Report Series
No. 40

Presenting Information to Managers

March 1984

The Butler Cox Foundation

THE BUTLER COX FOUNDATION

REPORT SERIES NO. 40

PRESENTING INFORMATION TO MANAGERS

ISSUED MARCH 1984

Abstract

This report is concerned with all aspects of the interface between managers and information systems. Its main purpose is to explain the nature and significance of recent advances in the technology for presenting information to managers. The report provides practical guidelines for applying the most relevant information presentation tools and techniques in a cost-effective manner.

We conclude that decision makers in large organisations require a different form of information systems support than has been provided by traditional data processing applications. In particular, business graphics is becoming an increasingly important element in presenting management information.

Research team

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THE BUTLER COX FOUNDATION

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Butler Cox is an independent management consultancy and research organisation, specialising in the application of information technology within commerce, government and industry. The company offers a wide range of services both to suppliers and users of this technology. The Butler Cox Foundation is a service operated by Butler Cox on behalf of subscribing members.

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REPORT SERIES NO. 40

PRESENTING INFORMATION TO MANAGERS

CONTENTS

PRESENTING INFORMATION TO MANAGERS

REPORT SYNOPSIS

Most organisations would accept that computer systems are powerful information processing tools, but that they fall far short of what might be achieved in directly conveying to senior managers the information that they need. Computer printouts tend to contain too much data; visual display terminals tend to be unfriendly to use — and in any case may not give access to the information that is really needed. As a result, senior managers look elsewhere for the information on which to base their decisions, and/or depend on subordinates to summarise the computer output for them.

But in 1984, it is possible to do better than that. Organisations should aim to produce information that matches the manager's needs, and to present it in a way that matches his way of thinking. If this is achieved, the manager will absorb and retain the optimum information for his task.

At present, most managers are deluged with data, but receive too little meaningful information. The distinction is important, and we would argue that most of today's 'information systems' are in fact data systems. What the manager needs is up-to-date 'core' information, representing his key business indicators. What he normally gets is a mass of detail which may well be out of date. One way of meeting the needs is to allow managers to set up their own special decision-support databases, and to provide them with access to databases or informal (unformatted) information sources.

To provide genuinely useful information for managers, system designers need to understand the human cognitive process — how people absorb data and transform it into information. As Chapter 1 of the report makes clear, one key aspect of this is the importance of graphical images. The human mind is very good at recognising patterns, and changes in patterns. Another key aspect is that the information presented must be relevant and meaningful.

In matching the manager's needs and way of thinking through the use of graphics, a number of ergonomic factors assume great importance. Characters and messages presented on display screens must be legible; colour can be a powerful aid but must not be used indiscriminately; response times should preferably be short, but above all should be consistent and appropriate to the user; and human psychology should be borne in mind when drafting the system messages that are intended to help the user in cases of error or uncertainty.

The design of screen layouts also is important. Poor screen layouts will reduce productivity and may deter managers from using the system at all. The report (Chapter 2) describes the five main types of layout: data-entry screens, enquiry screens, interactive screens, menu screens, and multi-window screens. The latter represents a powerful technique which is likely to be adopted widely as the technology advances.

A crucial element in determining the success of an information system is the man-machine dialogue. Indeed, to most users, the dialogue is the system. Experienced, frequent users of the system will respond best to one type of dialogue; inexperienced, infrequent users to another. The more experience a user has with a system, the more he is likely to favour a dialogue which he, rather than the system, controls. Thus an ideal man-machine dialogue would enable users to choose the degree to which they control the dialogue.

There are four possible modes of dialogue: direct, menu, form-filling and natural language. These are described in the report (Chapter 3). Direct-mode dialogues are suitable for trained and experienced users, while menus suit the novice or infrequent user. Form-filling is appropriate for all types of users, while natural-language dialogue (involving a human-like conversation) is not yet a generally available option. Chapter 3 also provides design guidelines for man-machine dialogues.

Computer graphics, long accepted in science and engineering, is now moving firmly into commercial applications. Business computer graphics software packages were first developed for use on mainframe computers, but are now available also for minicomputers and for microcomputers (a particularly fast-growing market). Chapter 4 of the report lists available packages, their characteristics and the applications to which they are suited, together with a discussion of graphic terminals and an assessment of their features.

Experience has shown that the initial response of a potential user community to the prospect of using business computer graphics tends to be limited, but that the usage grows at a compound rate once a system is introduced. To date, most successful implementations have been mainframe-based, but the situation is changing as powerful new minicomputer and microcomputer facilities become available. The case studies in Chapter 5 relate the experiences of specific companies.

Trends in the technology that is supporting the swing to business graphics show a number of significant changes on the horizon, though the present domination of the cathode ray tube for display devices is likely to continue for the next five to ten years. Colour displays will become the norm, resolution will improve, and the display devices will incorporate greater processing power.

Dot-matrix printers will increasingly take over from medium-speed line printers and daisy wheel printers, and will be used for graphics printing. Where higher printing speeds are required, and where complex images have to be formed, laser printing will be the dominant technology. In addition, small laser printers are emerging into the marketplace. The new technology of ion-deposition printing could make a significant impact in the future.

Graphics software technology development is likely to be directed towards four main areas: ease of use, greater device intelligence, integration with existing databases, and adherence to graphics software standards. Natural-language dialogue, voice input and response and more portable graphics software are among the expected innovations (Chapter 6).

Our research has confirmed that decision makers in large organisations need new forms of information systems support. Senior corporate staff are not prepared to invest a lot of time and effort in learning about and using systems that produce a mass of data that is irrelevant to their needs. Hence the active interest in harnessing the available technology to produce genuinely user-friendly, understandable, conversational and relevant systems that can present information to managers painlessly and effectively. Success in designing such systems will demand a knowledge of the human cognitive process and an appreciation of the needs of individual user communities, as well as a firm grasp of the technologies that are available.

PREFACE

Computer systems are good at presenting large volumes of data either as printouts or on visual display terminals. For many years now, clerical staff have used data in these forms as an integral part of their jobs, and there is now a well-documented history of the problems that can be created at the interface between people and their information systems. The Butler Cox Foundation has previously addressed these issues in Foundation Report No. 20, published in August 1980.

Since then, the use of information technology has been transformed by new products and services. In particular, far more people at senior levels in organisations now have access to some form of computing, either in the form of a terminal linked to a corporate computer or, increasingly, a dedicated personal computer. The challenge today is how to use information technology to provide these senior people with the management information they really need in a form that makes it easy for them to assimilate.

This report is concerned with all aspects of the interface between managers and information systems. Its primary purpose is to explain the nature, and significance, of recent advances in the techniques for presenting information to managers.

Structure of the report

The report begins by identifying the information needs of corporate decision makers, and shows that these needs cannot be met fully by conventional data processing systems. Information presented to managers (or to staff at any other level in the organisation) can be effective only if it can be easily assimilated by the human brain. This aspect has been largely neglected by system designers; in Chapter 1, we provide the basis for a better understanding of the human cognitive process.

The report next discusses the key ergonomic issues relating to the presentation of management information, and gives guidelines on character legibility, the use of colour, response times, system messages and screen layouts. Chapter 3 then provides specific advice and guidance on the design of man-machine dialogues. This topic is particularly important because, as far as non-computer specialists are concerned, the dialogue is the system.

The discussion in Chapter 1 shows that the most efficient and effective method of communicating with people involves the use of graphical images. Chapter 4 therefore concentrates on recent developments in the field of business computer graphics, and Chapter 5 presents, as case histories, the practical experience of five organisations.

Finally, in Chapter 6, the report highlights the key trends in presentation technology and techniques.

Research methodology

The research for this report was carried out during the third and fourth quarters of 1983. First, the available literature was thoroughly reviewed, and a wealth of information was obtained from research reports and periodicals. The research papers specifically mentioned in the body of the report are listed on page 43, and a comprehensive bibliography, arranged by subject area, is listed on pages 44 and 45.

During the second phase of the research, interviews were conducted in Western Europe and the United States with a representative sample of user organisations and suppliers.

The information gathered during the first two phases of the research was then augmented by participation in public seminars led by experts in the field of business computer graphics.

Intended readership of the report

The report is intended for management services planners and executives, for users of management information and for product and system designers. The aim of the report is to provide each of these groups of readers with practical guidelines for applying the most relevant information presentation tools and techniques in a cost-effective manner.

CHAPTER 1

MANAGERS' INFORMATION NEEDS

A survey of chief executive officers in "Fortune 500" companies carried out in 1981 showed that these senior managers rated their computer-based corporate information systems last among the major sources of information available to them for decision-making. It is widely known that many senior managers rarely use printed computer output, and rarely access business data via a display screen. This is not usually because senior managers are keyboard shy. Many of them have used computer outputs and computer terminals both in their university education and in other training arenas. Rather they find that computer outputs contain either too much data, or data that is poorly structured and incomplete for their decision-making purposes. So they prefer to work from summaries provided by their subordinates.

Various sources have estimated that between 75 and 90 per cent of all of the data presented to the users of computer-based information systems is either ignored or presented in an inconvenient form. Users are swamped by data provided (usually at great expense) by the corporate information system, and yet they still have to supplement the data with information from other sources. This additional 'informal' information helps them to focus quickly on and interpret that part of the computer-generated output that is specific to their immediate needs. Paradoxically, the growth of data available from computer systems has led to a growth in demand for other types of information from other sources as well. If information processing systems are to provide really effective support for decision makers, a new approach is required to the whole area of presenting information to managers.

The way to overcome the problem is to provide managers with less data, not with more. Research has shown that, in general, 80 per cent of business decisions can be made with access to only 20 per cent of the available data. Information processing systems should therefore be geared to providing this 'core' data for use by decision makers. The aim is to minimise the amount of data being presented, whilst maximising the information content.

DATA AND INFORMATION

We have used the terms "data" and "information" in apparently interchangeable ways. Before proceeding further, we should define what we mean by these terms as used in this report. The fundamental concept is that information systems present data for the user to transform into information. (We would argue, therefore, that most so-called information systems are data systems.)

Data provides the facts about entities or conditions in the real world. By itself, data has no meaning. For data to become information it must be intelligible and relevant to the receiver within a familiar context. That context differs from person to person, depending on environment, culture, background and so forth. Thus, the meaning assigned to a particular set of data can vary from person to person, and from time to time, depending on the context.

Information is knowledge communicated. Data is used to convey the 'knowledge message', and knowledge is communicated only where the recipient can establish the meaning of the data. This requires that the data sender and the recipient share the same perceived model of reality (that is, they share the same context). We explore the implications of this later in this chapter when we discuss the human cognitive process.

Obviously there are close relationships between data and information, the most important being that:

- Information usually results from recognising, understanding and manipulating the data received.
- The quality of the information depends directly on (but is not guaranteed by) the quality of the data.
- The completeness of the information depends on the complete collection of the data.

A necessary condition for data to be transformed successfully into information is that a manager must receive sufficient reward for the time invested in accessing the data. If the anticipated reward is insufficient, he will not even make the attempt to access the data. And the more senior the manager, the less time he will be prepared to spend on accessing the required data.

DECISION-SUPPORT INFORMATION REQUIREMENTS

Most successful managers have their own set of key indicators which they use to measure the performance of the business. These indicators provide a broad overview of trends and relationships, and they are used when making decisions about the day-to-day running of the business. Often, these key indicators can be obtained only by searching through massive end-of-month reports produced by the corporate systems department. Decision makers usually delegate this time-consuming and tedious task to a subordinate. Even so, the decision maker is only partly satisfied, because the key indicators are updated once a month at best — too infrequently for day-to-day decision-making purposes. Most corporate decision makers will prefer to receive information that is approximate but on time, rather than accurate but out of date.

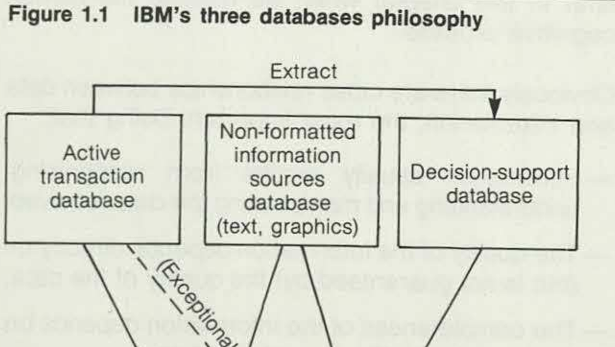
The solution to this problem is for the formal corporate information system to produce the key indicators on demand. But this is not easy to achieve. The required information needs to be tailored to the specific and volatile needs of a small number of individuals. Often it is not easy to define in system terms the transformations necessary to produce the information. Expert systems techniques, with their ability to capture knowledge and fuzzy data may, in the future, be applicable in this area.

The databases that exist in many organisations provide an excellent base for accounting systems but, for the reasons just discussed, they often do not provide senior managers with the information they require in the way they need it. Many of the recent developments in using computer technology for presenting decision-support information to managers have arisen outside the confines of the corporate information system. The increasing use of personal computing systems is but one example. Another example is the role that videotex is playing in making managers aware of the potential for obtaining decision-support information from a computer-based system. Many organisations are now successfully using private videotex systems as a means of ensuring that up-to-date information is available to managers. One such example is included in the case histories in Chapter 5.

Sometimes, users create and maintain their own smaller, more manageable sub-sets of the general corporate database for decision-support purposes. These decision-support databases are usually an integral part of a personal computing system. This approach provides several advantages. First, once the required information has been defined, access to it can be much faster. Second, the extracted data can be modified and manipulated (for 'what-if' purposes, for example) without having to worry about the effects on critical corporate data. Third, and perhaps most importantly, many of today's personal computing systems provide powerful display tools that permit users to experiment with various methods of presenting the data.

The importance of this trend has been recognised by computer suppliers. In recent discussions with senior product planning staff at IBM we were told that the company has incorporated the decision-support database concept into its model of future corporate information systems. Figure 1.1 illustrates IBM's 'three databases philosophy', which encapsulates the company's view of the future of corporate information systems.

Figure 1.1 IBM's three databases philosophy



In this model, there are three types of corporate database:

- The familiar active transaction-oriented database, containing structured data.
- A database of non-formatted information sources. This contains, in a machine-readable form, unformatted text, visual information, and so forth.
- Decision-support databases, which are created by extracting sub-sets of data from the main corporate database.

The decision-support database is accessed directly by decision makers (or their intermediaries), and is under their direct control. This concept is a key element of IBM's future model for corporate information systems, and the company has made significant investments in developing new decision-support software products (such as Intellect, Frango, and Profs). IBM sees these products being used to extract the decision-support database from the main database, maintain it and present data from it for use by decision makers.

The model also confirms IBM's view that decision makers will need access both to the non-formatted information sources database and to external databases as well. Sometimes, but only exceptionally, they may also require direct access to the main database.

THE HUMAN COGNITIVE PROCESS

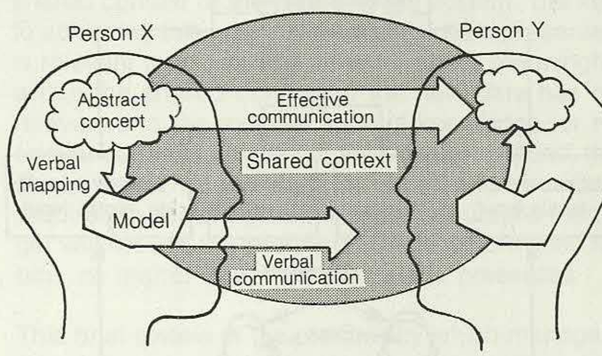
We noted earlier that, for decision-making purposes, data becomes useful only when it is transformed into relevant information by the person who receives it. To provide really useful information for managers, system designers therefore need to understand the way in which people assimilate and manipulate data as they transform it into information. This requires a basic understanding of the key components of the human cognitive process.

In Figure 1.2 we depict how a shared context exists between the participants in a conversation. Person X (the communicator) is uttering a sequence of words to person Y, with the aim of expressing an idea. If person X is successful in fitting his words to Y's context, then Y can re-create the mental image of the model of the idea that X is communicating. As the conversation progresses, new information is added to the shared context of X and Y, which means that future interactions between them will be easier to understand.

A similar situation exists when a person and a computer interact. In this case, however, the shared context normally depends entirely on the context as understood by the person who receives the data presented by the computer system. As long as the computer-generated messages are relevant to the person's context, the information content of the messages will be received successfully. When this is merged with the existing information in the person's context it enriches the body of knowledge in the human context. If the messages do not correspond with the context of the human receiver, then all that is received is data. At best this results in momentary confusion and additional work to augment the originally useless data, so that it can become useful information. At worst, the interaction becomes a total waste of time because the person either does not or cannot expend the additional time and effort required to interpret the data.

The designer of a human-computer interaction in-

Figure 1.2 The shared context of a person-to-person conversation



(Source: Mini-Micro Systems, September 1983)

evitably works with a conceptual model of the eventual user in mind. An important aspect of any computer user that is often ignored by such a model is the nature of human mental processes, the so-called cognitive modes of thought. These modes of thought are often classified into two categories corresponding to the left and right hemispheres of the brain. Recent research has indicated that this classification is oversimplistic, but it remains convenient for the purposes of discussion.

Cognitive modes of thought

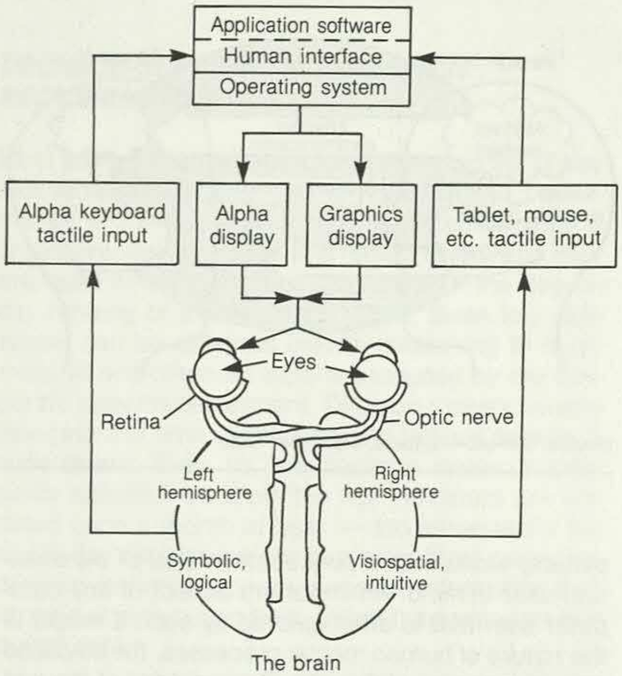
During the research for this report we spoke with Mr Marvin Patterson, a senior member of the Hewlett-Packard research and development staff in San Diego, California. He described Hewlett-Packard's model of the human cognitive process, which is depicted in Figure 1.3 (overleaf).

The model illustrates that there are two very different ways in which humans think — the symbolic, logical mode; and the visiospatial, intuitive mode.

In the logical cognitive mode, the human mind processes sequential tasks such as understanding language, reading and evaluating mathematical functions. This mode of thinking is generally associated with the left side of the brain which is the dominant side in most people. Data processed in the logical cognitive mode is usually sequential in terms of time or position. The left side of the brain is the verbal hemisphere. It uses words to name and define ideas and concepts.

The visiospatial, intuitive cognitive mode (sometimes known as the synthetic mode) is used for synthesising ideas and for recognising patterns. It is normally associated with the right side of the brain. For most people, it is the non-dominant mode of cognition. This

Figure 1.3 A schematic of the human-computer interface



(Source: Marvin Patterson, Hewlett-Packard Inc.)

mode appears to process data in a parallel or holistic manner, synthesising a 'whole' out of the individual parts. The intuitive mode tends not to use the spoken or written word. Some researchers believe that this mode is the source of creative ideas, and that the logical mode (or the left side of the brain) is used simply to verify and communicate ideas.

In recent research, Hewlett-Packard has determined that the data capacity of the human visual channel can be as high as three million bits per second from each eye to the brain. It is important to note that this capacity is more effectively utilised by the intuitive cognitive mode. The human visual channel seems to be vastly under-utilised by the symbolic, logical mode, which is the cognitive mode in use when a person is reading words or numbers presented on paper or on a visual display screen.

A second important component of the Hewlett-Packard model shows how the two cognitive modes allow the human mind to operate. In addition to the logical and intuitive states of mind, there is also the co-operative state, where both of the cognitive modes are available to process sensory inputs at the same time. Sometimes this results in interference between the two modes. But when they are operating in unison, they provide the most powerful means of perceiving and assimilating data. Indeed, the aim of many of the current developments in data-presentation techniques is to utilise the power of the co-operative state of mind. An example is the current interest in the use of integrated text and graphic techniques.

The human memory system

Psychologists disagree about the precise structure and function of the human memory system but, in general, they accept that it comprises three basic structures: sensory memory, short-term memory, and long-term memory.

Data initially enters the memory system through a temporary 'buffer', or sensory memory, which holds the contents of the observed data stream (images in the case of visual inputs) for a period of one to two seconds. The sensory input stream is then transferred to a second construct known as short-term memory, which holds the new data in raw form for a maximum of between 20 and 30 seconds.

Most researchers accept that the transfer channel from sensory memory to short-term memory has a limited capacity, so more data is 'sensed' than is actually stored in short-term memory. Short-term memory carries out immediate decision-making functions and controls the general flow of data within the overall memory system.

Once the mind has established that a relationship of some type exists between the data recently observed and the observer's real world, as defined by his existing knowledge, the data can be redefined as new information. From this point all the new information can be used either in a decision-making process, or stored away in long-term memory, or rejected, depending on its relative importance at that time.

Experiments by Miller in the 1950s (Reference 1) established that short-term memory is capable of holding between five and nine chunks of data (sets of coherent data) at any one time. Beyond about seven chunks the short-term memory function is easily overloaded. To avoid this situation, the memory system strives constantly to rid itself of unnecessary data. Subconsciously, we all seek to complete short-term tasks so that we may obtain the psychological relief associated with the clearing of excess data from short-term memory. This phenomenon is referred to as 'closure'. It is generally accepted that the process of closure allows information to be transferred from short-term memory to long-term memory where it is stored indefinitely, and is available for recall at a later time. The knowledge that makes up the shared context described earlier resides within long-term memory.

The human need to effect closure regularly is a key concept for system designers, and they must keep it in mind when they are designing the characteristics of human-computer interfaces. The closure phenomenon means that users often prefer to achieve an objective by performing several small tasks, rather than one large task. This approach enables users to monitor progress easily and without confusion. It also provides the maximum opportunity for closure to occur. A practical example can be seen in the common desire by word processing operators to use several separate simple commands, when one global command could be used to attain the same objective.

Implications for system designers

Our brief description of the human cognitive process shows clearly that the key to maximising the information content of a visually presented message is to activate the right side of the brain. This is achieved by using graphical images, rather than data presented in an alphanumeric form. The mind has very powerful capabilities for recognising patterns and changes in patterns. The present attention being focused on the use of computer-generated business graphics as a means of presenting information to managers is a good example of how these capabilities can be utilised.

System designers must also ensure that new data, once it has been perceived, can be easily linked with the body of existing knowledge that makes up the shared context of the user and the system. The key to achieving this is to ensure that the data presented is relevant to the particular need, and is meaningful within the shared context. If the new data has no relevance to the existing body of knowledge, or no relevance to the solution of the problem at hand, the observer will not gain sufficient reward for the effort required to access the data. If this occurs the manager will not use the information facilities provided for him, no matter how well the data is presented.

This brief review of the process by which managers transform data into information provides some important pointers for the ways in which management information should ideally be presented by computer systems. Some of these concern the ergonomics of presenting management information and man-machine dialogues (which we discuss respectively in the next two chapters). More significantly, this chapter has shown that computer-generated business graphics has a significant role to play, and we explore this issue in greater depth in Chapter 4.

CHAPTER 2

THE ERGONOMICS OF PRESENTING MANAGEMENT INFORMATION

We now turn to the ergonomic factors that need to be considered as the hardware and software elements of management information systems are chosen or constructed. We limit our discussion here to five key factors:

- —The legibility of characters presented on a display screen.
- —The use of colour on display screens or in computer-generated printouts.
- —The effect of variable system-response times.
- —The format and structure of system messages.
- —The format and structure of screen layouts.

Where appropriate, we provide practical guidelines for system designers under these headings. Another key ergonomic issue is the design of the man-machine dialogue, which is addressed separately in Chapter 3.

Ergonomics also includes wider issues, such as the design of equipment and of the workplace, and organisational and procedural considerations. Although we do not discuss these wider issues here, Foundation Report No. 20 — The Interface between People and Equipment — contains a full discussion of all the relevant ergonomic factors.

CHARACTER LEGIBILITY

Legibility should not be confused with readability, which is concerned with the style and grammar of a piece of text. Readability therefore determines the ease with which the information in the text can be understood. Legibility refers to the typography of the text, which determines the ease with which the text can be transferred into the human brain during the mechanical process of reading.

The mechanics of reading

Reading involves two stages. First of all, the reader has to look at the visual information and recognise the characters and character strings that form words. The second stage is to understand the information presented in the text. The process of understanding what is read involves matching the visual symbols with the existing knowledge contained within the shared context, as described earlier in Chapter 1.

During the mechanical process of reading, the eyes do not move from one character to the next. Instead, they scan along the line in a series of rapid jerks, not differentiating between individual characters, but focusing on particular character strings. The legibility of information displayed on a screen is therefore related to the shape and definition both of individual characters and of the whole text.

When printed material is being set out on a page, the art of typography is used to determine the most effective layout of an entire line, even an entire page. Today, the constraints previously imposed by the rectangular lead slugs used in traditional typesetting technology have been replaced by the constraints of the rectangular character matrices used to generate characters on a display screen. Both technologies present the same general problems, and the accumulated expertise from the field of typography can be applied to improve the legibility of information displayed on a screen.

The desirability of positive presentation

Because the understanding stage of the reading process requires the brain to match the recognised symbols with a pattern that is already stored in the mind, screen displays should be presented in a way that is as familiar as possible. At the present time, and for the foreseeable future, this means that screen layouts should be similar in appearance to a printed page.

Most printed material uses 'positive presentation', which means that dark characters are superimposed on a white background (as on this page). Many applied psychologists now accept that positive presentation is more legible than other forms of presentation. But it is not easy to achieve flicker-free positive presentation on a display screen. Terminal suppliers are finding that the only effective way of eliminating the perceived screen flicker that usually accompanies an increase in the brightness of the background is to increase the refresh rate of the display. Although it is technically possible to do this, it increases the price of the terminal.

Character design and size

Hundreds of different typesetters' character sets (fonts) are available. The designer of a font has to create characters that are functional, economical and clear, whilst also being aesthetically pleasing. Many typesetting fonts strive to achieve this ideal by using variable stroke widths within the same character. But the trend today is to use a stroke of uniform thickness, as in the characters produced by a typewriter, for example. Uniform stroke thickness does not hinder legibility, provided that the stroke width is about one-fifth of the total character width.

Research has also shown that the legibility of mechanically produced text is improved if the inter-character spacing is proportional to the character widths. Proportional inter-character spacing should not be confused with proportional inter-word spacing, which is discussed later on this page.

Most commercially available display screens use a character size of 3mm. Recent research has shown, however, that this is not the optimum size for reading efficiency. For viewing from the usual distance of about 75cm, the optimum character height is 4.75mm for digits and 3.96mm for letter strings. Reading efficiency depends on a continuous forward movement of the eyes, and these character heights are the optimum for achieving this. The research has confirmed that terminal users are quite justified in their dissatisfaction with the reading speeds they can attain.

The size of character ascenders and descenders also has a significant impact on character legibility. When reading, the eyes tend to move along the top 'coastline' of the line of text, picking up cues from the shape of the letters and their surroundings. The legibility of lower-case characters can be increased by lengthening the ascenders and shortening the descenders. This creates a problem for today's dot-matrix printing technology, which uses a limited character matrix. For characters displayed on a screen, ascenders and descenders can only be used with a matrix of at least 7 x 9 positions, and a larger matrix is required to differentiate the lengths of ascenders and descenders (as we explained in Foundation Report No. 20, on the interface between people and equipment).

Line length

Line length is another important element of legibility. If a line is too long, the eyes either lose track or have difficulty in locating the beginning of the next line. The classic example of the disadvantages of an over-long line length is provided by the standard 132-position computer printout. Either the reader has to place a ruler under the line being read or special 'music score' stationery has to be used to provide the reader with visual cues.

The ideal line length depends on the character set used, the character size and the amount of space between lines of text. Typographic researchers have determined that a line length of between 80mm and 90mm, with ten to 12 words (60 to 70 characters) per line, provides the maximum legibility. The line length on this page is 80mm.

The use of space and shape

Legibility also has to do with aesthetics. By creating a well-balanced pattern, the typographic design of a line or paragraph can stimulate a discerning reader. Typographers have known this for many years, but information system designers are only now beginning to realise that layout, in terms of space and shape, has a significant impact on the ease with which data can be assimilated.

Most material displayed on a visual display terminal is not intended for long, continuous reading sessions. Very often the reader has to re-focus from one part of the screen to another, or from the screen to a written document and vice versa. Typographic cues, in the form of space, are an essential element in conveying the structure of the text or data displayed on the screen. For example, indentation and horizontal spacing can be used to signal logical groupings to the reader.

For maximum legibility, text displayed on a screen should be punctuated correctly, a factor that many information systems designers seem to ignore.

Much attention is also paid as to whether text should or should not be right-justified (that is, should the line-ends form a straight or ragged line). In recent experiments, the use of unjustified lines with standard inter-word spacing resulted in no significant differences in reading speed or comprehension. Another advantage of unjustified text is that it is not necessary to hyphenate words at the end of lines, which also improves the readability of the text.

Right-justification of computer-generated text (printouts or screen-based) is usually achieved by inserting extra complete character positions between words. This can cause excessive inter-word spaces, which interrupts the pattern-recognition processes of the human visual system. To create the best aesthetic effect, right-justification requires that inter-word and inter-character spacing are adjusted in proportion to each other. It is not possible to achieve this ideal with the fixed-width characters used by most printers and display devices.

Scrolling techniques

Various scrolling techniques are used with visual display terminals. Research has shown that most users find that non-smooth, irregular (or jump) scrolling is distracting. They prefer a smooth scrolling technique, where the text appears to move continuously up or down (or across) the screen. Smooth scrolling can be achieved — but at the cost of more expensive electronics.

A common compromise is to provide 'partial-page erasure with continuation'. This technique moves the last two or three lines from the previously displayed screen to the top of the next. The text display then continues below the re-positioned lines. Although partial page erasure is not as pleasing as smooth scrolling, it can be achieved at relatively little additional cost, and has been shown to be more effective (in legibility terms) than jump-scrolling.

THE USE AND ABUSE OF COLOUR

In the past, using colour for computer-generated information was expensive, and its use was therefore limited. Colour is now readily available for display screens, printers and plotters at a price that permits a much wider use. But the tendency is to use colour just because it is available, without too much thought about whether it is appropriate for the particular circumstance. Used properly, colour can convey very strong messages, but it should never be used merely to make a display or printout look pretty. System designers should also bear in mind that eight per cent of the population are colour-blind.

Different techniques are used for generating colour on a display screen and a printed page. Visual display terminals and projection systems respectively use luminous sources and reflective surfaces. Light enters the eyes either directly from a display terminal, or indirectly after it has been reflected off a screen, and the various hues are created by combining the three additive primary colours: red, green and blue, as shown in Plate 1 on page 19.

The additive method of producing colour results in a significant difference in the luminance of different colours. For example, green would have only 59 per cent of the luminance of white; red would have 30 per cent; and blue would only have 11 per cent. This explains why red or blue text on a display screen can be illegible.

With coloured printed pages, ambient white light from the sun or an artificial light source bounces off a coloured surface before entering the eyes. Unlike a television display, printed surfaces do not adjust the amount of red, green and blue light being transmitted. Instead, they reflect the spectral components of light that are not absorbed by the inks forming the image. The spectral characteristics are defined when the page is printed, not when it is viewed as with a display screen.

Colour printing uses the subtractive primary colours: cyan, magenta and yellow. By using pure dyes, the additive colours (red, green and blue), can be obtained by mixing the subtractive colours in appropriate proportions. Combining all three equally produces black. Plate 2 on page 19 shows how the subtractive primary colours can be mixed to create various hues.

The properties of colour

A person's perception of colour can involve subjective judgements. The statement "His car is blue" may cause one person to think of the colour of the sky, and another to think of the colour of a favourite article of clothing. In order to provide some precision when describing colour, it is often discussed in terms of three properties:

—Hue, which describes the particular colour's position in the overall spectrum of colours.

—Value, or luminosity, which describes the brightness of a colour.

—Chroma, or saturation, which describes the purity of a colour. For example, a vivid blue mixed with grey gives a duller blue that is said to have less chroma.

One system that is used to categorise colours is the Munsell colour solid, which is illustrated in Plate 3 on page 19. Hues are depicted on the circle around the structure, values are measured along the axis of the globe, and chroma is measured from the axis to the surface of the solid. Pure colours are on the surface of the structure. The Munsell colour solid can be used by information system designers to determine special relationships between colours, by helping to highlight how they will work in combination. A colour wheel, of the type shown in Plate 4, can also be used to determine which colours should and should not be used in conjunction with each other.

The impact created by a particular colour is also strongly influenced by its surroundings. In the example shown in Plate 5, the squares of colour were each drawn with the same ink. The different backgrounds cause the colours to appear different. This is an important point to remember when transferring a colour image from a display screen to a pen plotter. Colours that look good against the display background may not be as effective on white paper.

The use of colour with visual display terminals

Because colour is self-evidently attractive, many people assume that computer-generated colour displays automatically bring benefits in the form of improved performance or efficiency. There now appears to be little justification for such assumptions. But those who believe that the use of colour will improve staff morale or job satisfaction are more likely to have their hopes fulfilled.

The main difficulty is that, at the present time, not enough is known about the effect that luminous colours, as generated by a display terminal, have on the human work process. The available data about the use of colour derives mainly from studies of non-luminous (printed) colours. Further research is required to determine if the findings of these studies apply also to the use of luminous displays. Human factors studies concerning the use of luminous colours have focused on the use of CRT displays. The findings of such studies are often made obsolete by new technological advances. And, as yet, little work has been done on the use of colour with plasma displays and other display techniques. As a consequence, it is not yet possible to provide ergonomics recommendations concerning the use of colour with such devices.

Colour coding is a very powerful way of conveying important information. Because the technology of colour displays is still evolving, system designers need to beware of choosing a colour-coding scheme that may be made obsolete by further technical developments. Once a particular colour-coding scheme has been selected for use in a particular context, it is very difficult to change or replace it. Meanings associated with a particular colour cannot easily be re-assigned without leading to user errors that may be dangerous.

Significant benefits can be gained in specific applications by using colour displays, as a recent survey in the United Kingdom carried out by Storage Technology Limited showed. The aim of this study was to determine the impact of colour displays on the productivity of data-entry operators. The results of the survey were:

- —74 per cent of the operators surveyed said they preferred to work with colour.
- —52 per cent said the main reason for preferring colour was that they believed it caused them to make fewer errors.
- —48 per cent said that using colour terminals reduced eye strain and headaches.
- —33 per cent said that using colour terminals made them less tired.
- —80 per cent believed, incorrectly, that their productivity had not increased.
- —13 per cent believed that their productivity had increased.

These results show clearly that, for this specific application, the use of colour terminals led to significant benefits. System designers should not assume, however, that introducing colour terminals into other types of application will automatically guarantee improved performance. Appropriate use of colour can, without doubt, reduce the time required to find information displayed on a screen, and it can assist in the cross-referencing of information. But, as David Hopkin, psychologist at the Royal Air Force Institute of Aviation Medicine has pointed out, the real benefits of colour displays are likely to be in the form of more favourable attitudes by users, and in greater job satisfaction (see Reference 2). These benefits may, of course, lead indirectly to improved performance in specific circumstances.

Practical guidelines for using colour

System designers need to take account of five factors when they are defining computer-generated colour output, and examples of some of these factors are illustrated in Plates 6 and 7. We now provide practical guidelines on each of these five factors.

1. The number of colours

The optimum number of colours that should be used within one display or printout depends on the type of application. Where absolute colour recognition is required (that is, each colour has to be identified positively in the absence of all the others), as few as four carefully chosen colours may be the optimum number. Using more than this could easily result in the occasional mistake.

A larger number of colours is appropriate only where all or most of the colours are displayed simultaneously, so that the user can easily discriminate between colours in the range. An example is a map of the world, colour-coded to show mean annual temperature.

However, even with present state-of-the-art display technology, proposals to use more than about six colours simultaneously should be greeted with scepticism. In general, the higher the number of colours used simultaneously, the more critical becomes the actual choice of colour.

2. The dominance of colour coding

Colour coding is a very powerful means of conveying information, and it is important that the same colour is not given a different meaning in different parts of the information system. Severe difficulties could be experienced if staff who are used to one meaning have to switch to a different meaning for the same colour when they change jobs. Colour coding dominates other forms of visual codings. In general, its use should be reserved for highlighting very important distinctions.

Another factor to bear in mind when deciding on a colour-coding scheme is that colour display technology is still improving. In the future it will be possible to use greater subtlety in colour coding. But if this involves a major recasting of an existing scheme, it will be difficult to make the best use of the newer technology because of the difficulties mentioned above.

3. The extent to which colour should be used
Because colour facilities are available there is a great temptation to use colour indiscriminately. For many business purposes, a display that is largely monochrome is perfectly adequate, with colour used sparingly to draw attention to selected or transient information. (Flashing could also be used initially to draw attention to the same information, but this feature is irritating if it persists for more than a few seconds.)

Colour terminals are often proposed as a replacement for existing systems, based on monochrome terminals, which already contain ways of discriminating between different types of information. Any proposal to replace an effective monochrome system with a colour system should therefore be viewed with caution, because the changeover could result in operator errors and confusion.

4. Using colour as a cross-reference aid
Although our research did not identify any specific examples of colour being used as a cross-reference aid, we believe that, potentially, this is an important application. For example, all the information relating to one particular task could be displayed in the same colour.

5. The optimum use of colour is task-related
Laboratory studies of people's reactions to colour coding usually employ a single task, and use a coding scheme that is tailored specifically to that task. Most real-life situations are more complicated than that, typically involving multiple tasks. The optimum colour-coding scheme for one task may not necessarily be the optimum scheme for another task and may, in fact, hinder the performance of the other task. Any colour-coding scheme therefore needs to take account of all of the tasks for which it may be used.

The use of colour can be associated with various types of task. For example, colour is usually a positive factor in searching tasks, but research by Carter and Carter in 1981 (Reference.3) has shown that, if the colour of the desired information is not already known, it takes longer to search for the required information, in a multi-coloured display.

The benefits of using colour need not be confined to the actual interaction between user and terminal. Another task-related benefit of colour is that it helps the user to remember specific aspects (perhaps a particular data item) of the task at a later time.

RESPONSE TIMES

Recent research with videotex systems has shown that many users of computer systems find variable response times to be more frustrating than consistently slow response times. Nevertheless, the ideal for which the system designer should strive is to provide a consistently fast response time. The optimum is to simulate conversational interaction between two people where, if there is a break of more than about two seconds, closure (as defined in Chapter 1) occurs. Most systems should aim for a response time of less than two seconds. Some should aim for significantly less. For example, where the user interacts directly either with a touch-sensitive screen or with a light pen, response times should appear to be instantaneous.

There are many examples of the economic advantages of faster response times. For high-volume applications, a ten per cent reduction in the time taken for each transaction can often lead directly to an equal reduction in staff, terminals and other hardware. One dramatic example is provided by the Quality Inn motel chain in the United States, which, on average, was taking 150 seconds to service a reservation request. This organisation has invested heavily in developing an improved online reservation system as a means of reducing the time. It estimates that each second by which the average service time is reduced produces an annual saving of $40,000.

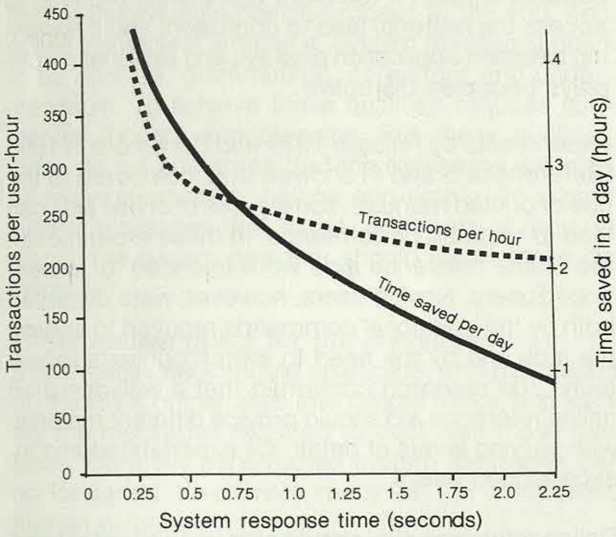
According to a study by IBM, productivity measured in terms of transactions per hour continues to improve as response time is reduced down to 0.18 seconds (see Figure 2.1). Error rate also decreases as response time decreases.

Response-time guidelines

During the research for this report we examined a variety of studies that had investigated the effects of response times. We set out below the most relevant guidelines obtained from these sources:

- Feedback from typing and cursor movement commands should generate results in no more than one-tenth of a second.
- Responses from simple commands should take less than one second.
- Responses from other commands may take more than one second, but the response times for similar commands should all be about the same. The variation in time should be no more than about 20 per cent from the average response time.
- Faster response times are not always advisable. As the response time shortens, users increase the speed with which they respond to the system and may make hasty (and wrong) decisions. This is particularly true for inexperienced users.

Figure 2.1 The relationship between user productivity and system-response time



The data relates to a computer aided design application. The time saved by improved response times is compared to a 3 second response time, when system users can complete only 180 transactions per hour.

(Source: IBM)

— Faster display rates are preferable if the user is familiar with the displayed material, or if only a small part of the display needs to be examined.

— Slower display rates (of about 15 to 25 characters per second) should be used for inexperienced users. Tests have shown that inexperienced users prefer slower display rates and make fewer errors when they are used.

— If the full text displayed on a screen is to be read, then there is no advantage to be gained from using display rates that are faster than normal reading speed.

FORMAT AND STRUCTURE OF SYSTEM MESSAGES

Most users of computer systems are not computer specialists, and many of them experience their greatest difficulties when they make a mistake or are not sure what they should do next. In these situations, system messages such as "fatal error", or "illegal command", or obscure codes such as "OC7", are totally inappropriate. The reactions of inexperienced users when they are first confronted with such messages range from confusion to dismay. Instead of being helpful, the messages may actually discourage the user from continuing with the transaction. Figure 2.2 illustrates some well-meaning attempts by computer professionals to create user-oriented messages, and the reaction of typical end users to these attempts. In this section of the report, we provide advice on how to construct system messages that are helpful to the users of the systems.

Error messages

Error messages are inevitably displayed at a time when the user is confused, or has incomplete

Figure 2.2 Typical examples of unfriendly dialogues

The figure illustrates some well-meaning attempts by computer professionals to design user-oriented software, and the reactions of typical end users to these attempts.

Quality intended	*Typical example*	*Quality shown*
Patience	"YOU HAVE BEEN IDLE FOR TOO LONG" (message to user of timesharing system)	Impatience
Tolerance	13/04/81 not accepted as valid date because system expects month/day/year	Intolerance
Warmth	"FATAL ERROR" "TERMINATE" "ILLEGAL ENTRY"	Intimidating/hostility
Politeness	"ERROR" — means "I'm sorry I don't understand"	Arrogance
Understanding	"REMOTE TERMINAL" — means a terminal remote from the computer, which is probably on the user's desk	Self centred
Helpfulness	"HO70" (on the IBM 5260 retail system). The manual reads: "The personalisation change control number on the diskette that is in the machine does not match the personalisation change control number that is in the protected totals area of the machine — it means that you have put in the wrong diskette"	Obscurantism
Sincerity	"HELLO" response by a terminal, instead of a light to show the power is on	Insincerity

(Source: VRS '83, Butler Cox & Partners Limited, 1983) knowledge. Because of this the impact of error messages is more powerful than that of other forms of system message. Experiments by Schneiderman in 1982 (Reference 4) produced a series of guidelines for generating system error messages. The most important are summarised below:

— Do not condemn the user for making the error, but use positive messages that indicate what must be done next. Avoid using terms such as illegal, invalid, error or incorrect. For example, instead of displaying "illegal password", use "your password does not match with a valid password. Please try again".

— Use terminology with which the user will be familiar. Avoid the vague "syntax error" or obscure internal codes. Instead of displaying "invalid data" in an inventory application, use "the part number you keyed in was outside the valid range x to y".

— Make the users feel they are in control of the situation, and provide enough information for them to take the next action. For example, instead of the domineering "enter next request", display "ready for next command".

— Use an uncluttered and consistent format. Avoid long numeric codes and obscure mnemonics.

— Ensure wherever possible that the text of an error message is complete in itself. Avoid the situation where the user has to search through a mass of reference material in order to translate the message.

Composing good error messages requires experience, practice and understanding of how the user will react. Nevertheless, the skills can be acquired and refined by system designers. Even so, it is extremely difficult to construct ideal error messages without first testing them on the intended user community in the same way as other elements of the total system.

Online reference aids

Many people use computer systems infrequently and irregularly. Some may not use a terminal for weeks at a time, but may then use one intensively for several days. Such users are continuously changing from novice to expert, then back again. They have a need for reference material, but experience has shown that interrupting a session at a display terminal to find a printed reference manual and locate the relevant material discourages use of the system.

To overcome this problem, many system designers provide sufficient online tutorial and reference material to make printed manuals unnecessary. The advantages of this approach are that the online material can be focused on the user's current task, can be updated regularly, may be less difficult for the user to locate, and avoids the costs and delay of printing and distributing manuals. But there can also be disadvantages, particularly if the quality of the online material is poor, if the extra commands required to access the material lead to confusion, and if switching between application displays and explanatory displays becomes disruptive.

Experiments by Rilles in 1979 and Dunsmore in 1980 (References 5 and 6) showed that, compared to the use of printed manuals, some types of online aids can lead to reduced performance. In these experiments, the online reference aids were intended for experienced users. Novice users, however, were disturbed both by the additional commands required to access the aids and by the need to switch contexts repeatedly. The research confirmed that a well-designed online reference aid should provide different material, with varying levels of detail, for experienced and inexperienced users.

Online reference aids should also use consistent and uncluttered screen formats, so that users know where to look for specific information and specific types of messages. This type of layout also allows positional cues to be used when searching for previously retrieved information.

In summary, novice users require well-structured and detailed information; experienced users become frustrated if they have to plough through the same material. Although we did not discover any examples, we believe that the use of multi-window display techniques could be used to advantage here.

Drawing attention to system messages

Sometimes, system messages need to be reinforced by the use of an attention-grabbing mechanism, such as increased brightness, colour, flashing, or reversing the image. Such mechanisms should be used in moderation, and the need to use them is determined by how well the message stands out from its surroundings. Over-using these features can easily cause distraction, so reducing their impact. A flashing message, for instance, can be a powerful means of attracting attention when used with discretion. But persistent flashing (continuing for more than a few seconds) can also be extremely distracting. Highlighting a message by increasing the brightness, or by using a bright colour, or by reversing the image, or by underlining are also effective, but they can reduce legibility.

A special character, such as an asterisk, is sometimes used to signify a system message. This is not a particularly good way of gaining the user's attention, but a special character can be an effective means of signifying that a message is of a particular type. For example, an asterisk could be used to denote all error messages.

Guidelines for creating system messages

All system designers want to create effective system messages. In reality, however, they often leave this part of the systems design process to the end, and spend insufficient time on it. System messages need to be concise, grammatical, consistent and understandable. To achieve these qualities requires substantial thought and planning. But these qualities alone do not guarantee that the messages will also be relevant, specific, helpful and timely. To create system messages that satisfy both sets of requirements, the system designer should follow these six steps:

1. Set human goals for the messages
System designers should anticipate, and be tolerant of, the kinds of mistakes that people make, and identify the messages required to deal with those mistakes. Carefully constructed system messages can be designed to correct many of the anticipated human errors.

2. Apply psychology when composing messages
The designer needs to know how people think and feel about information systems. Messages should match users' expectations. They should also be designed to put users at ease, and be completely intelligible the first time they are encountered. The designer should first decide what meaning to convey, then select the information required to convey that meaning and choose the appropriate language in which to present it.

3. Evaluate the messages
Before the messages are actually coded, they should be evaluated by the users. Construct a prototype system, and observe the ways in which the users react to the system messages. Allowing the users to try the system in this way can be most instructive, and can avoid surprises at the system implementation stage.

4. Edit the messages
After the messages have been evaluated, the language used should be edited to ensure it is clear. System messages should use familiar terminology. Ideally, they should adopt a conversational tone, and use standard punctuation. Messages of the same type should also use similar wording.

5. Design the message-generation routines
The designer can now define the functions of the programs or system that will produce the system messages. Steps 1 to 4 above ensure that human requirements will not be compromised for programming convenience at this stage.

6. Test the messages
The ease with which system messages can be used should be evaluated again after the program or system is working. This should be done by observing the ways in which the system is used in realistic situations.

FORMAT AND STRUCTURE OF SCREEN LAYOUTS

Although the importance of designing good screen layouts is now widely recognised, the actual process of designing layouts is not yet a precise science. The body of knowledge derived from experimental studies is, as yet, limited. Little attempt has been made to apply the wealth of available information about the design of printed materials (such as books and newspapers) in a systematic way. In reality, most screen-layout designs depend more on the whims of the individual designer than on any other factor. As a result, many of today's screen layouts are difficult to use because they are cluttered and lack visual clarity.

At best, a poor layout can adversely affect productivity. At worst, it can deter people from using the system at all. A complex screen layout can lead some users to infer that it requires more effort to understand than they are prepared to make. Those who have the choice (particularly managers and professionals) may decide not to use the system at all.

Two basic concepts should be applied when designing screen layouts:

- —The users' learning requirements should be kept to a minimum.
- —Skills acquired by users in one situation should be transferable to a similar situation.

Both of these concepts require that screen layouts be designed in a consistent manner.

Design consistency is usually achieved by applying design standards or guidelines, some of which are set out below. Such guidelines are often very wide in scope. Occasionally, they conflict with each other or with machine processing requirements. In resolving such conflicts, the system designer must consider the alternatives and reach a decision based on accuracy, time, cost and ease of use.

Guidelines for designing screen layout

In setting out guidelines for designing different types of screen layouts, we have identified five main types: data-entry screens, enquiry screens, interactive screens, menu screens and multi-window screens.

1. Data-entry screens
Data-entry (or data-collection) screen layouts are normally used by specialist operators to collect large amounts of information quickly and accurately. Typically, they comprise a large number of labelled fields

into which data is keyed. Data-entry screens are sometimes referred to as fixed-form or form-filling screens. In many data-entry applications, the screen layout is not of prime importance because the operator focuses on a source document for most of the time, looking only occasionally at the screen.

2. Enquiry screens
Enquiry screens are used to display the results of an enquiry that has been made to a computer file or database. Once it has been displayed, the data on an enquiry screen is not changed. The overriding design objective should therefore be to structure the layout as clearly as possible, so that the user may easily scan the screen to locate the required data. Specific guidelines for the layout of enquiry screens are:

- Display only the data which is necessary to satisfy the enquiry. Do not display data that is never used.
- If multi-screen displays are necessary, place the most frequently used data on the first screen. Within a screen layout, place the most frequently used data in the top left-hand corner. If necessary, repeat from screen to screen the data that is frequently used.
- Use easily identifiable logical groupings of data, so that the user can quickly scan the screen to locate a required item. This can be achieved either by using columns or, if colour is available, by colour coding groups of related data.

3. Interactive screens
Interactive (otherwise known as conversational) screen layouts are used for a series of short alternating communications between user and system. Typically, the system provides a prompt, and the user responds; or the user makes a short unprompted request and the system responds. The dialogue proceeds on this basis, with the computer and the user sharing in a continual step-by-step interaction. Interactive screens thus contrast with the two types of screen already described, where the communication occurs on a full screen basis, with the system using all of the available display area, and the user being able to work with the entire screen before sending back a response to the system.

Interactive screens may also be used for data-entry purposes, or to display the results of enquiries. They are, however, not very efficient when used in these ways because of the excessive amount of communication resources required.

Two key ergonomic factors need to be considered when an interactive screen layout is being designed:

- To avoid exceeding human memory limitations (as discussed in Chapter 1), an interactive conversation needs to be based on short messages.
- If the user's response is based on a previous message, that message should still be visible on the screen at the time the user is required to respond.

4. Menu screens
The primary purpose of a menu screen is to permit the user to select one or more items from a list of alternatives. As such, it combines in a unique way the characteristics of both data-collection and enquiry screens.

Menu screens are particularly effective because they utilise the powerful human skill of visual recognition. The primary design objective for menu screens is ease of visual scanning. The secondary objective is ease of selection.

Menu screens are, without doubt, of great value to the inexperienced or infrequent system user. But an experienced user can find it tedious to have to step through a series of menu screens. The designer of menu screens must therefore consider the conflicting requirements of inexperienced and experienced users.

A series of menu screens should be structured in a hierarchical, or tree, manner with the primary or basic choices listed on the first screen, and lower-level choices on subsequent screens. The user may then step down the various levels until the desired alternative is reached. This hierarchical structure is recommended because the display of all possible, but not necessarily relevant, choices interferes with the user's performance.

Experiments by Ramsey in 1979 (Reference 7) showed that a hierarchical series of menus on separate screens, with the menu always displayed in the same area of the screen, was preferable to several menus being presented simultaneously on different parts of the same screen.

Nevertheless, menu screens should be designed so that the user need not always step through several levels to reach a particular point. A bypass mechanism should be provided to allow multiple menu selections to be made at one time. Similarly, an escape mechanism should be provided to allow the user to exit from a particular level to the main menu screen at the top of the tree.

Specific guidelines relating to menu screens are set out below:

- Abbreviations should be avoided wherever possible.
- The words describing the choice should be consistent with those used in the transaction or data screen being accessed.

—The order in which menu items are displayed depends on the number of items and their frequency of use. With seven or fewer items, sequence them with the most frequently used item at the top. If there is no significant difference in the frequency and use, display the items in alphabetical sequence. If the menu contains eight or more items, display them in alphabetic sequence irrespective of their frequency of use.

—Mixing information with the menu provides users with some reward for their effort.

—Users should be able to step back up through the hierarchy, retracing the route of their descent.

—Users should be able to retain a mental model of the root structure of the tree. Cross-routeing between different branches of the hierarchy can cause users to become disoriented.

—Finally, menu screens should be avoided where the data is complex or unstructured.

5. Multi-window screens

Windows are a recent innovation, by which two or more discrete displays may be shown simultaneously on the screen of an intelligent terminal or personal computer. The technique demands complex software, as well as high-performance hardware with a bit-mapped high-resolution screen (upwards of 512 x 512 display positions), a large display memory and a powerful processor. First introduced on the Xerox Star, windows were later adapted by Apple for the Lisa personal computer and more recently by other suppliers of personal computers and intelligent terminals. As the cost of hardware continues to fall, so more devices may be expected to offer window features. The Xerox Star, for instance, was priced at about $15,000 in 1981. By early 1984, its price had been reduced to $10,000, about twice that of a conventional personal computer. The price differential of devices with and without multi-window display features may be expected to drop in the future, perhaps to as little as 20 per cent by 1986.

Because windowing techniques are still new, little formal research has yet been undertaken into the human factors associated with their use. In our research we found that senior managers who have become pioneers in using multi-window displays are generally enthusiastic about them. Compared with conventional displays, their main benefit is the ease of use, and particularly the ease with which information (text or graphics) can be transferred from one application window to another. A typical example we encountered was that of a manager using a Lisa for VisiCalc, graphics plotting and text editing in three concurrent windows. Windows enable one part of a display to be used for data and text while another part is used for graphics.

To take full advantage of the ability to transfer information between windows requires a method of rapidly identifying points on the display. For this, some users find the conventional keyboard-operated cursor control to be less than satisfactory. One alternative is the mouse, though our research revealed mixed feelings about it: newcomers like it, but experienced users saw little advantage in it. Another alternative is to touch the screen, either with a finger or a light pen. Again, we encountered mixed feelings about these methods.

At present, windows are used mainly with stand-alone personal computers. There is very little use of windows in corporate applications. However, a few organisations (for example, the Greater London Council) are experimenting with systems in which one or more windows on a single device can act as terminals to a mainframe, whilst other windows carry out local word processing, graph plotting, and so forth. The idea is to access information processed on mainframes, or available from external sources, and to manipulate it locally for inclusion in other documents.

In summary, windows appear to be a powerful tool for presenting information to managers. We expect them to become more widely used as prices fall and as devices with windowing techniques are connected to corporate systems.

SUMMARY

In this chapter we have reviewed the most important ergonomic factors relating to the successful design and implementation of systems that present management information. The key message is that the characteristics of the specific user community towards which an information system is oriented must be the paramount consideration in the mind of the system designer. Whether the designer is making decisions about legibility, or the use of colour, or appropriate response times, or message and screen formats, or the use of multi-window displays, the effective performance of users must always take precedence over technical convenience.

CHAPTER 3

MAN-MACHINE DIALOGUES

Everyday communication between people allows for many inaccuracies in the language used. If a speaker or writer makes a syntactic or spelling error, the listener or reader readily corrects it. Because present-day information systems lack this corrective ability, they are a source of frustration — particularly to infrequent users such as middle and senior managers.

Systems typically respond only to commands that are structured with total accuracy, using a highly constrained artificial language. Users who mis-employ the language, or make the smallest syntactic mistake, are greeted by a response from the system which is often a cryptic error message: quite unlike the type of response that the user would expect in a person-to-person communication.

The computer industry has become increasingly aware of this man-machine communication barrier, and a shift in emphasis is now in progress. As James Martin stated more than a decade ago, "Increasingly, man must become the prime focus of systems design. The computer is here to serve him, to obtain information for him, and to help him do his job. The ease with which he communicates with it will determine the extent to which he uses it. Whether or not he uses it properly, will depend on the man-machine language available to him, and how well he is able to understand it." Despite this warning, the current state of man-machine dialogues is still far from ideal.

System designers must take account of three basic factors concerning man-machine dialogue before they can hope to implement systems that successfully present data to managers:

—The importance of dialogues.

—The characteristics of the various dialogue modes.

—The choice of an appropriate dialogue mode.

In this chapter we provide an overview of each of these factors, together with practical guidelines for dialogue design.

THE IMPORTANCE OF DIALOGUES

A computer dialogue has been defined as a set of procedures for exchanging data, commands and responses between a computer-based system and its users, via the medium of an interactive device such as a display screen or a keyboard/ printer terminal. This interchange between system and user is called a dialogue because it implies initiative by both parties, and because, at least in a limited sense, it has the properties of a conversation.

The structure of the man-machine dialogue is fundamental to users' perception of how a system operates. As far as users are concerned, the dialogue is the system, to a great extent. If users enjoy the dialogue and understand its characteristics, they are likely also to accept the system in general and be able to use it effectively. If, on the other hand, the dialogue proves awkward and unfriendly to use, or implies subservience to the system, then users are likely to take a hostile view, thereby reducing the overall effectiveness of that system. Again, this reaction is particularly true of senior managers.

Good dialogue design is therefore of crucial importance. In many cases, it can be the key to success or failure of the total system.

Man-machine dialogues should take account of people's varying needs for feeling that they are in control of the system. In using information systems, the desire for control apparently increases with people's experience. Inexperienced users may be quite happy for the computer to take the initiative in the dialogue and issue instructions for them to obey, or questions for them to answer. But psychological studies have shown that, as users gain experience of a system, they usually begin to resent domination by the system. They find that a machine-controlled dialogue becomes a constant irritant that impedes their efficiency. The ideal man-machine dialogue should allow users to choose the degree to which they control the dialogue.

Dialogue design factors

The primary objective in designing a dialogue is to create an environment which makes it as easy as possible for the user to understand and absorb the system's part of the dialogue. There are four key considerations in achieving this ideal:

—The designer must be aware of the limitations of the human short-term memory system, and the associated need for frequent closure. (The phenomenon of closure was explored more fully in Chapter 1.)

—The designer must be aware of the degree of control over the system that the user is most likely to desire — allowing, within any one transaction, for the most appropriate conversational 'atmosphere'.

—No single dialogue design can ever be equally acceptable and effective for all users at all times. From the first stage of system design, therefore, it is vital for the designer to construct the dialogue with the characteristics of the intended user population very much in mind.

—The designer must provide the means to change the style of the dialogue. Inexperienced users prefer a machine-driven dialogue. Experienced users need to feel that they are controlling the system.

DIALOGUE MODES

All information system dialogues can be categorised into one of four modes: direct mode, menu mode, form-filling mode, and natural-language mode. We discuss in this section the characteristics of each of these modes, together with their specific advantages and disadvantages. Later in this chapter we provide practical guidelines for the use of each of these modes.

Direct-mode dialogues

Direct-mode dialogues require the system user to enter commands using a syntactically formatted command string, with little or no prompting. Two forms of syntax are used with direct-mode dialogues — positional syntax and keyword syntax.

With positional syntax, the parameters are identified by their position in the command string. Usually, delimiters such as commas or other characters are used to separate adjacent parameters. With keyword syntax, however, the sequence of the parameters does not matter. Instead, each parameter is individually labelled with a keyword, which should have an obvious relationship to the reason for the parameter's existence in the command.

Figure 3.1 provides a summary of the advantages and disadvantages of direct-mode dialogues.

Figure 3.1 Advantages and disadvantages of direct-mode dialogues

Advantages	*Disadvantages*
Concise and precise syntax. Suitable for frequently entered commands. Experienced users can take the initiative. Experienced users find it to be the fastest way of entering commands.	Extensive training, followed by regular use, may be required to become fully proficient in using the dialogue. The user may need to retain a lot of information in his memory. Frequent references to printed manuals or online aids may be required. With positional syntax, the system may have difficulty in detecting errors made by the user.

Menu-mode dialogues

Menu-mode dialogues are computer-initiated dialogues that present the user with all the possible options that he can choose from at a particular point. The user responds by typing an item number or letter associated with the option, or entering the item name or an abbreviated form of the name, or selecting the item by direct screen interaction with a lightpen or similar device (such as a mouse, or finger touched on a sensitive screen).

Figure 3.2 provides a summary of the advantages and disadvantages of menu-made dialogues.

Figure 3.2 Advantages and disadvantages of menu-mode dialogues

Advantages	*Disadvantages*
Ideal for use by inexperienced or infrequent users. A minimal amount of typing is required. The user does not need to retain a large amount of information in his memory. The user may break off from the task in hand, and easily return to it later.	Experienced users find this dialogue mode to be slow and tedious. Time can be wasted by following the wrong path down the hierarchical structure. Users can lose track of where they currently are in the hierarchical structure. For a large number of possible choices, menu-mode dialogues can be very inefficient.

Form-filling-mode dialogues

Form-filling mode is a computer initiated dialogue where the display screen is formatted in a similar way to a paper form. The descriptive areas of the screen

Figure 3.3 Advantages and disadvantages of form-filling-mode dialogues

Advantages	Disadvantages
Training requirements are minimal, and inexperienced users can easily use this dialogue mode. Form-filling is a familiar activity for most office staff. The user does not need to retain a lot of information in his memory. Lengthy menu displays are not required.	Some users experience difficulty in positioning the cursor at the appropriate place on the screen. Data fields are displayed in a fixed sequence, irrespective of the user's preference. Most people dislike filling in forms.

cannot be modified from the keyboard, whilst other areas can be used for the entry of specific data items.

The advantages and disadvantages of the use of form-filling-mode dialogues are shown in Figure 3.3.

Natural-language dialogues

In a natural-language dialogue a user instructs the computer, in text or the spoken word, in the same way as he would another person. At present, there are very few examples of true 'natural-language' man-machine dialogues. Those examples that do exist demand that the domain of the conversation is limited, and that the natural language is restricted in both syntax and vocabulary. In most cases the language used in the man-machine communication has to be a stylised formal version of the full language used in everyday conversation.

Computer systems that can understand fully a natural language in the way that humans can will not be developed in the foreseeable future. Such systems would require both advanced linguistic capabilities, and knowledge about the world and the complex reasoning capabilities of humans. As a result, true natural-language dialogues will remain limited in scope for many years to come. Nevertheless, they will be used successfully in specific applications, and they will be used more widely when workstations (and other terminal devices) are provided with substantial amounts of processing power, and when connected-speech voice-recognition systems become commercially available.

Figure 3.4 Advantages and disadvantages of natural-language dialogues

Advantages	Disadvantages
Resemble everyday communication most closely. Extremely flexible and powerful. Stimulate users to experiment.	Users find it difficult to use the strict grammatic structure. Compared with a face-to-face conversation, users do not find them 'natural'. Many people express themselves in language that is inconsistent and ambiguous. Inexperienced users may expect truly human conversational characteristics from the information system.

The advantages and disadvantages of natural-language dialogues are summarised in Figure 3.4.

CHOOSING THE APPROPRIATE DIALOGUE MODE

Selecting the appropriate dialogue mode is an important decision for the designer. When making the choice, the designer must first consider the characteristics of the planned man-machine dialogue, and then must match the dialogue mode to the particular application.

Dialogue characteristics

The characteristics of man-machine dialogues can be classified under five main headings: initiative, flexibility, complexity, power and information load.

Initiative

The party that controls the flow of a dialogue is said to have taken the initiative in the dialogue. In a system-initiated dialogue, the user inputs command parameters or values in response to some form of prompting by the computer system. The most common forms of system-initiated dialogues are menu dialogues and form-filling dialogues.

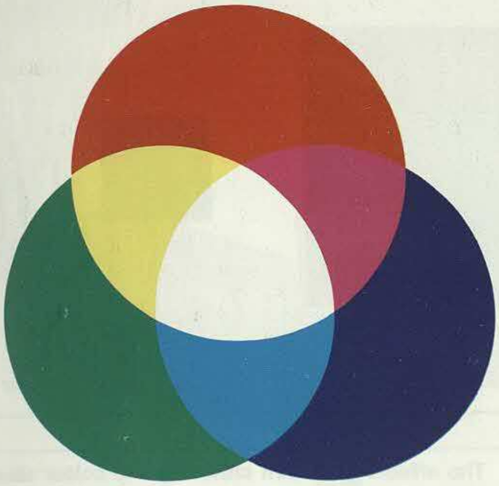
System-initiated dialogues are preferable for inexperienced or infrequent users, but experienced users find them satisfactory only when there are a few transactions, or when the system response time is very short. Regular or experienced users find long response times with a system-initiated dialogue to be very distracting.

Flexibility

Flexibility is a measure of the number of ways in which a dialogue can be used to accomplish a given function. High flexibility can be achieved either by providing users with a large number of commands, or by allowing users to define (or redefine) the commands as they see fit.

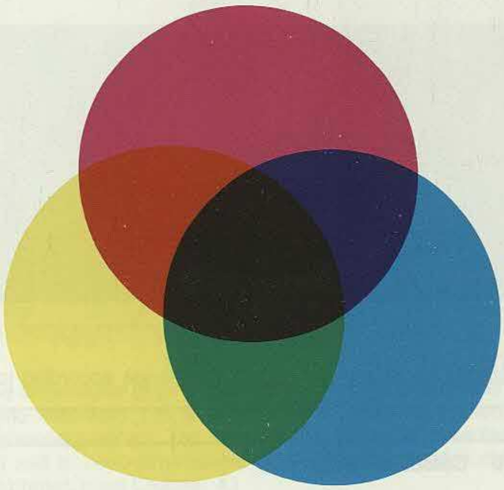
Flexible dialogues can impair the performance of inexperienced users by causing them to make more

Plate 1 Additive colour generation



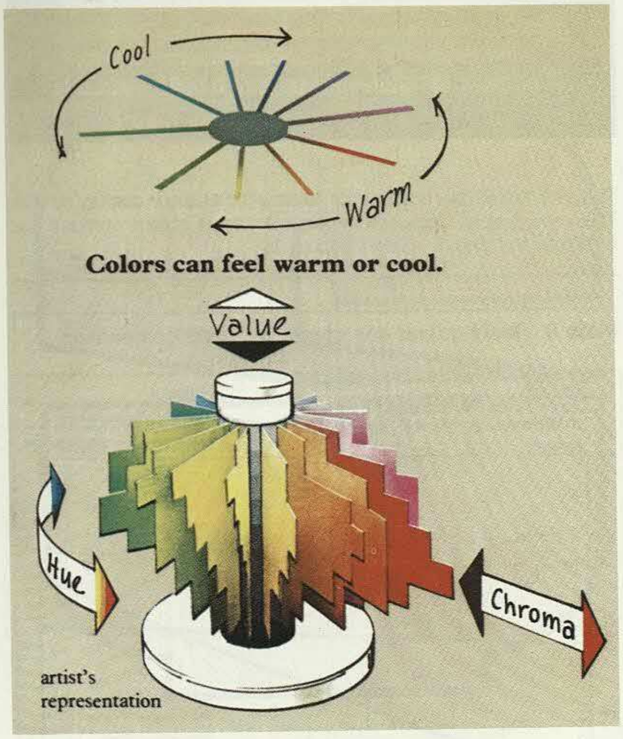
Luminous colours, such as those generated by a display terminal, are generated by mixing the additive primary colours. (See Chapter 2.)

Plate 2 Subtractive colour generation



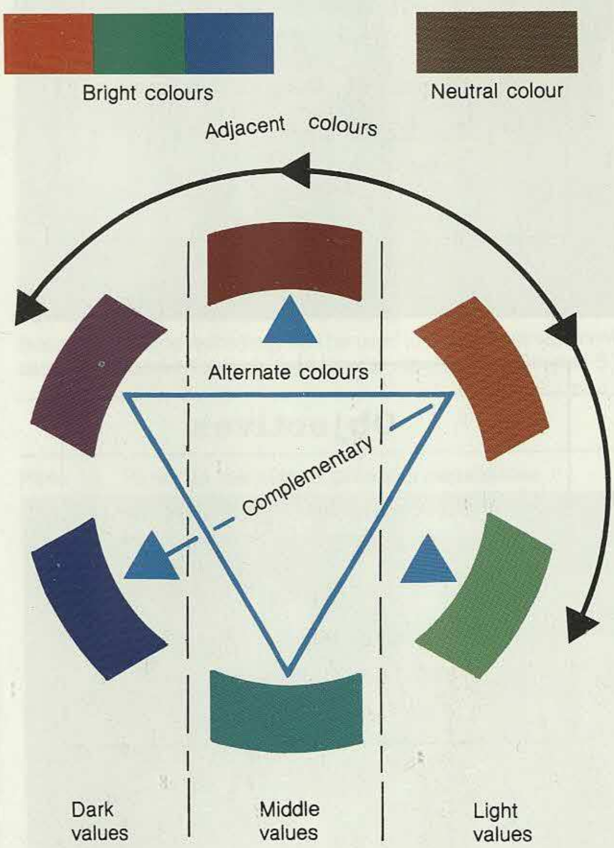
Colour hard copy devices, such as plotters, use subtractive colour generation to deriving secondary colours from subtractive primary colours. (See Chapter 2.)

Plate 3 The Munsell colour solid



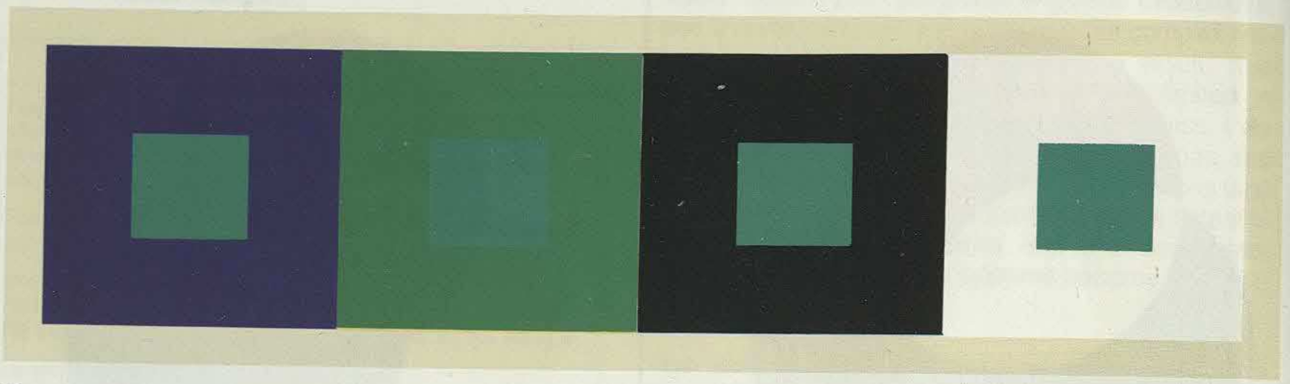
The Munsell colour solid is a device that is frequently used to organise colour. This device looks like an irregular globe. Values are measured along the globe axis: lighter colours at the top and darker colours at the bottom. The Munsell colour solid is used by graphic designers to choose complementary colours. (See Chapter 2.)

Plate 4 The colour wheel



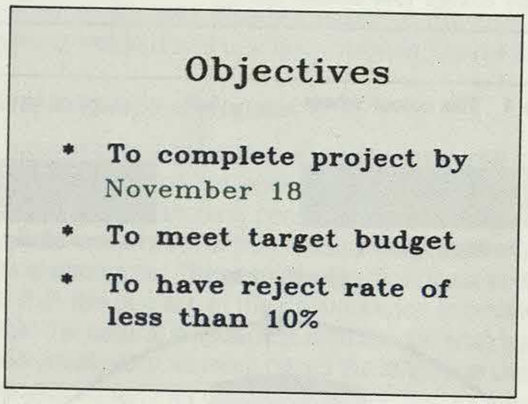
A colour wheel contains a selection of colours arranged in order according to their sequence in the spectrum. This arrangement allows the relationships between the individual colours to be identified. (See Chapter 4.)

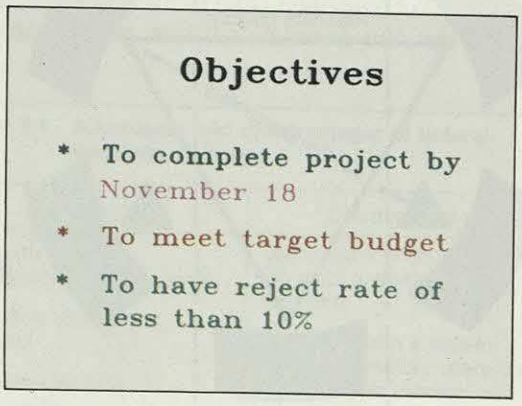
Plate 5 The effect of background on colours



The appearance of any one colour will change according to the colour of the background upon which it is displayed. (See Chapter 2.)

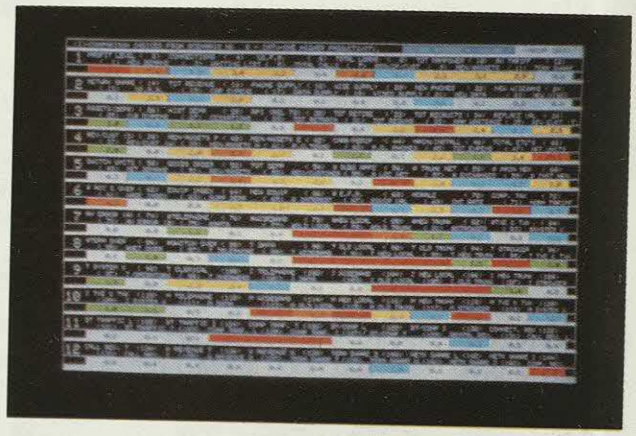
Plate 6 Colour for emphasis





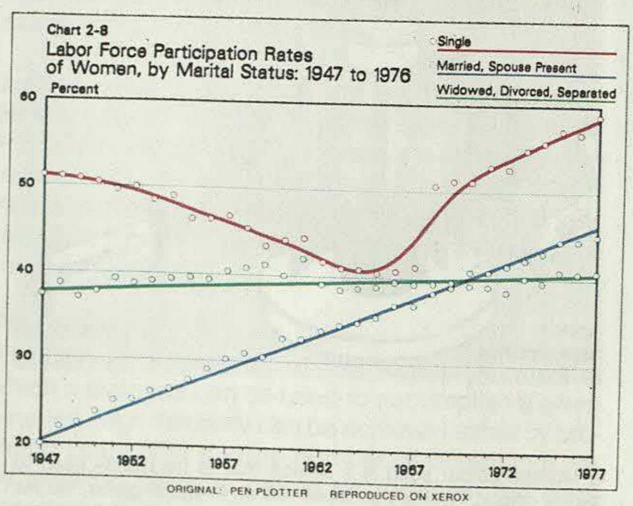
Colour can be an excellent mechanism for providing emphasis if it is used sparingly. The top example of a text slide shows how using one colour can alter dramatically the impact of a monochrome image. The bottom example contains many colours resulting in a confused graphic message. (See Chapter 2.)

Plate 7 The effects of screen crowding and colour abuse



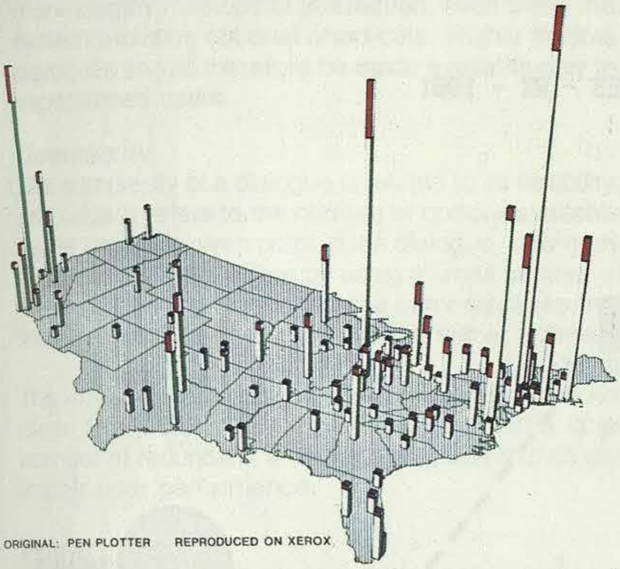
This is an example of what not to do with a colour display device. The crowding of data and excessive use of colour confuse and frustrate the viewer. (See Chapter 2.)

Plate 8 Multi-colour line charts for trend comparison



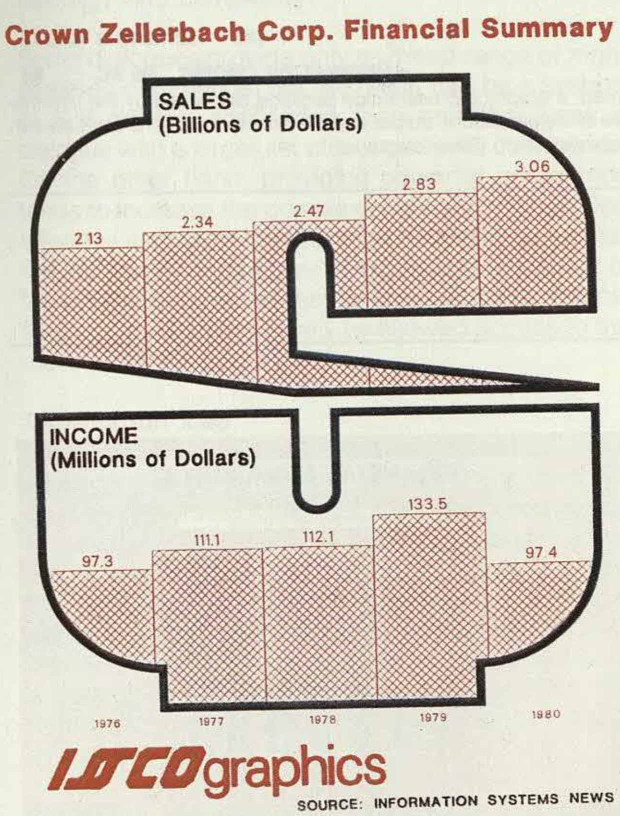
This type of simple three-colour linechart can easily and quickly be output to low cost pen plotters for use in statistical analysis. (See Chapter 4.)

Plate 9 Graphic presentation of geographic data



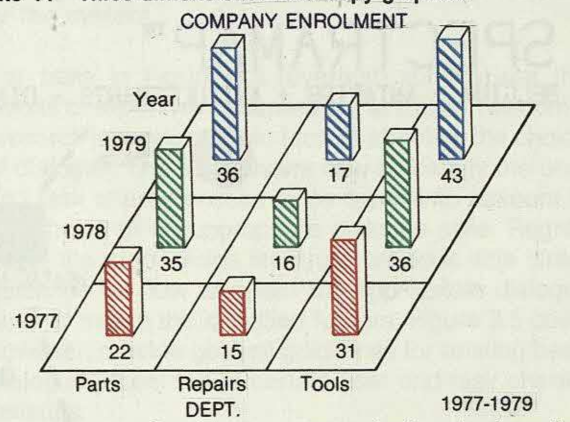
This example shows one commonly used application of colour hard copy business computer graphics. This technique allows the viewer easily to perceive the relative distribution of sales over a large geographic area. (See Chapter 4.)

Plate 10 Multi-colour overhead projector slides



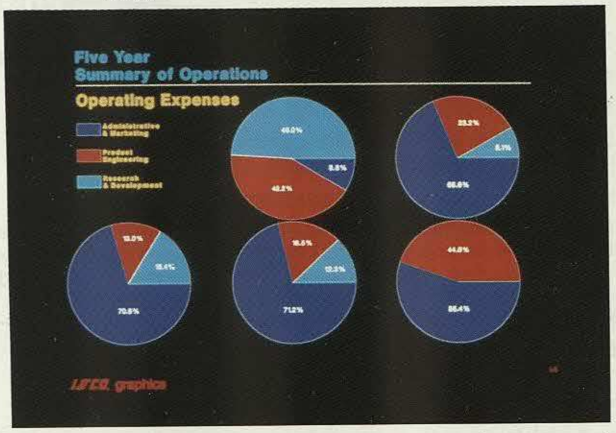
Management presentations can be made more effective through the creative application of business computer graphics facilities. (See Chapter 4.)

Plate 11 Three-dimensional hard copy graphics



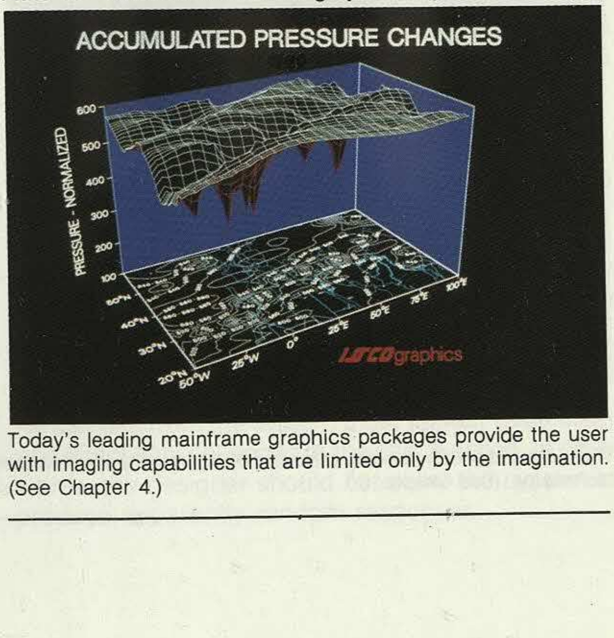
Three-dimensional graphic techniques can be abused and are often applied incorrectly. This is an example of intelligently applied, three-dimensional graphics. The nature of the data to be presented lends itself well to three-dimensional display and the chart is clear and uncluttered. (See Chapter 4.)

Plate 12 Rapid and effective communication of business data



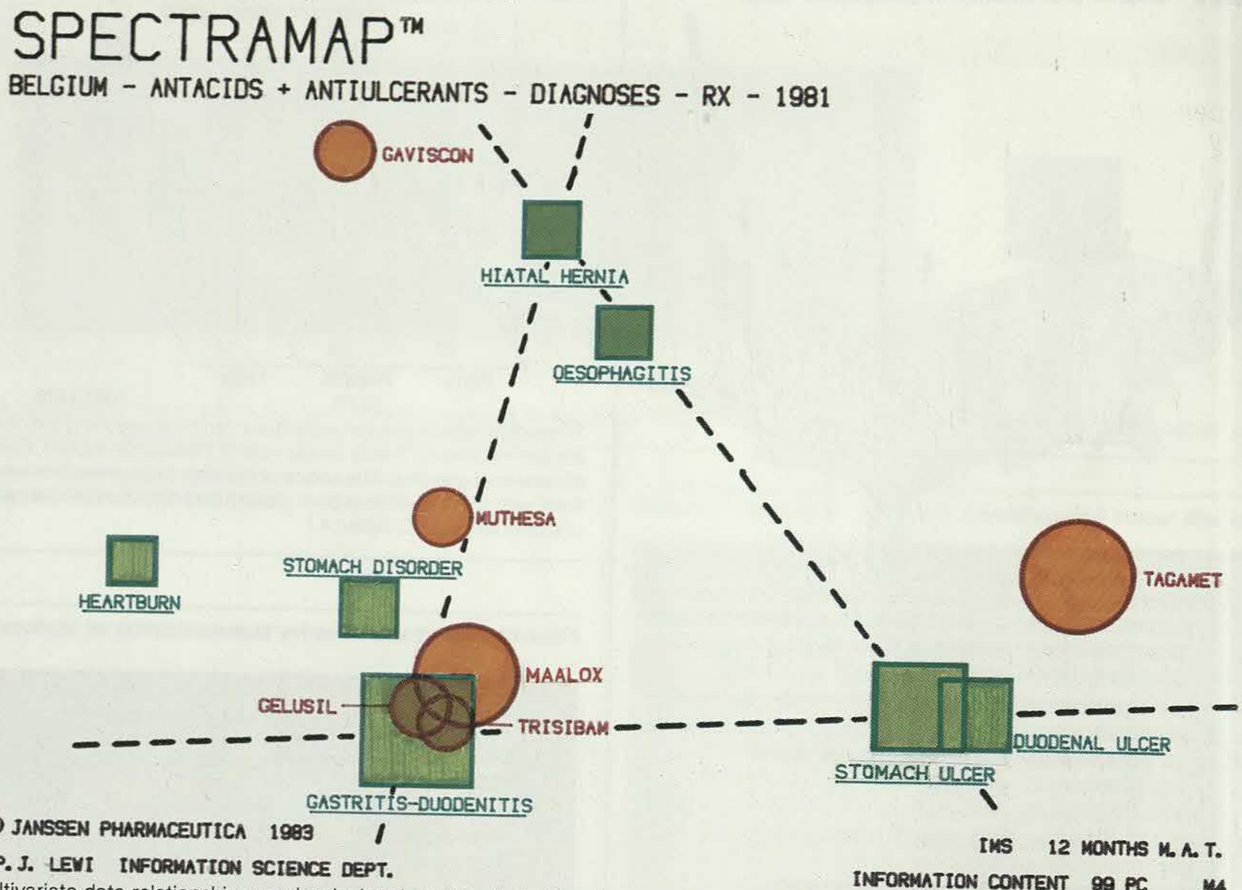
Business graphics technology can be used to present management data much more effectively than tabular reports. (See Chapter 5.)

Plate 13 Powerful mainframe graphics capabilities



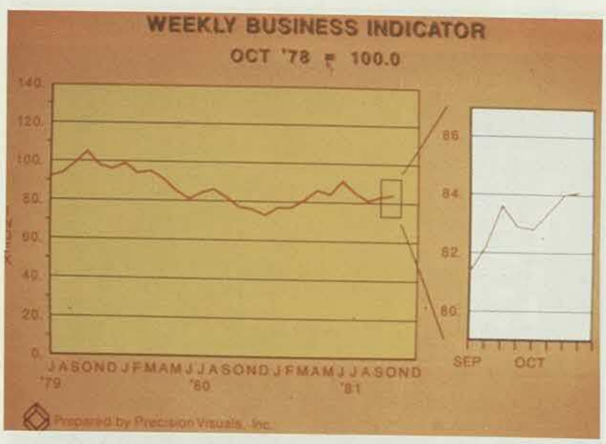
Today's leading mainframe graphics packages provide the user with imaging capabilities that are limited only by the imagination. (See Chapter 4.)

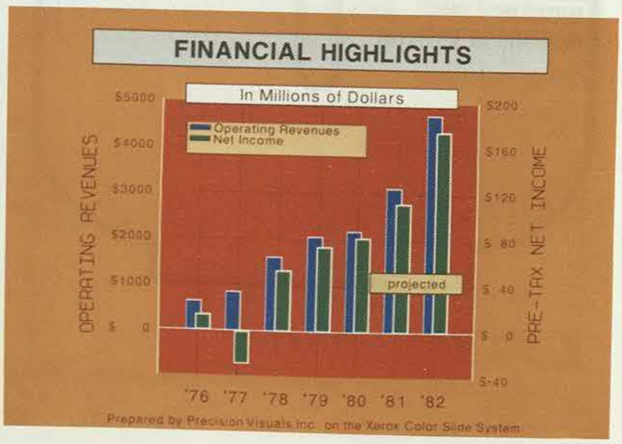
Plate 14 Colour hard copy output from Spectramap



Multivariate data relationships can be depicted graphically by Spectramap, a graphics presentation package developed by the information services division of Janssen Pharmaceutica, Belgium. This example of colour plotter output depicts how the relationships between medical disorders and medications can be reported to product development staff. (See Chapter 5.)

Plate 15 35mm slides from graphic display images





These reprints of 35mm slides, produced by high-quality screen copiers, depict two excellent examples of effective corporate data presentation techniques. (See Chapter 6.)

errors. Inexperienced users often prefer familiar but more lengthy methods of interaction, even when the system provides optional short-cuts. Highly flexible dialogues should therefore be made available only to experienced users.

Complexity
The complexity of a dialogue is related to its flexibility, and usually refers to the number of options available to the user at a given point in the dialogue. Low complexity is achieved either by using a small number of commands or by partitioning the commands, so that the user selects from only a small set at a time.

The effects of providing a complex dialogue are not clear, but there is evidence to suggest that a large number of redundant, or overlapping, commands can impair user performance.

Power
The power of a dialogue is defined as the amount of work accomplished by a system in response to a single user command. A powerful dialogue means that the user can accomplish a complex operation with a single command. The same operation would require several commands in a system with a less powerful dialogue. Dialogue power is related both to flexibility and complexity.

Some dialogues provide only a limited range of high-powered commands, but the result can be a system of less-general application than one that uses a dialogue with a larger set of less powerful commands. On the other hand, providing powerful commands tends to increase the complexity of the dialogue. One effective approach is to partition the dialogue so that the less experienced user is exposed to a sub-set of the simpler commands. As the users gain experience, they can then progressively be allowed access to the more powerful commands.

Information load
Information load relates to the extent that the dialogue interaction employs the memory and/or cognitive processing resources of the user. User performance can be adversely affected if the information load is either too high or too low. The basic principle here is that the designer must compromise between making a dialogue difficult and bewildering for the user, or making it over-lengthy and tedious to use. The user's efficiency can just as easily be reduced by confusion at one extreme as by boredom and frustration at the other.

Matching the dialogue mode to the application

Two basic principles need to be applied when selecting an appropriate dialogue mode for a particular application. First, the designer must be aware of the characteristics of the user community for which the dialogue is intended. Second, the designer must know a good deal about the tasks that will be performed by the system.

The table in Figure 3.5 (overleaf) summarises the results of experiments carried out at British Telecom's research laboratories into factors affecting the choice of dialogue. The table shows how to identify the user and task characteristics to be taken into account in the choice of an appropriate dialogue style. Regrettably, the ergonomics literature provides little direct guidance on how to select the appropriate dialogue style to match the identified factors. Figure 3.5 does, however, provide general guidelines for relating basic dialogue properties to certain user and task characteristics.

PRACTICAL GUIDELINES FOR DIALOGUE DESIGN

During our research for this report we examined several approaches for designing information system dialogues, identifying nine practical guidelines:

1. Use prototypes
Before producing the final version of any interface or system the designer should build a trial model, or prototype, for a thorough evaluation by the intended user population. The structure of the system should be modular, so that the dialogue can be changed easily to reflect experience gained during evaluation.

2. Provide users with immediate feedback
The system should provide users with an immediate and unambiguous response. The feedback should be sufficient to identify the type of activity taking place, and it may occur even before the activity is completed (to make the user aware that the system has accepted the command and is processing it).

3. Use familiar terminology
The dialogue should be designed as if it were a conversation between two members of the user community, so the terminology employed should be familiar to those involved in the particular interaction and application.

4. Ensure consistency and uniformity
The designer must ensure that all terminology and operations are consistently applied and universally available throughout the entire system. Once a user has employed a procedure or a set of rules, he may reasonably expect them always to be applied in the same way in similar contexts.

5. Relate systems responses to user actions
Responses from the system must appear to be clear and direct consequences of the user's action. In other words, the designer should not allow the system to produce apparently random responses.

Figure 3.5 Factors affecting choice of dialogue

Factor	*Parameters*	*Comments*
Purpose of dialogue	Enquiry/data input/ database administration	
User type	Specialist/regular/casual	Specialised languages are suitable for specialist users only. Regular users can remember command codes, parameters, formatting rules, etc. without much prompting.
User role	Active/passive	An active terminal user initiates computer operations, e.g. making enquiries, entering data, etc. A passive user responds to actions initiated by the computer, e.g. computer requests for information, etc. Many users have both functions at different points in the dialogue.
User intelligence	Average → high	Over- or underestimating a user's capacity for logic, storing new information, his speed of operating, etc. can adversely effect his performance.
User tolerance	High → low	Some users are easily frightened by error messages or by the dialogue failing to go according to plan. Others will persist until they overcome the difficulties. May be necessary to design dialogues deliberately for the 'non-rugged' user — i.e. stable dialogues where user who strays from the right path can return to it easily.
Level of user harassment	High → low	Working conditions of user are important to dialogue. If user is working under stress, time pressure, people interrupting him, etc. then necessary to construct a brief simple dialogue allowing easy recovery from distraction, e.g. not entering long command strings, etc.
Level of user training	<5 mins; <1 day; >1 day; >1 week	Not all users can receive a long and detailed training. Dialogue can be designed very differently if the user is to undergo extensive training. Appropriate degree of user vs. computer initiation will vary with the amount of user training.
System response time	<1 sec; 1-4secs; >4 secs/; >15 secs	
Type of data	Complex → simple Numerical/alphabetical/ graphical	Affects what dialogue type, display format, command structures, etc., are appropriate.
Volume of data	High → low Input/output	
Order of data input	Sequential/changeable/ random	If sequential, fixed sequence dialogue is appropriate. But sometimes may be easier for the user to be able to enter data in any sequence he chooses (e.g. in directory enquiries operator's task).
Importance of data accuracy	Very important → unimportant	On some systems, accuracy of user input is crucial. In these cases, choose data structures which lessen the chance of user errors, e.g. multiple checking, high redundancy on items, etc.
Source of data	Form/document of standard format/over telephone/ user's memory	As far as possible, relate computer dialogue organisation to format and sequencing of input source.
Terminal type	Keyboard printer (fast or slow)/VDU	Speed of terminal affects what type of dialogue is appropriate.
Type of processing	Local intelligence at terminal or not	Affects system response times, error handling, editing, etc.
Number of applications	Single/multiple applications per terminal	If only one dialogue per terminal, dialogue can be differently structured than if there are several. With multiple applications, usually unwise to employ specially labelled keys or to use mnemonics that could be remembered for one application but not for others.

(Source: Man-machine dialogue design, British Telecom Research Laboratories, 1982; adapted from Design of Dialogues for Interactive Commercial Applications, Infotech State of the Art Report: Man/Computer Communication, 1979; © David Hebditch Ltd., 1979)

6. Ensure flexibility
The dialogue must be flexible enough to allow the characteristics of the system interface to be changed as users gain experience, and as their ability to use the system improves. The dialogue design should not be a constraint on the inherent human ability to find new ways of performing the same task.

7. Provide positive control
The user needs to feel that he is in control of the system, so he needs to know where he currently is in the system hierarchy, how he got there, and where he can go to. In addition, the user should be provided with a reset key or command that aborts the current activity cleanly and returns him to the previous state.

8. Validate dialogue inputs
The syntax and contents of dialogue inputs should be at least partially validated immediately they are entered. Wherever possible, the input process should automatically try to correct obvious syntax or content errors. Failing this, the user himself should be given the opportunity to revise incorrect inputs before the system attempts to act on them.

9. Log all activities
The system should be used to keep records of system and user activities, so that the behaviour of both can be evaluated regularly. The log can also be used as an audit trail.

Design recommendations for dialogue modes

We now provide a series of specific design recommendations for each of the four dialogue modes described earlier in this chapter on pages 17 and 18.

Direct-mode dialogues
Direct-mode dialogues are suitable only for frequent and experienced users who have received a significant amount of training. In order to reduce the user's memory load, direct-mode dialogues should use easily remembered and explicit command words, consistent formats, and short command strings. A help facility should also be available so that the user can easily remind himself of the syntax rules. Keyword (as opposed to positional) syntax should be used when the application requires lengthy command strings, or if the sequencing of data is variable. If positional syntax is used, the sequence of the items should be as close as possible to the natural order that would occur when the user thinks about the command.

With direct-mode dialogues it is particularly important for error messages to be presented clearly, so that users can identify errors within a command string without needing to refer to an external information source.

Menu-mode dialogues
Menu-mode dialogues are particularly suitable for inexperienced or infrequent users. Nevertheless, a multiple selection technique should be employed so that an experienced user can enter several menu choices at the same time. This procedure allows the experienced user to proceed rapidly through multiple levels of the menu to reach the required level.

The actual method used for selecting the menu options must also be chosen carefully. Devices such as light-pens, a mouse or touch-sensitive screens do not allow a sequence of menu options to be preselected. Their use should be restricted to applications where the majority of users are inexperienced, or where usage is infrequent.

Form-filling-mode dialogues
Form-filling-mode dialogues are suitable for all types of users, and particularly for applications that have a significant data-entry element. Form-filling is suitable for applications in which the user input is dominated by parameter values rather than by system commands. If an input form is used, the order of parameters on the screen should correspond with that on the source document. Alternatively, the parameters should be presented in the sequence in which the user may logically be expected to think of them.

Natural-language-mode dialogues
When using a natural-language dialogue the user must not be led to believe that the system has greater intelligence than it actually possesses, nor that the computer can make inferences in the same way that a human does. The system designer must therefore provide a dialogue language that makes apparent to the user the logical procedures on which it is based.

Except for some specialised applications, natural-language dialogues are unlikely to be cost-effective for several years to come. Indeed, for many applications they could prove to be a poor substitute for structured, unambiguous command languages based on a restricted grammar.

SUMMARY

The man-machine dialogue is a crucial element in determining the success of an information system. In this chapter we have discussed how different types of users and applications require different dialogue modes. In particular, inexperienced and infrequent users of information systems have requirements that are different from those of experienced and frequent users. The application of information technology continues to develop at a rapid pace. The trend is for more and more people in all types of organisations to use computer systems as and when it is convenient for them to do so. System designers can no longer count on a dedicated group of users, prepared to overcome every obstacle to get at the information they require.

We now turn our attention to the recent developments in the use of business computer graphics which, to a large extent, are responsible for widening the information systems' user base.

CHAPTER 4

BUSINESS COMPUTER GRAPHICS

Computer graphics techniques have been used for many years in scientific and engineering applications such as laboratory test analysis and computer-aided design and manufacturing. More recently there has been a surge of interest, particularly in the United States, in using these techniques for commercial applications such as financial planning and analysis, management reporting, and production and inventory management. Plates 8 to 12 show some typical graphics displays produced by some of these applications.

In the United States, the installed base of mainframe graphics software packages has grown rapidly. The acknowledged market leaders in the field of mainframe-based business graphics software are SAS Institute (who supply SAS/Graph), and Integrated Software Systems Corporation (ISSCO). The SAS/Graph package increased its user base from 750 installations in December 1981 to more than 2,500 at the end of October 1983. ISSCO, which specialises in graphics packages, has enjoyed even greater success with its Disspla and Tell-A-Graf packages.

The earliest users of business graphics were often in organisations that already were using colour graphics for other applications. Pharmaceutical companies are a case in point. They first used colour graphics systems for laboratory test analyses, later widening their applications to include business graphics. This trend is now evident also in Europe, where Janssen Pharmaceuticals in Belgium uses business graphics for market analysis. (This application forms one of the case histories in the next chapter.)

We believe that computer business graphics will play an increasingly important role in presenting information to managers. In this chapter, we provide an overview of the present state of development of this field. We first focus on graphics software. Next we provide guidance on selecting graphics terminals. Finally, we summarise the experience to date of implementing business computer graphics systems.

BUSINESS COMPUTER GRAPHICS SOFTWARE

Recent technological developments in graphics displays and hard-copy devices have reduced their prices to levels where they can now be cost-justified for a wide range of commercial applications. But, as with other computing devices, graphics hardware also needs good general-purpose graphics software to support it.

Until recently, most of the graphics software development effort was devoted to mainframe-based packages. Business graphics specialists, such as SAS Institute and ISSCO, concentrated on this type of system, because the packages (largely coded in Fortran) required mainframe processing power. In addition, early users of graphics software packages were large organisations who could afford to pay the high prices necessary to recover the substantial development cost incurred by the suppliers.

Today, these mainframe-based business graphics software packages are becoming available also for a wide range of minicomputers and 32-bit microcomputers. Other graphics packages are being developed specifically for 8 and 16-bit microcomputers. For example, ISSCO's Tell-A-Graf package, which is aimed at end users rather than development staff, is now available for use with more than 30 operating systems, including Unix.

Mainframe-based business graphics software

There is a strong and increasing demand for comprehensive mainframe-based business graphics facilities. Compared with a microcomputer-based package, a mainframe-based package has the advantage that it permits several users simultaneously to access the same database and use the same graphics software. In this way, a graphics software package can be used simultaneously by up to 100 users (the precise number depending on the hardware and software facilities available). Some loss of immediacy is inevitable, however, because users will not always have access to dedicated stand-alone graphics equipment. But users who have a regular requirement to produce charts, for example, are often content to enter their request into the system and then pick up their charts a few hours later.

A second advantage of a mainframe-based graphics

Figure 4.1 Leading mainframe-based graphics packages

Company and products	Description	Market share (%)
ISSCO		76
Tell-A-Graf*	A user-friendly, command-oriented system for transferring data into charts and graphs.	
Disspla*	Comprehensive set of 700 sub-routines that allow graphics to be integrated into many applications.	
IBM		12
GDDM (Graphic Data Display Manager)	A basic set of routines that allow programmers to create graphics programs on an IBM colour terminal and printer.	
Interactive Charting Utility	A menu-driven demonstration program that makes bar, line, and pie charts on the basis of data typed at a particular IBM colour graphics terminal.	
Tektronix		7
Easy Graphing	A command language to produce bar, pie, and line charts on Tektronix terminals and plotters.	
Interactive Graphics Library	A sub-routine package to do three-dimensional and other charting on Tektronix equipment.	
SAS (Statistical Analysis System)		4
SAS/Graph	A line, bar, pie chart, and mapping package integrated into SAS, which drives a limited number of graphics devices.	
SPSS (Statistical Package for the Social Sciences)		1
SPSS/Graph	A line, bar, and pie charting system that offers device independence integrated into SPSS.	

*Device independent; drives all graphics devices.

(Source: Proceedings of the Online Computer Graphics '82 conference, London, October 1982)

package is that it is only this type of graphics software that can provide the wide range of powerful facilities required to satisfy the diverse requirements found in a typical large commercial organisation.

Figure 4.1 lists the leading mainframe-based graphics packages, together with their key characteristics. The entries are listed in the sequence of the suppliers' share of the United States market in 1980, but the overall picture has not changed significantly since then.

The graphics packages listed in the figure fall into two types:

—End-user systems that can be accessed by people without specialist data processing skills. ISSCO's Tell-A-Graf, IBM's Interactive Charting Utility and Tektronix's Easy Graphing are all in this category.

—Sub-routine libraries that must be included in a PL/1, Cobol or Fortran program. Examples include ISSCO's Disspla, IBM's GDDM and Tektronix's Interactive Graphics Library.

The SAS/Graph and SPSS/Graph packages can be classified as pseudo end-user systems. Although they cannot be used readily by inexperienced staff, they are easy to use by those who are already thoroughly familiar with the SAS and SPSS statistical packages.

The fastest growth rate in the use of mainframe graphics software is in the area of end-user systems. The great attraction of packages such as Tell-A-Graf and Interactive Charting Utility is that they can be used without reference to a Fortran or Cobol programmer. Typically, a secretary, technician, or even a manager, can be using this type of graphics system productively after a morning's tuition. Nevertheless, the sub-routine libraries are also selling well, and are being purchased to provide facilities not available with the end-user systems.

At the end of 1983, mainframe-based graphic software packages cost from $2,500 for Easy Graphing to $25,000 for Tell-A-Graf. The SAS, SPSS, and IBM packages could only be rented, however. SAS/Graph cost (in addition to the cost of the SAS statistical package) $2,500 for the first year's rental, and $1,500 per year thereafter. The IBM package cost approximately $3,000 per year (depending on the features chosen). SPSS/Graph cost about $8,000 in the first year, and $4,000 in subsequent years. With all of these packages, users can select from options that determine whether the package is device independent, the flexibility of the package, the graphics resolution, and the level of support from the supplier.

The trend is for data processing departments to purchase (or rent) mainframe graphics packages that can be shared by a large number of users. In this circumstance, cost is not an obstacle, because the data processing department wishes to acquire a fully featured package that can be used by the widest possible community. Plate 13 illustrates the type of graphical output that a fully featured mainframe computer software package can provide.

Selecting mainframe-based business graphics software

Mainframe business graphics packages often provide a bewildering choice of options. There are, however, ten key software characteristics that are important.

1. User-friendliness
The package should encourage people to use it, so the quality of the man-machine dialogue must be evaluated carefully. The ideal package provides natural-language commands, supplemented (where appropriate) by prompts. Such command-driven systems avoid the constraints of prompt-driven or menu-driven dialogues (see Chapter 4). Nevertheless, judicious use of prompts can be helpful, particularly for inexperienced or infrequent users, because they remove the need to remember every command in the language. It is also desirable that the software package should allow the user to choose the type of dialogue mode he wishes to use.

2. Flexibility and quality
Flexibility relates both to the range of possible applications and to the range of graphic features available. The quality of the graphics is concerned with features such as the thickness and smoothness of lines on the display or printout, automatic layout of the graphics, the sharpness of colours, the ease with which different shadings can be differentiated, and so forth.

3. Multi-plotting features
The package should be able to prepare multiple high-quality plots on one page. Although a page of output should not be crowded with an excessive number of plots, there are instances where the presentation of multiple images on the same page is the only effective way of presenting a graphic message.

4. Device and layout independence
Ideally, graphics software should be able to support all current and future graphics devices. But, in addition to device independence, the software should also enable a chart to be reformatted automatically to take advantage of the particular graphics device being used.

5. Machine independence
The graphics software should not be restricted to use on one range of hardware.

6. Use of non-graphics terminals
Many of the potential users of the graphics software do not have immediate access to a graphics terminal. Some graphics packages provide the option to preview a graphics image on a regular display terminal before the final hard copy is produced on a graphics printer or plotter.

7. Links with personal computers
Some users will already have personal computers on

Figure 4.2 Graphics software characteristics by application type

Applications \ Software capabilities	End-user friendliness	Flexibility and quality	Multiple plotting per page	Device independence	Machine Independence	Previewing on non-graphic terminals	Access from personal computers	Storage of custom designs or chartbooks	Instant production of executive charts	Integration with data processing applications and databases
Financial reporting	○	○	●	○				●		●
Executive management information	●	●	●	○	○	○	○	●	○	
Charts for briefings, etc.	●	●	○	●	○	○	○	○		○
Colour slides for presentations	●	●	○	●	○	○	○	○		
Project management		○	○	○	○			●		●
Research and analysis	●	○	○	○	○	○	○	○		●
Engineering data analysis	●	○	○	○	○	○	○	○		●
Strategic planning	●	●	○	○	○	○	○	●	○	○
Graphic artist productivity	●	●	●	○	○	○		●		
Computer performance evaluation	○	○	○		○			○	○	●

● Mandatory characteristics ○ Preferred characteristics

(Source: Integrated Software Systems Corporation) their desks and will want to be able to use them to initiate a request for a chart. Ideally, they should also be able to preview the chart on their personal computers.

8. Pre-formatted charts
Once a chart format has been defined, the software should be able to store it ready for future use. Sets of designs should also be combined into chart books for each application area. This capability is a particularly useful means of extending the use of computer graphics to a wider audience in the organisation.

9. Instant production of executive charts
Senior managers should be provided with rapid and easy access to the graphics facilities. Usually, this will mean that a fully composed set of charts is available 'at the touch of a button' to senior executives.

10. Integration with data processing applications and databases
In most organisations, there are many possibilities for using graphics software in conjunction with existing application databases. The graphics package selected should be able easily to interface with programs written in most of the well-known mainframe languages.

Matching graphics software characteristics with applications

Different types of application require different mixes of the ten key graphics software characteristics outlined above. Figure 4.2 (page 29) identifies the characteristics that are mandatory for a range of common graphics application areas.

Microcomputer-based business graphics software

The Xerox Star and Apple Lisa products pioneered the use of graphics features as an integral part of a microcomputer-based system. Now every business microcomputer or personal computer offers some form of graphics. Digital Research and Microsoft have both recently announced extensions to their operating system products that make it possible for virtually any microcomputer to provide business graphics features such as multi-window displays, mouse cursor control, icons and screen painting. The Microsoft-Windows software is available to hardware manufacturers and OEMs at a cost to the end user of less than $100. By the end of 1983, more than 20 manufacturers, including Data General, Digital Equipment Corporation, Hewlett-Packard and Texas Instruments had concluded agreements with Microsoft for this product.

We are convinced that the availability of microcomputers with an easy-to-use, graphics-based man-machine interface is of fundamental significance in presenting management information. Many managers from a wide variety of industries are realising that systems such as these, are a very effective means of removing the barriers between an information system and its users — particularly if these systems also provide access to corporate databases.

SELECTING GRAPHICS TERMINALS

Having reviewed the field of computer graphics software both for mainframe and microcomputers we turn now to look briefly at the question of selecting graphics terminals. Some useful guidance was provided to delegates on the 1983 Foundation Study Tour by J Warner of Precision Visuals Inc. Mr Warner said that the starting point, in common with any other equipment selection exercise, is to set down in writing a summary of application requirements. Surprisingly, this seemingly obvious task is often overlooked by people who become over-enthusiastic about the technology.

Graphics terminals today offer a wide range of features. As with many other hardware devices, not all of the features are justified by the typical application. In Figure 4.3 we list the features under four headings, in descending order of importance.

Having determined what features are needed, the next step is to assess suppliers' products, using a checklist such as the one set out in Figure 4.4.

Figure 4.3 Typical categorisation of graphics terminal features

Essential features
- Serial interface to host
- Host compatibility
- Hardware lines, symbols, text
- Use for standard alphanumeric applications

Important features
- Colour (eight or more)
- Hardware polygonal fill
- At least four character sets
- Pixel addressable characters
- Hardware linestyles
- Medium resolution (512 × 390)

Less important features
- Compact co-ordinate protocol
- Hardware shading patterns
- Different hardware typestyles
- Linewidth control
- Background colour and colour lookup tables
- Operator control of graphics and alpha planes
- Locator input
- Scrolling alphanumeric window
- Audio options
- Local hardcopy option

Non-essential features
- Pixel manipulation capabilities
- More than 16 concurrent colours
- Device-level display list
- Local image transformations

IMPLEMENTING BUSINESS COMPUTER GRAPHICS

The biggest difficulty facing an organisation that wishes to introduce a business computer graphics system is to estimate what the user demand will be. If the potential user community is asked about the likely applications and the volume of output, the response will be limited. The problem is that most people cannot envisage in advance how they can successfully use business graphics.

This apparent lack of user demand often means that the first business graphics implementation is on a small scale. Typically, the task is assigned to a technical group, or to a single application programmer, or as a part-time activity. In this situation, computer graphics usually becomes the exclusive technical domain of data processing staff, and never becomes a corporate resource.

Nevertheless, many of the organisations in the United States that have implemented computer graphics systems have managed to avoid this difficulty. The key to success lies in anticipating a broader demand for business graphics than was originally suggested by user predictions, and in building an environment in which computer graphics can be used easily by a wide variety of staff. Experience has shown that the use of business graphics grows at a compound rate after its initial introduction.

To date, most of the successful implementations of business graphics have involved the use of mainframe-based packages with comprehensive graphics facilities. But the situation is now changing, and many of today's minicomputer and microcomputer-based business graphics packages are now able to meet the needs of many diverse users.

During our research we encountered many successful implementations of computer business graphics. In the next chapter we present five of these as case histories.

Figure 4.4 A buying checklist for graphics terminals

Know your environment
- General or specific applications?
- Comfort requirements of the 'typical' user
- Where will the device be used?
- How often will the device be used?
- Ergonomic considerations

Understand your performance
- Develop a measure of picture complexity
- Speed of picture display
- Serial vs. parallel interface
- CPU-bound vs. I/O bound
- Arrange a demonstration

Talking with your computer
- Availability of standard communication protocols (for consistent and predictable communications, look for a safe and simple protocol)
- Different communication speeds
- Handshaking procedures
- Use of special control characters
- Vendor-supplied hardware and software for parallel communication

Special features in the graphics device (do you really need them?)

Pro
- Improved performance
- Improved operator interaction/ergonomics
- Improved image quality

Con
- You normally pay for them
- They require device-dependent programming
- Can lock you into the vendor

Available software
- Third party machine/device-independent
- Hardware vendor software
  - Device-independent
  - Device-dependent
  - I/O level software
- Special application/turnkey software
- Building your own

Documentation
- Can you fully understand the device capabilities?
- Can you fully understand the operation of the device?
- Can you test the device stand-alone?
- Illustrations
- Troubleshooting

General
- Price
- Installed customer base
- Product family
- Maintenance/reliability/upgrading
- Ease of installation
- References

CHAPTER 5

BUSINESS COMPUTER GRAPHICS CASE HISTORIES

The use of computer graphics techniques for presenting information to managers is a fairly recent development. We now describe the experiences of five medium-to-large organisations who have successfully implemented business graphics systems. Four of these organisations are based in the United States, and this reflects the greater use being made of business graphics in that country.

We also describe the way in which a private videotex system is being used in the United Kingdom to present information to senior managers. Although videotex is not strictly an example of business computer graphics, it does enable information to be presented, in colour, in a graphical format.

PEPSICO

Pepsico is the parent company of the multinational food and beverage organisation whose best-known trademark is Pepsi-Cola. Pepsico has its headquarters in New York State, and the activities related in this case history are based there.

At Pepsico, the use of business computer graphics evolved from three corporate objectives:

— To develop more efficient and effective methods for communicating information to decision-making executives.

— To identify business opportunities and risks.

— To find new tools to help with the decision-making process.

The project was initiated in 1979, with the full support of executive management. Its aim was to provide interactive decision-support graphics on a corporate-wide basis. In the four years since Pepsico began using business computer graphics, the applications have been in the areas of financial reporting, personnel administration, marketing and sales. The company now uses two financial graphics reporting packages, a personnel administration package with graphics output, and three applications that present divisional marketing and sales-volume information.

At the Computer Graphics '83 conference in London, Susan Ulicny, manager of information systems at Pepsico, said that corporate management considered all of these computer graphics facilities to be a success because:

— Each package is customised to match the requirements of a specific sector of the business.

— Each application is backed up by readily available summary and detailed data, which can be accessed when queries arise.

— All of the data used by the graphics packages is integrated with the company's databases and is updated automatically, so that the most accurate and current data is available for graphical presentation.

The information services departments provide a complete graphics support service for the corporate headquarters and the five major operating divisions. The service includes requirements analysis, chart design and programming, and the production of slides and copies of business graphics outputs. Pepsico's management believes that this arrangement allows users to concentrate on getting benefits from business graphics which help them run their business operations more productively, rather than on the details of generating the business graphics in the first place.

The business computer graphics services provide more than 600 monthly charts for the corporate-finance vice-president and various corporate business planners. About 150 of these charts are seen also by senior managers in the operating divisions. In addition, in the Pepsi-Cola Company (which is the largest unit in the beverages division), two graphics packages present more than 1,000 charts each month for senior executives, including the president. These charts depict financial results, market performance and administrative statistics. Other operating units also make regular use of graphics output, and more than 500 slides per year are requested for ad-hoc presentations.

Pepsico's business computer graphics services are based on a wide variety of graphics hardware and software. The most significant elements are:

—Chromatics colour terminals. These are eight-colour interactive graphics workstations that can also be used either as stand-alone computers, or as terminals to the company's IBM mainframes.

—A Xerox 6500 colour copier. This device can be used either as a stand-alone colour copier or as a screen-copier driven by a Chromatics terminal.

—A Matrix 4007 camera, which can be interfaced to a Chromatics terminal to produce 35mm slides, instant prints and overhead transparencies.

—ISSCO's Tell-A-Graf software. This powerful end-user oriented graphics software package runs on the IBM mainframe under CMS, and generates images which are transferred to a Chromatics workstation. Pepsico also uses ISSCO's Tag-Prompter, an English-language front-end for Tell-A-Graf.

—Standard IBM 3279 colour terminals, which are used for interactive graphics. (IBM 3287 colour dot-matrix printers are also used.)

Pepsico's executives believe that the combination of high-quality presentation and interactive graphics helps them to make faster and better-informed decisions. The company's experiences with these applications have demonstrated that business computer graphics can meet the data presentation needs of a large, diversified organisation.

JANSSEN PHARMACEUTICA N.V.

Janssen Pharmaceutica is a Belgian-based subsidiary of Johnson & Johnson. Janssen concentrates on the research and development of the pharmaceutical products that are manufactured and marketed by other Johnson & Johnson companies.

In 1975, Janssen's information services department began to look for new information systems techniques that would allow the company's marketing function to use the wealth of existing corporate and industry data more effectively in product planning. The department decided to concentrate on the use of graphics to present the results of analyses of a wide range of industry variables. Data about these variables had been available to Janssen for several years from an independent data collection service that maintains a world wide pharmaceuticals database. The problem was that Janssen's marketing staff found it difficult to use effectively the tabular reports provided by the database company. In particular, they were unable to correlate sensibly the key variables contained in the mass of available data.

Under the supervision of Dr Paul J. Lewi, Janssen's information services manager, this problem was solved by applying the proven techniques of multivariate statistical analysis to the tabular data. Then, aided by its insights into the key aspects of Janssen's business, Dr Lewi's team was able to develop a presentation package for Janssen's IBM mainframe. This package depicts graphically the relationships between the key industry variables that determine the success of a new product in the pharmaceuticals industry.

Plate 14 provides an example of the type of hard copy graphics prepared by the Spectramap package. This graph shows the degree of correlation between various medical conditions and leading medications prescribed by a sample of physicians. The closer a particular medication (orange circles) appears to a particular complaint (green squares), the more applicable the medication is to that complaint. In Dr Lewi's words, this is a measure of the "attraction" of a medication to an illness. The graph can be used to identify potential opportunities in the marketplace for new medications by focusing on an illness that has not "attracted" many medications. It is also interesting to note that the relative sizes of the circles and squares indicate respectively the number of occurrences of the condition or medication in the sample of data.

The Spectramap package has been used by Janssen's marketing departments since 1977. It has now been used for six product groups in 14 countries. Reaction from the marketing staff varies. Some say they could not perform adequately without it, while others say that Spectramap is a useful complement to other data sources.

At the end of 1983, Janssen was discussing a possible arrangement with the database company, which would permit Spectramap to be used by other clients as well. In addition, Janssen is evaluating the potential of the package for use by other industries.

AMERICAN HOECHST COMPANY

American Hoechst is the United States subsidiary of one of the world's largest pharmaceutical companies. The parent company is based in West Germany. American Hoechst recently implemented a comprehensive business computer graphics facility that has provided a very high return for the initial investment. The company's vice-president of information processing stated recently that the graphics software package (ISSCO's Tell-A-Graf) had become the single most widely used program on the IBM 3033 mainframe. Moreover, one of the divisional data processing executives told a meeting of the Drug Information Association in Boston in 1981 that the business graphics system had reduced by nearly a year the time required to bring a new product to the market.

A unique feature of American Hoechst's graphics system is that every terminal connected to the IBM computer can be used to request charts and plots. The graphics output requested is routed automatically to one of the eleven digital plotters (supplied by Zeta Inc.), that are distributed throughout the organisation. These plotters are attached to the central IBM computer as remote-job-output stations, and the graphics output can be obtained from a plotter in the same way that a computer printout can be obtained from a remote printer. In addition, American Hoechst uses colour terminals and Xerox 6500 CGP colour laser printers, which allow high-volume colour prints to be produced by the computer at 180 pages per minute.

American Hoechst has developed a most effective training programme that introduces those staff not familiar with computers both to computing and to the Tell-A-Graf package. The training programme is repeated at regular intervals and is aimed at clerical staff, laboratory technicians and professional staff. As a result of these programmes, secretaries have become enthusiastic users of computer graphics. Many of them now use the Tell-A-Graf English-like commands to produce charts for briefings. In addition, the company's research staff use the software package to produce clinical charts that have proved most effective during clinical research review meetings.

American Hoechst's advice to other organisations considering the development of corporate-wide business graphics facilities is as follows:

- —Make the graphics facilities available to all your computer users. Do not install the graphics equipment in an isolated, inaccessible location.
- —Ensure that your training programme covers the basics of computing before it attempts to describe the graphics package. Non-technical staff need to be familiar with computing concepts before they begin to learn about computer graphics.
- —Involve the senior data processing executives. They can play an important role both in making graphics facilities widely available throughout the organisation, and in promoting their use.

GENERAL MOTORS, DETROIT

We spoke with Mr Bobby Corr, manager of operations planning and analysis in the General Motors Corporate Comptroller's Office. He described two very successful implementations of business computer graphics in General Motors.

Early in 1982, management of the Delco division, in conjunction with the Corporate Comptroller's Office, selected the Fingraph financial graphics package to assist in presenting financial and operational data to management. Fingraph is a graphics software system designed to present management data in a consistent and easily assimilated form. The system is supplied by Fingraph Corporation of Springfield, Illinois.

The Delco division uses Fingraph on its VAX hardware to provide management with 70 different graphic reports, mostly in the form of screen displays. The reports are used by about five senior managers and 15 middle managers as an aid to the division's decision-making process.

The Fingraph package is also used in the office of the corporate vice-president for mechanical components. This user regularly requests 20 to 25 different hard copy charts which depict both the financial performance of his area of responsibility and the various key operational performance indicators.

According to Mr Corr, the main benefits of the approach chosen by General Motors for these applications were that the graphic representation of key performance indicators had both speeded up the decision-making process and improved its effectiveness.

Fingraph was chosen because it was the only software package available that combined an effective decision-support database management tool with a structured presentation format in a package that could be easily and quickly implemented.

Examples of some of the standard graphics outputs available from the Fingraph system are shown in Figure 5.1.

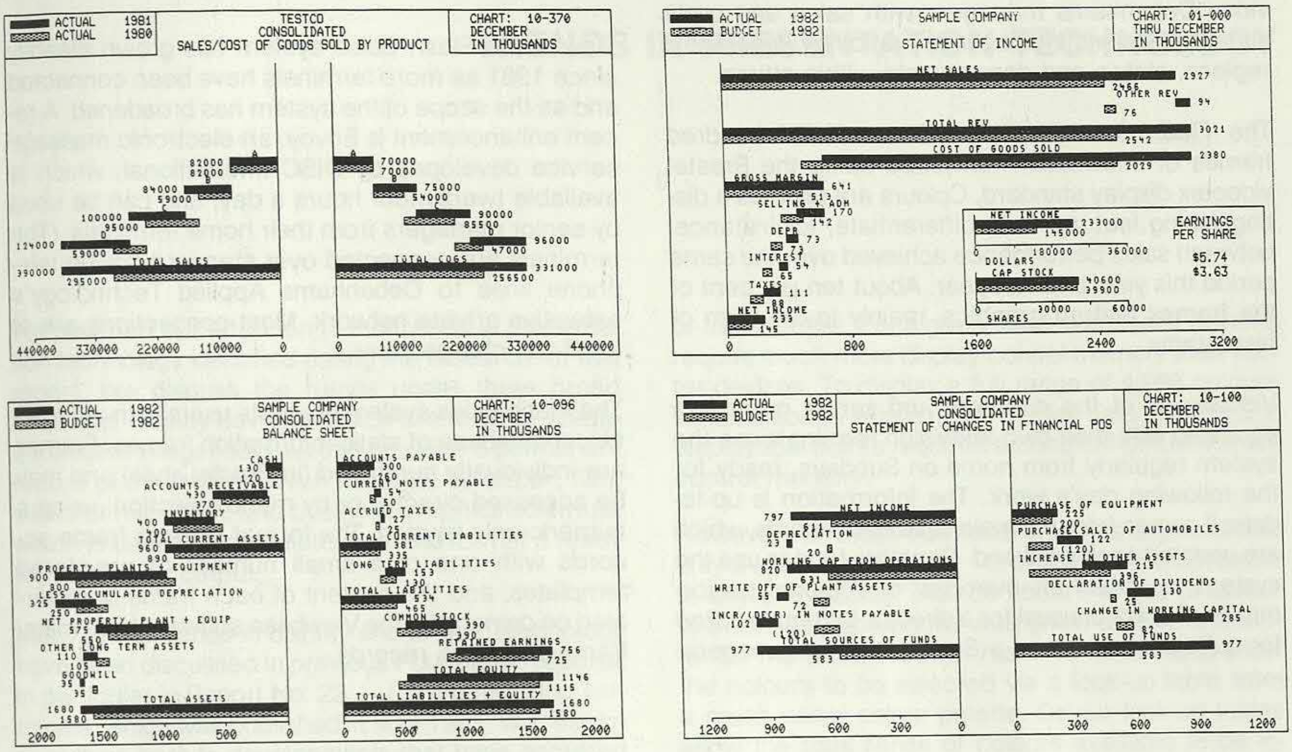
CODMAN & SHURTLEFF

One company that has successfully begun to exploit minicomputer-based business graphics for data presentation and decision-support purposes is Codman & Shurtleff, a Massachusetts-based manufacturer of surgical instruments and supplies.

Codman & Shurtleff's information systems are based on a variety of hardware including a Wang VS-100 minicomputer. During 1981, the company added a colour business graphics facility to the systems supported by the Wang hardware. This facility allows the corporate data files to be accessed by any Wang VS workstation, and the retrieved data to be presented graphically. The graphics peripherals chosen include Hewlett-Packard eight-pen plotters and Ramtek colour display terminals.

The graphics software package chosen by Codman & Shurtleff was EDC Graphics Impact from Engineering Design Concepts Inc. This package is designed for use on a computer that is already running several different user applications. According to Codman & Shurtleff's staff, the EDC software is menu-driven and

Figure 5.1 Examples of graphics outputs available from the Fingraph system



(Reprinted by kind permission of Dr. Irwin Jarett, Chairman of Fingraph Corporation)

can easily be operated directly by end users without the need for programming support. The menus and control procedures were designed to be similar to those for other Wang-based applications, and this feature has reduced the time required to learn how to use the system. Another factor that influenced the company's choice of graphics software was the attraction of a package that did not require a substantial contribution from the system development staff.

Codman & Shurtleff also uses a financial modelling package that is linked to the graphics facilities. This package makes it easy to display graphically various sets of hypothetical financial data.

So far, the company has used its graphics facilities only for preparing graphics for presentation purposes. At the time of writing this report, the company was experimentally using the package to extract data from the main Wang VS data files and format it for graphical presentation.

DEBENHAMS

There are now several hundred private videotex systems operating in the United Kingdom. Many of these systems provide an information retrieval service for directors and senior managers. One of the best-established applications of videotex for managers is at Debenhams. The Debenhams Group is amongst the United Kingdom's largest retail chains, operating 67 major department stores throughout the country. Annual revenues in 1983 exceeded £700 million ($1.05 billion). Debenhams' private videotex system, known as Viewbase, was developed by DISC International, (now a separate company that is part-funded by Debenhams), and is now operated on behalf of the company by Debenhams Applied Technology Limited, the software and services subsidiary of Debenhams plc.

Viewbase was originally implemented in 1981. Its purpose is to improve and extend the updating of and access to, records stored on Debenhams Applied Technology's computers. Today, more than 250 colour videotex terminals are linked to Viewbase. About two-thirds of the terminals are installed in the stores, where they are used by Debenhams store managers and staff, by shop-in-shop concessionaires, and by store customers. The remaining terminals are located in the homes of Debenhams directors and senior managers.

Several applications have been implemented on Viewbase. They include a carpet inventory and order processing system, a credit card record enquiry service, and a stock replenishment service for use by suppliers. But the application that is most widely used by senior managers is the Flash Sales system. It provides Debenhams managers with sales and profit statistics and with management ratios for geographic regions, stores and departments within stores.

The Flash Sales system offers several hundred frames of information formatted using the Prestel videotex display standard. Colours are used as a distinguishing feature — to differentiate, for instance, between sales performance achieved over the same period this year and last year. About ten per cent of the frames feature graphics, mainly in the form of histograms.

Virtually all of the directors and senior managers equipped with their own television terminals use the system regularly from home on Sundays, ready for the following day's work. The information is up-to-date; it comes from the main database records, which are updated each weekend. Directors tend to use the system to obtain an overview of regional performance. It is not unusual for a director to remain online for quite some time on a Sunday. Store managers, on the other hand, tend to use the service for comparative information about store performance.

Use of the Flash Sales system has grown steadily since 1981 as more terminals have been connected and as the scope of the system has broadened. A recent enhancement is Envoy, an electronic message service developed by DISC International, which is available twenty-four hours a day, and can be used by senior managers from their home terminals. (The terminals are connected over standard dial-up telephone lines to Debenhams Applied Technology's extensive private network. Most connections are at local-call charge rates.)

The Flash Sales system presents users with a hierarchical database of static information frames. Frames are individually numbered (in Prestel style) and may be accessed directly, or by menu selection, using a numeric-only keypad. The format of each frame accords with one of a small number of pre-stored templates, and the content of each frame is generated on demand by the Viewbase software from mainframe database records.

CHAPTER 6

TRENDS IN PRESENTATION TECHNOLOGY

We now turn our attention to the trends in presentation technology identified during the research for this report. We discuss the trends under three broad headings: display devices, which are used to create a transient image; devices that produce a permanent record of the image, which might be on paper, film, slides or microfilm; and business graphics software, which is used to manipulate data and format it ready for display or output.

Many of the trends in display and printer technology have been discussed in previous Foundation reports, in particular in Report No. 23 — Communicating Terminals, which was published in May 1981. We restrict ourselves here to developments that have occurred since that report was published, focusing in particular on developments that are significant for business graphics applications.

DISPLAY DEVICES

Cathode ray tube technology dominates the field of graphics displays at the present time, and is likely to continue to do so for at least the next five to ten years. Flat panel displays, the only viable competition to raster technology, will not make a significant impact for several years.

Cathode ray tube devices

Two basic methods can be used for creating an image on a cathode ray tube: raster-mode refresh and vector-mode refresh. Raster displays are used with regular television receivers, and so the technology is well-proven and can benefit from the cost reductions brought about by mass production. With a raster display, the electron beam follows a fixed pattern and refreshes the whole of the screen at regular intervals. With a vector display, the electron beam only passes over the area that needs to be illustrated. The resulting refresh pattern is therefore determined by the characteristics of the particular image being generated.

For both types of display, information about the picture to be generated needs to be stored in a temporary buffer, known as the display control memory or frame buffer. For a given resolution, raster devices require much more display control memory than vector devices. To display a full range of 4,096 colours simultaneously with a raster display having 512 x 512 displayable points requires around 3M bits of display control memory.

However, in most business graphics applications, only a small number (say 16) of colours are advisable in any one display. (Advice about the use of colour in business applications was given earlier, in Chapter 2.) The trend in colour raster terminals is to allow the colours to be selected via a look-up table from a much wider colour palette. Colour look-up tables allow the total range of colours available to be increased greatly without a proportional increase in the storage required.

Colour look-up tables also have another advantage. By removing the one-to-one relationship between bits in the display control memory and displayable points, they enable colours to be changed instantaneously and independently simply by changing the colour specification in the appropriate cell of the look-up table. Careful use of this technique can create the impression of simple animation.

A variation of vector-mode cathode ray tube technology is the direct view storage tube (DVST), introduced originally by Tektronix Inc. in the late 1960s. This device removes the need for continually refreshing the display by using the inside of the screen itself for storage. Once an image has been displayed it remains on the screen until it is replaced by a subsequent image. During the early 1970s, the introduction of DVST devices was responsible for reducing the cost of computer graphics output devices by a factor of about ten. Developments in DVST technology are still continuing, with the most significant advances occuring in the areas of larger screen sizes and improved circuit design.

In spite of these advances, raster-based display devices still outnumber DVST systems by about four to one. Even with the larger amount of memory required for raster displays, they will continue to be less expensive than other types of cathode ray displays. Their cost advantage is likely to continue for as long as raster technology is used for mass produced televisions. Today, a vector refresh colour display can be 25 times as expensive as a raster display. The gap is likely to widen, rather than close.

Flat panel displays

The only recent practical applications of flat panel displays have used plasma display technology. A plasma display consists of two sheets of glass, with a layer of gas, such as xenon or argon, sandwiched between them. A grid of fine wires is inserted in the gas between the glass plates. Sometimes the wire grid is replaced by a series of electrodes that have been photo-deposited onto the glass sheets. When a grid-intersection (or electrode) is charged, the gas trapped in the panel at that point is ionised and glows, usually as a dull red or orange colour. Because the charge builds up on the glass itself, the gas continues to glow until the charge is removed. A plasma display can therefore behave in a similar manner to a direct view storage tube.

Sometimes the whole panel is transparent, permitting back-projected images to be merged with information generated by a computer system. This technique was used in the devices made by Magnavox, and which were used with the Plato computer-aided instruction system.

Plasma panels produce a very stable and sharp image, with a resolution of up to 1,024 x 1,024 displayable points. They can easily be used to display large-character fonts, and it is possible to interact with them by using a light pen. At present, there are no commercially available plasma display products with grey-scale or colour facilities, although several suppliers are experimenting with these features. Plasma displays are now used successfully in military applications but, because of their present single-level monochrome-only limitation, they have not yet been used widely for business graphics applications. As the present experiments with grey-scale and colour lead to commercial products, plasma displays (and other flat panel displays) will provide an alternative business graphics display technology.

Figure 6.1 Characteristics of four main display technologies

Characteristic	*Vector*	*Raster*	*DVST*	*Plasma*
Screen capacity	Fair	Very good	Very good	Good
Display quality	Fair	Good	Very good	Moderate
Speed	Very good	Moderate	Poor	Poor
Drawing type	Realistic	Realistic	Line	Line
Cost	High	Low/mod.	Moderate	Moderate
Colour	Limited	Full	No	No
Interaction	Very high	High	Low	Low
Motion	Dynamic	Dynamic	Static	Static
Steadiness	Fair	Good	Very good	Very good

(Source: Proceedings of the Online Computer Graphics '82 conference, London, October 1982)

Comparison of display technologies and future developments

The characteristics of the four main display technologies (vector, raster, direct view storage tube and plasma) are summarised in Figure 6.1.

As the demand for information systems continues to increase, the cost to the user of all types of display devices will continue to fall, mainly because suppliers will be able to mass-produce the electronic components. But for the foreseeable future, raster technology will continue to have an unassailable price advantage over other display technologies.

Colour displays will become the norm and, as the costs of electronic memories and control circuits continue to fall, the resolution of displays (in terms of displayable points per screen) will improve. High-resolution colour displays will be widely used for business graphics applications. In turn, this will lead to a need for greater processing power in the display device itself. Processing graphics information imposes a large load on a centralised mainframe, and it makes sense to off-load as much as possible of this to the display device.

We believe, however, that display devices will not evolve to become all-purpose multifunction devices. Instead, suppliers are likely to provide multifunctionality by making available special-purpose hardware modules that can be used to customise a display for a particular application. An example of this approach can be seen in IBM's plans for optional components that can be added to the basic 327X type of display. These components can be used to provide features such as a professional-quality keyboard, interfaces for special control devices, special function keys, a voice-recognition facility, and so on.

Many of these special features will become increasingly important as a means of improving the man-machine interface, particularly as the use of display devices widens to include a greater number of infrequent and inexperienced users.

PERMANENT-RECORD DEVICES

In many management information applications, the transient image presented on a display screen is not the 'action' document. Once the screen image has been defined, it is often transferred to a more permanent medium, such as paper, film or slides. We now review briefly the trends in printers and film output technology.

Printers

In the short to medium-term, the most dramatic developments will occur in dot-matrix printing technology. This type of printer will increasingly be used for applications where previously medium-speed (300 to 600 lines per minute) line printers or daisy wheel printers were the norm.

Dot-matrix printing technology can now match the speed of these line printers, and can match the quality of daisy wheel printers. In addition, they will be used for low and high- resolution graphics printing. Furthermore, colour printing is increasingly available with dot-matrix technology and, for some applications, dot-matrix colour printers will be a viable alternative to pen plotters.

Where higher printing speeds are required, laser printing will be the dominant technology. Laser printing is also most suitable where complex images have to be formed. The price of laser printers is falling, and will continue to do so as the market expands. In addition, continuing improvements in laser technology will reduce this price further.

Laser printing technology will continue to be used when there is a requirement for high-speed bulk printing. Some laser printers, such as the high-resolution Xerox 9700, are so fast that they are now used to produce on-demand copies of reports and forms, and even books. The high cost of the equipment at the present time can, in these circumstances, be offset by the savings made because it is no longer necessary to print and store many copies in anticipation of future demand.

At the other end of the scale, smaller and less powerful laser printers will play an increasingly important role during the next few years in the office systems marketplace. Several small laser printers had already been announced by the end of 1983, including products from Canon, Ricoh, Fujitsu, Minolta, Hitachi and Roneo-Alcatel.

Laser printers such as the Xerox 6500 are also now able to produce colour hard-copy output. Typically, these printers can produce a resolution of 100 dots per inch, and can produce one copy in about 20 seconds at a cost of about four cents per copy. By the end of the decade, colour laser printers will be available with a better throughput rate and sharper resolution than today's line printers.

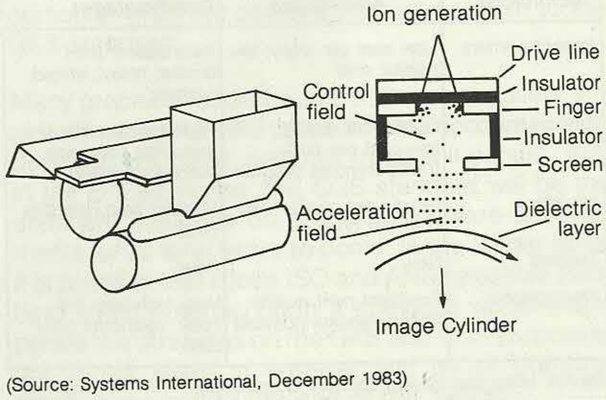
For the sake of completeness, we should also mention ink-jet printers. Ink-jet technology has been employed for more than ten years but, except in certain niche markets, it has not been widely used. There are three variants of ink-jet technology: continuous, drop-on-demand and impulse jet. Each of these has been employed in commercial products, but drop-on-demand ink-jet technology is gradually becoming the dominant variant. This type of technology could find uses in areas currently served by conventional graph plotters.

There is also a newly emerging printing technology that could make a significant impact in the future. This technology is known as ion-deposition printing and it was developed specifically for high-speed non-impact printing. It uses an electrical charging process that is simpler and less costly than xerography. The technology has been under development by the Dennison Corporation in the United States since the mid-1970s, and commercial products are now manufactured by the Delfax Corporation in Canada.

Ion-deposition printing is a four-stage process. First, a high-frequency electrical field creates a cloud of free ions in a cavity. A second field then accelerates some of these ions through an aperture and onto a dialectric surface. By controlling either the ion-generation field or the accelerating field the stream of ions can be turned on and off as an image-transferring drum passes under it, thereby creating a series of charged strokes on the drum's surface. Finally, toner is picked up by the charged strokes and deposited on plain paper. Figure 6.2 shows the simple nature of ion-deposition printing technology.

The most significant potential benefits of ion-deposition printing arise from its inherently low-cost, reliable technology. The mean time between failures, or the mean number of copies before failure, should be substantially better than with laser xerography. (Some estimates indicate that there should be a fourfold increase in reliability.) The built-in design simplicity should also substantially reduce the mean time to repair a fault, once it has occurred. All of these

Figure 6.2 Ion-deposition printing process



(Source: Systems International, December 1983) factors should lead to a reduction in the total cost per printed sheet of about 50 per cent compared with laser xerography.

Film output devices

Film output devices are used primarily where high-resolution and high quality colour hard-copy is required. They are particularly useful for producing either colour photographs of graphics displays for use in reports, or 35mm slides for use in presentations. In general, however, film output devices are costly and cumbersome to use, and there is a time delay before usable output is produced.

Apart from the obvious method of photographing a display screen with a tripod-mounted camera, there are three types of film output device: terminal-driven devices, stand-alone devices, and direct-drive film recorders.

Terminal-driven film devices can be used to produce photographic records (in the form of microfiches, 35mm slides or polaroid prints) of graphic images displayed on a screen. The output quality is better than that obtained by manually photographing the screen, because the colours are optimally mixed for the type of film being used, and ambient light does not affect the result. (Plate 15 illustrates the quality of the output that can be produced.) Nevertheless, the resolution of the final record is determined by the resolution of the display screen. Examples of terminal-driven film devices in common use include those from Dunn Camera (models 631 and 632), and the Matrix 3000 and 4007 devices.

Stand-alone film output devices typically comprise a camera system, tape drive and high-resolution video monitor. The whole system is usually controlled by a built-in minicomputer. Inputs to the system may be from magnetic tape, or direct from the minicomputer, or through an online link to other computers. The minicomputer decodes the input instructions, constructs the image on the display, and then controls the camera and film movement operations. Some products can generate high-quality typographic fonts, which can be merged with graphics images. Usually, a full range of colours is available with this type of device.

A wide range of output formats can be generated from these devices, including 16mm and 35mm film, 105mm microfilm and microfiches. Some devices can produce positive film of fully composed pages, which can then be used to make printing plates.

The best-known manufacturers of stand-alone film devices are Dicomed, Information International Incorporated and Celco. Their products produce very high-quality graphic arts output, but they are very expensive to purchase and operate. Many organisations find it more economical to use a specialised bureau service that operates this type of equipment.

Direct-drive film recorders (or slide composition systems) are connected to computers in the same way as other output devices. Compared with terminal-driven devices, their major advantage is that they can reduce considerably the host-computer resources required to produce a permanent record of a graphics image. These devices typically have a built-in high-resolution raster display, with a resolution which is usually about four times that of a display terminal. Suppliers such as Dicomed, Genigraphics and Matrix have all recently developed products that are very competitively priced.

With their advantages of high resolution, low cost and availability to many users, direct-drive film recorders are certain to be used widely, and may well become the dominant type of film output technology.

Figure 6.3 Advantages and disadvantages of different permanent-record technologies

Technology	*Advantages*	*Disadvantages*
Impact printers	Low cost per copy; low capital cost	Inconsistent print quality; noisy; limited colours
Xerographic	Good print quality; low cost per copy; transparencies possible	High capital cost; restricted copy size; bulky equipment
Ink jets	Good print quality; low cost per copy	Minimal field reliability data
Thermal	New	New
Photographic	Excellent print quality; transparencies possible	Very high cost per copy; restricted copy size

(Source: Integrated System Software Corporation)

Comparison of permanent-record devices

Figure 6.3 summarises the advantages and disadvantages of different technologies that can be used for producing a permanent record of computer-generated management information. Irrespective of the technology used, our research has shown that the development and use of colour facilities will be a significant element in the effective presentation of information to managers.

BUSINESS GRAPHICS SOFTWARE

This report has shown that computer business graphics is set to become a major growth area in many organisations. Earlier in this chapter we reviewed the trends in hardware technology, focusing on their significance for business graphics. Developments in business graphics software are equally important, and they are likely to be concentrated in four areas: ease of use, greater device intelligence, integration with existing databases, and adherence to graphics software standards.

Ease of use

The trend is for all types of software, and particularly graphics software, to be used increasingly by business users, rather than by data processing specialists. To be really useful to the user community, the software has to be easy to use. Graphics software packages will therefore be provided with a natural-language dialogue as a matter of course. Another likely development is that business graphics software will be provided with voice input and response, as has happened with some computer-aided design and manufacturing applications.

Increased device intelligence

The present trend is for hardware suppliers to provide graphics devices with more intelligence. This development provides both opportunities and problems for graphics software suppliers. By transferring unformatted data, together with instructions for displaying it, the graphics software can reduce the processing load on the host computer and improve response times. The problems stem from the increased software development load necessary to achieve this. In particular, separate device drivers have to be developed for each type of graphics terminal.

A trend in graphics software is for the device-handling software to be packaged separately so that it can act as an interface between the host software and the device itself. The advantage of this approach is that graphics software will become more portable, and will be able to support a wider range of graphics devices.

Integration with existing databases

As the use of computer business graphics spreads throughout an organisation, the graphics software will increasingly need to interface with conventional database management software. One development would be to make the link between graphics software and databases much more dynamic: for instance, to change the shape of a graph which has already been displayed, in response to interactive changes made to the variables in a financial model.

Business graphics software standards

The business graphics software industry is still relatively young, and different development groups have adopted different design philosophies and standards. In the medium-term, this uncoordinated approach will give way to a need to adhere to commonly agreed standards.

Much attention has recently been focused on efforts to define a computer graphics software standard that is acceptable to most users. At present there are four contenders, known respectively as Gino-F, Plot-10, CGS and GKS.

Gino-F is a set of Fortran routines designed to assist the user in graphics input and output. Gino-F originated in the mathematics laboratories of Cambridge University, England. It is by no means a complete standard but, because of its historical links with the graphics community, it is being considered by the International Standards Organisation as the basis of a standard.

Plot-10 is the de-facto contender in the graphics standards debate. It was developed by Tektronix, the company that has perhaps done more than any other to popularise the use of graphics (and which is now the acknowledged leader in the graphics hardware market). Tektronix compatibility is as much desired in the graphics marketplace as Centronics compatibility is in the printing marketplace.

CGS (Core Graphics Standard) was formulated in the United States by the Association for Computing Machinery's Siggraph Graphics Standard Planning Committee. It is the favoured standard in the American marketplace, where it has been implemented in several commercial products. Because of that country's present dominance of the graphics industry, CGS is likely to remain in popular use irrespective of any official pronouncements by standards organisations.

GKS (Graphics Kernel System) is the graphics standard most favoured in Europe, and at present is the one most likely to be adopted by the International Standards Organisation. It has reached the stage of becoming an ISO DIS (International Standards Organisation Draft International Standard), and is likely to be ratified fully some time in 1985 or 1986. GKS is a graphics software standard and, as such, it will have no direct influence on the standardisation of graphics devices. It is interesting to note, however, that a working group of the American National Standards Institute (ANSI) is currently formulating a standard for computer graphics devices that will conform to the GKS standard.

Many graphics hardware and software suppliers are already taking the GKS proposals into account in their development plans, and this trend will persist. But, in the United States, the CGS standard will be the dominant influence on graphics software developments for several years to come. In the longer term, it is possible that a joint ISO and ANSI graphics standard could emerge. Such a standard would incorporate the strengths on the GKS and CGS proposals, but is not likely to emerge and be of practical significance before the end of the 1980s.

CONCLUSION

Our investigations for this report have clearly shown that decision makers in large organisations require a better form of information systems support than has been provided by traditional data processing applications. In particular, senior corporate staff are not prepared to invest large amounts of time and effort in learning how to use systems that provide them with a mass of data which is not relevant to their immediate needs. Systems for presenting information to managers must therefore be easy to use, and they must provide relevant data in a form that can be readily assimilated.

To achieve these goals, it helps if system designers have a basic understanding of the human cognitive process. The three key elements of this process are a shared context, the structure of the human memory system, and the efficiency of translating data into information. Each needs to be taken into account when a management information system is being designed.

Careful attention should be paid to the topics of response times and screen formats and dialogues. Our research has shown that slow response times need not, in themselves, reduce the efficiency of management information systems. But it is important to ensure that response times for the same, or similar, operations do not vary widely.

A theme throughout the report has been that business graphics is becoming an increasingly important element in presenting management information, since people can absorb large amounts of information when it is presented graphically. We believe that computer business graphics has an important role to play in providing effective support to corporate decision makers.

On the other hand, we are more cautious about the use of colour in presenting management information. At the present time, there is a tendency to use colour simply because it is available. Yet excessive or unwarranted use of colour can actually be counterproductive. Futhermore, little research has yet been carried out into the optimum use of colour in visual displays.

Recent technological developments in displays, printers, film-output devices, graphics software and so forth have created very powerful media for presenting information to managers. This report has identified the opportunities created by the technology.

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