<u>CPU</u>
ALU
Control Unit
Registers
Internal Bus

Most CPU chips and microprocessors are composed of functional sections: (1) an arithmetic/logic unit; (2) registers; (3) control section; and (4) an internal bus. The arithmetic/logic unit gives the chip its calculating ability and permits arithmetical and logical operations. The registers are temporary storage areas that hold data, keep track of instructions, and hold the location and results of these operations. The control section has three principal duties. It times and regulates the operations of the entire computer system; its instruction decoder reads the patterns of data in a designated register and translates the pattern into an activity, such as adding or comparing; and its interrupt unit indicates the order in which individual operations use the CPU, and regulates the amount of CPU time that each operation may consume.

The last segment of a CPU chip or microprocessor is its internal bus, a network of communication lines that connects the internal element of the processor and also leads to external connectors that link the processor to the other elements of the computer system. The three types of CPU buses are: (1) a control bus consisting of a line that senses input signals and another line that generates control signal from within the CPU; (2) the address bus, a one-way line from the processor that handles the location of data in memory addresses; and (3) the data bus, a two-way transfer line that both reads data from memory and writes new data into memory.

The Arithmetic and Logic Unit

ALU
addition
subtraction
multiplication
division
less than
equal to



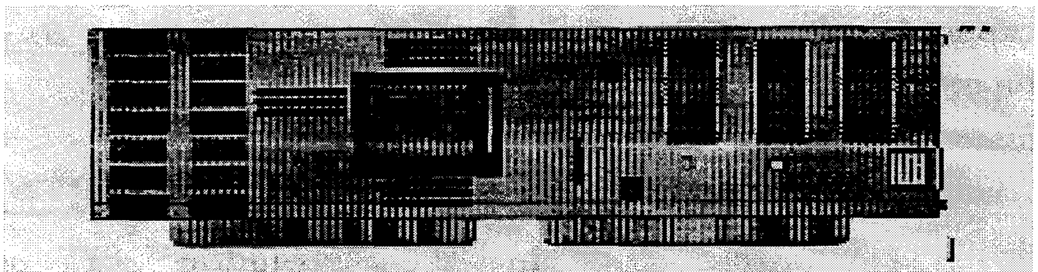
The arithmetic and logic unit (ALU) is part of a CPU where all arithmetic and logical functions are performed. The basic arithmetic functions include addition, subtraction, multiplication, and division. Advanced mathematical functions, such as logarithms, trigonometry, and other specialised operations, are also performed here. A logic function is one where numbers or conditions are compared to each other. Examples of logic functions are greater than, less than, equal to, not equal to, greater than or equal to, and less than or equal to. People make logic decisions every day. When you buy clothes for instance, you compare price, quality, and style from one garment to the next, and from one store to the next.

The Control Unit

The control unit interprets any instructions it receives from memory and directs the sequence of events necessary to execute each instruction. The control unit also establishes the timing of these events. It is basically the "traffic cop" of the system. For example, data can flow both in and out of the central processing unit, but the control units keeps this from happening simultaneously in order to prevent garbled information. To control all that is going on in a CPU, the control unit uses a system clock, which synchronises all tasks by sending out electrical pulses.

Read Textbook: Introducing Computers
What is a Processor, p1 0-112.
The Processor at Work, p114

Communication Pathways



• Expansion card with 16 bit data bus

To function as a complete unit, the arithmetic and logic unit, the control unit, and the main memory unit must communicate. The links among and within the various units are called buses. A bus is no more than an electrical path for signals to flow from point to point in a circuit. A bus is classified according to its function. For example, a control bus is a unidirectional pathway for all timing and controlling functions. It is sent by the control unit to the other units of the system and regulates what happens on the other two buses. An address bus is a unidirectional pathway used to locate the storage position in memory for the next instruction to be executed or the next piece of data. A data bus is a bi-directional pathway in which actual data transfer takes place. Input and Output (I/O) circuits are located along each bus, coupling the assorted support and memory chips to the bus.

The speed at which a bus can transfer data, the amount of data that the bus can transfer, and the plug-in cards that can be used are major characteristics of bus architecture. Not all personal computers use the same bus architecture. For example, in the high performance 32-bit personal computer market (its 80386 PS/2 line of computers), IBM uses Micro Channel architecture (MCA), while others embrace the Extended Industry Standard Architecture (EISA), which was developed by nine computer manufacturers. There are many bus architectures, such as the XT bus for the 8-bit IBM and compatibles, the AT bus for the 16-bit IBM and compatibles, and NuBus used by the Apple Macintosh, to name a few. Some are only partially compatible with others while some, like MCA and EISA, are not compatible at all. A plug-in card for expanding memory in a computer using one bus architecture will not always work in a computer using another. Whether you are choosing a complete system or selecting an accessory card, compatibility is a key issue.

Read Textbook: Introducing Computers
Buses p113-p114

Intel Microprocessors

In the evolution of personal computers, many different microprocessors have been developed. The microprocessors developed by the Intel corporation have become the standard CPUs around which IBM and compatible PCs are made. The history is as follows:

- 8086
- 8088
- 80286
- 80386
- 80486
- Pentium (P5)

8086

Introduced in 1978, these CPUs have a 16 bit architecture (16 bit processor and 16 bit external data bus). The 8086 could control up to I Megabyte of main memory.

8088

Existing hardware was unable to take full advantage of the 8086 chip, therefore Intel produced the 8088 (1979) for the first IBM PC. It functioned the same as the 8086 but addressed an 8 bit external data bus. Also known as the XT computer (eXtended Technology).

80286

Introduced in 1984 the 80286 had 5 major advantages over the competition:

- Could access up to 16 Mb of main memory

- Has Virtual Memory capabilities - Virtual memory allows the processor to use disk drive space to simulate main memory, the 286 or AT (Advanced Technology) could simulate up to 1 Gigabyte (GB) of main memory.

- Multitasking. Hardware Multitasking allows the computer to work on more than one program at a time, (a multitasking operating system is also required) e.g. if you need to move data from a spreadsheet to a wordprocessor, the multitasking capability allows you to move back and forth between the applications without exiting either program.

- 2 modes of operation. Real address mode and protected address mode. Real mode makes the computer operate as an 8086/88 which prevents multitasking. In protected mode multitasking is supported as programs are operated in separate compartments of memory. This prevents conflicts between the programs. In this way programs are effectively protected from each other.

- Clock speeds up to 20 Megahertz (MHz) or 20 million pulses per second.

80386

The 80386 introduced 32 bit processing.

- It can control up to 4GB of main memory and 64 Tetrabytes (TB) of virtual memory.

- Much hardware was still unable to use this 32 bit bus, so Intel introduced the cheaper 80386SX which remained a 32 bit device internally but communicated with the data bus in 16 bit fashion.

- The 80386 operates at clock speeds up to 40MHz.

80486

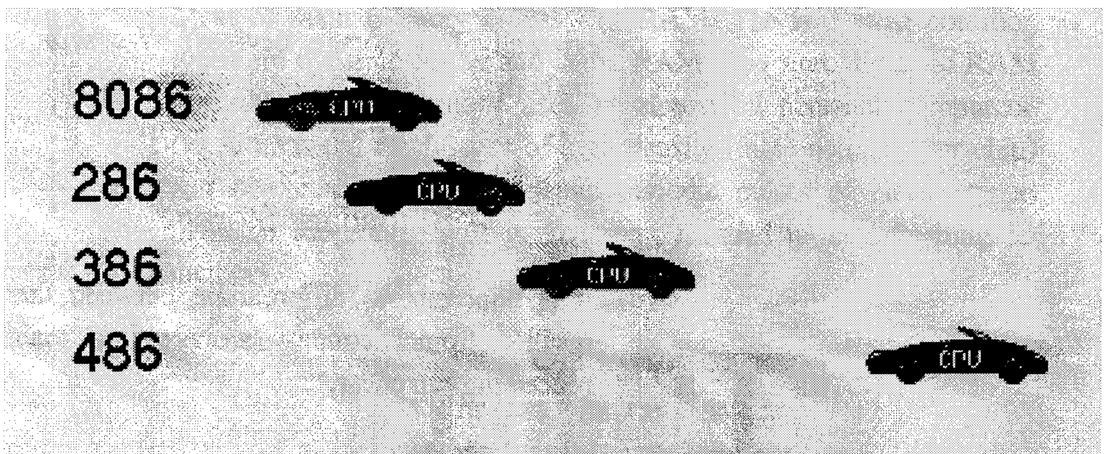
- The 80486 incorporates into one chip the 80386, a maths co-processor and a cache memory controller.

- In previous systems if a maths co-processor was required it was added as an extra chip in the system board.

- Clock speeds up to 66MHz
- Backwards compatible with all other Intel microprocessors

PENTIUM (P5)

The Pentium is the first 64 bit processor to appear in the personal computer world. Whilst it has a 64 bit data bus, most system hardware caters for a 32 bit data bus, so the Pentium rarely performs to its potential. It is the fastest processor currently available and is available with clock speeds of up to 100MHz. As an example of the technology of the Pentium Microprocessor, the chip contains in excess of 3.2 million transistors.



- Relative speed of Intel Microprocessors

Computer Speed

Computer speed is dependent on a number of factors, the main ones are:

- Clock Speed,
- Processor Architecture, and
- Bus Width.

Many people mistakenly consider the speed to be purely the clock speed. This is shown to be untrue when considering two processors with the same clock speed requirement, but a different architecture, e.g. 386 & 486. The 486 is clearly faster

than the 386 despite identical clock speed. A more precise method of classifying the speed of computers is the amount of instructions that can be processed in a given time frame, usually measured in millions of instruction per second (MIPS). This then takes into consideration the many variables listed above.

Read Textbook: Introducing Computers **Microprocessor Trends p114-117**

Data Storage Devices

Computer systems can store data internally (in memory) and externally (on storage devices). We will call these two storage methods:

- Main Memory, and
- Secondary Storage.

It is important to differentiate between the two as data must be recalled from storage into main memory before processing can occur.

The Main Memory Unit

The main memory unit is the internal memory of a computer, which can store computer program instructions and data during execution. The main memory also provides temporary storage during program execution. Part of the main memory may contain permanently stored instructions that tell a computer what to do when it is turned on, as a check to make sure that everything is working properly and to see what peripheral equipment is attached. Because the main memory is located inside a computer and is linked directly to the components of the central processing unit, access to instructions and data is very fast.

The process of entering data into the main memory is called writing. When data is placed in, or written to, the main memory, it replaces what was originally there. This procedure is equivalent to deleting a word with a pencil eraser and writing a new word in its place. The process of retrieving data from the main memory is called reading. The reading process does not change the data in any way.

Semiconductor Memory

Semiconductor integrated circuits can be designed to function as memory chips. The two most common forms of semiconductor memory are random-access memory and read-only memory.

Random-access Memory (RAM) is the part of main memory where data and program instructions are held while being manipulated or executed. This type of memory allows you to enter data into memory (write) and then to retrieve it from main memory (read).

<u>Memory</u>
ROM
Read only
non volatile
Read-Write
Volatile

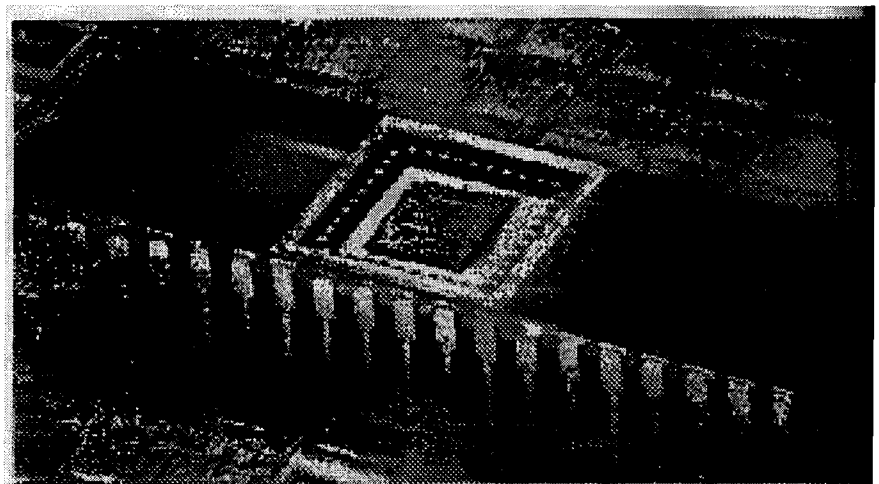
Most of main memory consists of RAM. The two most common types are dynamic RAM and static RAM. The first, dynamic RAM (DRAM), is the memory used in almost all personal computers. DRAM has the advantages of high density (more memory per chip) and low cost, but it must have periodic pulses of electricity to maintain the contents of its memory, referred to as refreshing its memory.

The second type of RAM is called static RAM (SRAM). SRAM has faster access times and does not need to be refreshed. Its main disadvantage over DRAM is cost.

In either case, when the power to a computer is shut off, everything stored in RAM is lost. In other words, RAM is volatile.

Read-only memory (ROM). The contents of read only memory can only be read. Data cannot be written into read-only memory. ROM may contain information on how to start the computer and even instructions to the entire operating system. The actual contents of ROM are usually set by the computer manufacturer, and they are unchangeable and permanent. Because the contents cannot be altered and they are not lost when the electric current is turned off, ROM is non-volatile.

Several types of read-only memory can be programmed according a user's specifications. Programmable read-only memory (PROM) allows a chip to be programmed by a user once; then, it cannot be altered further. A type of ROM in which the contents can be changed is called erasable programmable read-only memory (EPROM). An EPROM chip has the features of PROM, but it also has a transparent quartz window covering the internal circuitry. By removing the chip from the circuit and exposing the window to ultraviolet light, you erase the contents. Then, you can reprogram the chip for another application.



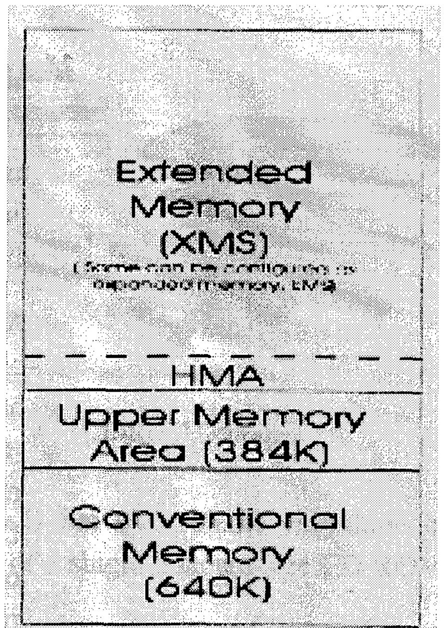
• EPROM Chip

Another type of ROM chip is the electrically erasable programmable read-only memory (EEPROM). This chip can be erased reprogrammed electrically, so there is no need to remove it from the circuit as with an EPROM. This type of memory chip is used in grocery store computers, where price changes occur frequently.

Read Textbook: Introducing Computers **What is Memory p112-p113**

System Memory

The RAM component of main memory is configured by the PC as system memory. The first 640 Kilobytes (KB) is termed conventional memory, the next 128 KB is reserved for video and the next 256KB is reserved for system ROM usage. This makes up the first MB of RAM. Memory in excess of this is termed extended memory. The 640 KB of conventional memory is the memory used by DOS to operate programs. For DOS to access the memory above 1MB it needs to be capable of transferring blocks of data back and forth between conventional and extended memory. Special programs such as Microsoft Windows are necessary to do this. Software called Expanded Memory Managers can be used to configure memory as expanded memory. This can allow DOS programs to break the 640KB barrier. EMM386 bundled with MSDOS is one such program.



• System Memory Map

Secondary Storage Devices

Secondary store devices, which may physically reside within the computer's main unit, are external to the main circuit board. The main types of secondary storage devices in use are:

- Magnetic
- Optical

Read Textbook: Introducing Computers Mass Storage p131 - p141.

Magnetic

These devices store data as charges on a magnetically sensitive medium such as a tape or, more commonly, on a disk coated with a fine layer of metallic particles. The most common external storage devices are so-called floppy and hard disks.

Magnetic Storage
Tape
Floppy Disk
Hard Disk

A **Floppy Disk,** is a round, flat piece of Mylar coated with ferric oxide (a rustlike substance containing tiny particles, capable holding a magnetic field) and encased in a protective plastic cover (the disk jacket). Data is stored on a floppy disk by the disk drive's read/write head, which alters the magnetic orientation of the particles. Orientation in one direction represents binary 1; orientation in the other, binary 0. Typically they are 3.5-inch disks encased in rigid plastic; older floppy disks are 5.25 inches and flexible.

A **Hard Disk** consists of one or more inflexible platters coated with material that allows the magnetic recording of computer data. A typical hard disk rotates at 3600 RPM (revolutions per minute), and the read/write heads ride over the surface of the disk on a cushion of air 10 to 25 millionths of an inch deep. A hard disk is sealed to prevent contaminants from interfering with the close head-to-disk tolerances. Hard disks provide faster access to data than floppy disks and are capable of storing much more information. Because platters are rigid, they can be stacked so that one hard-disk drive can access more than one platter. Most hard disks have from two to eight platters.

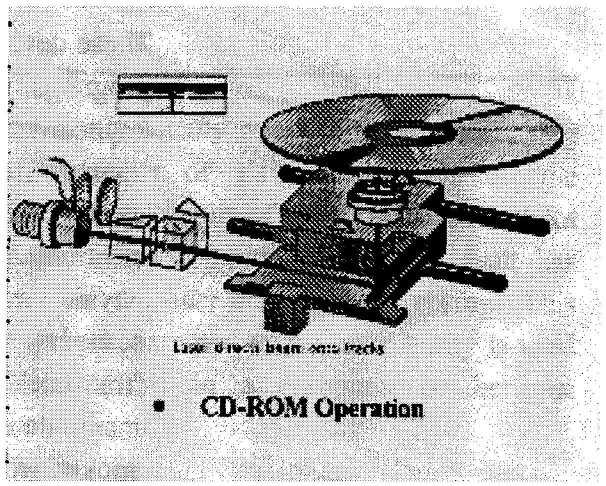
Fig 2-1 Hard Disk

Optical

Optical Storage
CD-ROM
WORM
Floptical
optical tape

Types of optical storage include Optical Tape, Compact Disk Read Only Memory Devices (CD-ROM), WORM Drives and Floptical Disks. They are gaining increasing acceptance due to their large storage capacities and decreasing cost.

CD-ROM, acronym for compact disc read-only memory, is a form of storage characterised by high capacity (roughly 600 megabytes) and the use of laser optics rather than magnetic means for reading data. CD-ROM devices are strictly read-only. An indication of the capacity of a CD-ROM disk is that a 28 volume encyclopedia would fill only about one quarter of a single standard-size CD-ROM disk.



• CD-ROM Operation

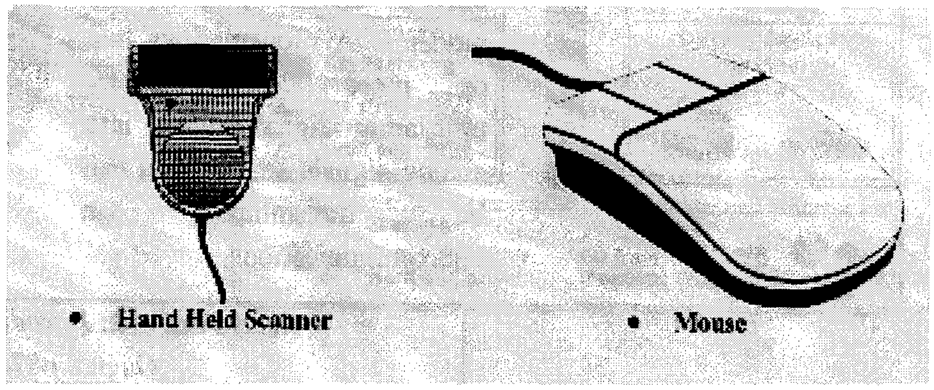
WORM (computer drive), acronym for "write once, read many", is a type of optical disk that can be read and reread but cannot be altered after it has been recorded. WORMs are high-capacity storage devices. Because they cannot be erased and rerecorded, they are suited to storing archives and other large bodies of unchanging information.

The **Floptical** drive is an erasable optical disk and drive unit. They are removable and can hold data up to 1GB.

Optical Tape is similar to magnetic tape in that data is accessed sequentially. Data is stored using optical laser techniques. They come in cassette form and can store over 8 GB each.

Input Devices

INPUT
Keyboard
Mouse
Microphone
Joystick
Barcodes
Lightpen
Scanner



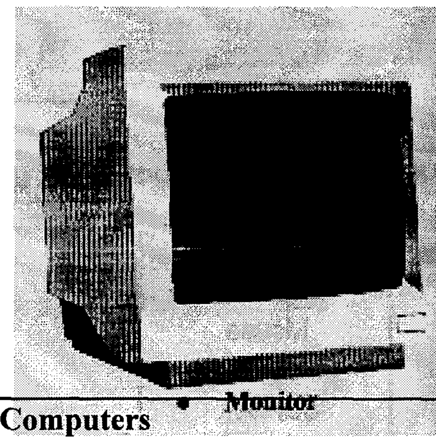
These devices enable a computer user to enter data, commands, and programs into the CPU. The most common input device is the keyboard. Information typed at the typewriter-like keyboard is translated by the computer into recognisable patterns. Other input devices include light pens, which transfer graphics information from electronic pads into the computer; joysticks and mice, which translate physical motion into motion on a computer video display screen; light scanners, which "read" words or symbols on a printed page and "translate" them into electronic patterns that the computer can manipulate and store; and voice recognition modules, which take spoken words and translate them into digital signals for the computer. Storage devices can also be used to input data into the processing unit.

Read Textbook: Introducing Computers
Input p69-p81.

Output Devices

OUTPUT
Monitors
LCD Screen
Gas Plasma Screen
Laser Printer
Dot Matrix Printer
Bubble Jet Printer

These devices enable the user to see the results of the computer calculations or data manipulations. The most common output device is the video display terminal (VDT), a monitor that displays characters and graphics on a television-like screen. A VDT usually has a cathode-ray tube (CRT) like an ordinary television set, but small, portable computers may use liquid crystal displays (LCD) or electroluminescent screens. Other standard output devices include printers and modems. A modem links two or more computers by translating digital signals into analog signals so that data can be transmitted via telecommunications.



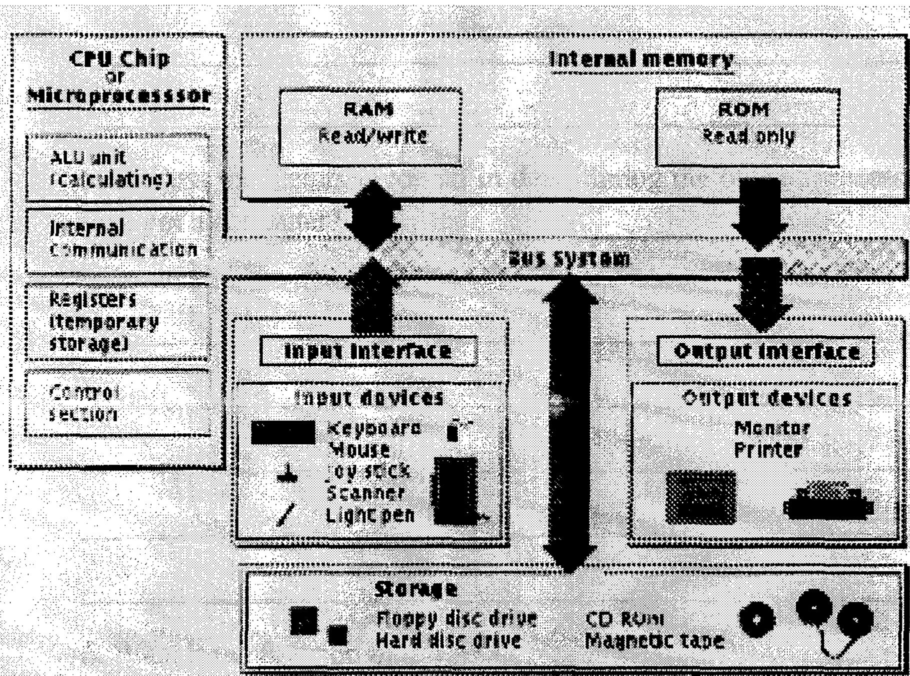
Read Textbook: Introducing Computers
Output p87-p102

Bit Parity

In reference to computers, parity usually refers to an error-checking procedure in which the number of 1's must always be the same--either even or odd--for each group of bits transmitted without error. If the number is incorrect, a parity or memory fault has occurred and the computer will consider the data to be corrupt. This causes an error message to be transmitted to the user. Parity is used for checking data transferred within a computer or between computers, e.g. by modem.

Putting the Pieces Together

In isolation from one another the central processing unit, input devices, memory storage devices, output devices, and buses are of very little use. The following block diagram illustrates the relationship between these components.



• Personal Computer Block Diagram

Summary

Personal Computers have affected virtually every aspect of modern life. Primarily computers process information, a sequence of acquiring, storing, manipulating, and communicating information.

A PC consists of a Central Processing Unit (CPU), communications network, input devices, output devices, and memory storage devices.

The CPU or microprocessor controls the operation of the computer. It consists of the ALU, control unit, registers, and an internal bus. Communications pathways consist of the data, address, and control buses. Input and output devices allow communication with the user and memory devices and store data for long or short periods of time.

Review Exercise

1. A microprocessor controls the:
   a. ALU and Main Memory
   b. Control Unit & RAM
   c. RAM & ROM
   d. ALU & Control Unit

2. Main Memory refers to:
   a. Permanent ROM storage only
   b. Internal storage for programs or data
   c. Disk storage of data
   d. External permanent storage

3. Describe the purpose of the Data Bus

   ____
   ____
   ____

4. What does the term volatile mean as it pertains to computer memory?

   ____
   ____
   ____

5. Discuss the factors involved in determining the overall processing speed of a computer?

   ____
   ____
   ____
   ____
   ____
   ____

6. What is the function of the ALU?

   ____
   ____
   ____

7. What is the most common type of secondary storage medium?

   ____

8. What is the function of the Control Unit?

   ____

9. List 6 Input devices.

____
____
____
____
____
____

10. List 4 Output Devices.

____
____
____
____

11. If using a worm drive the storage medium being used is:
  a. Optical Laser disk
  b. Main Memory chip
  c. Magnetic Disk
  d. Operating System

12. Draw the block diagram of a Personal Computer.

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Vita

Flight Lieutenant Linda M. New [redacted] She graduated from Warwick State High School in December 1981. In January 1984, she joined the Royal Australian Air Force (RAAF) as a Supply Officer Cadet. In December 1985, she graduated from the Darling Downs Institute of Advanced Education (now the University of Southern Queensland) with a Bachelor of Business with a double major in Computing and Accounting. At the same time, she received her commission as a Supply Officer in the RAAF. During her career in the RAAF, FLTLT New has performed duties as Stock Control and Procurement Officer, Catering Officer, Movements Officer, and Systems Manager for a distributed computer system for the Air Intelligence Centre. She entered the Graduate School of Logistics and Acquisition Management, Air Force Institute of Technology, in May 1994.

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