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*The integration of hospital information systems through user centred design.*

FRASCINA, Anthony Cosimo

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**THE INTEGRATION OF HOSPITAL INFORMATION SYSTEMS  
THROUGH USER CENTRED DESIGN**

A. C. Frascina

A thesis submitted in partial fulfilment of the  
requirements of  
Sheffield Hallam University  
for the degree of Doctor of Philosophy

1994

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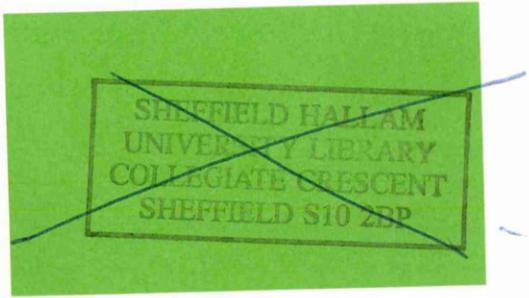
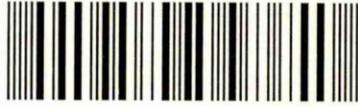
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## Abstract

The development of computer systems in UK hospitals has in recent years been focused on the provision of hospital-wide information systems, known as Hospital Information Support Systems (HISS). This development has been motivated by National Health Service reforms and a realisation that earlier fragmented systems were not meeting the requirements of clinical and nursing staff in the most effective way. Such systems were often developed by external, centralised agencies using systems analysis techniques appropriate to the development of information systems in product orientated organisations. However, the hospital ward, an environment existing at the 'sharp end' of health care, in which many diverse and non-computer related activities take place, presents the system designer with many of the classic problems with which the discipline of Human Computer Interaction (HCI) is concerned. Although a HISS has the potential to improve both the work conditions of clinical staff and the delivery of health care, this may be impeded by many of the common obstacles associated with the introduction of a large and complex computer system into a work environment where tasks are ill defined.

This thesis reports on a project that is based upon the application of HCI methods to the health care environment and their contribution to the solution of the problems that such an environment presents. Requirements for the users' interface to the potential HISS are derived using a task analytic approach, involving Task Analysis for Knowledge Descriptions (TAKD). A prototype system has been designed and subsequently evaluated in a hospital ward. The contribution of TAKD to the design and its further applicability to the environment are assessed.

The research represents an original application of a formal task analysis method to the design of ward based computer systems, and as such makes a valuable contribution to the areas of medical informatics and HCI. It shows that TAKD has real but limited applicability in this sphere, in that its use can lead to the design of more usable interfaces, while there is a need to combine it with methods aimed at broader systems design if these benefits are to accrue in the development of a HISS. The potential for the integration of task analysis with Design Rationale methods is also demonstrated.

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# Chapter 1

## Introduction

The drive towards Hospital Information Support Systems (HISS) in the UK has brought with it many of the challenges that come with any large information system development. The implementation of a HISS represents a major investment of resources, of an order far greater than that for the smaller systems which have existed at the departmental level for several years. Such investments are not without their associated problems; Gough (1991a; 1991b) reports on the severe difficulties encountered in some of the HISS pilot sites. Moreover, the risks associated with failure are exacerbated by the public's perception of a resource-starved National Health Service squandering funds on information technology, with the highly publicised recent problems in the Wessex Health Authority (Warren, 1992) and the London Ambulance Service (Brown, 1992) doing little to allay these concerns.

The objective of a HISS, as stated by Gronlund (1991) is:

*".....to provide support in the operational activities of a hospital, in the day to day work of nurses, clinicians, and other hospital staff, and in providing an improved service to patients."*

Given this acknowledgement of the pivotal role of the ward staff in a HISS, it is clear that the end users should be of prime concern throughout the HISS life cycle. It will be their experiences, as they interact with the computer system, which will be one of the major determinants in the success of the system. The work which forms the basis for this thesis takes this assertion as its underlying theme. This chapter sets the scene for the research work undertaken, initially by presenting the historical background to the development of hospital information systems. It follows on by giving a justification for the user centred approach upon which this work is based, and finally gives an account of the current situation in hospital wards firstly with respect to the use of computers, and secondly with respect to approaches to investigating the ward environment.

## **1.1 Historical perspective of information technology in hospitals**

The context within which this thesis is set is the outcome of an evolutionary process originating in the USA in the early 1960s, when automation was first introduced into hospitals. Over the last three decades, the direction in which healthcare informatics has developed has been the result of many pressures. The principal early stimulus for automation in the USA came from the Medicare and Medicaid programmes, which were aimed at care for the elderly and the poor respectively. Accompanying these programmes was a huge increase in the amount of administrative activity in hospitals seeking reimbursement from Medicare, Medicaid and similar insurance companies. Even at this early stage, it can be seen how developments in medical informatics came as responses to financial and administrative needs. Indeed, by the 1970s, commercial hospital accounting systems had become the norm in American hospitals. Departmental computerisation had begun in clinical laboratories by the late 1960s, driven by pathology specialists. Their interest lay in the benefits that would accrue as a result of improvements in laboratory efficiency ensuing from automation. Meanwhile, patient care systems, based on automating the nursing station, initially met with developmental problems, and did not become common until well into the 1980s. However, they are now well established and are becoming more sophisticated in meeting the needs of nursing and other clinical areas of hospitals.

Development in the UK has proceeded more slowly than in the USA (Dorenfest, 1993; Thorp, 1993). At first computerisation was on a piecemeal basis; individual hospital departments would acquire scientific systems, for example in radiology, or following the American example, in clinical laboratories. However, by the mid 1970s, although there were a few integrated laboratory systems linked to ward VDUs, such as at the Charing Cross Hospital, London, most major systems were concerned with accounting and hospital supplies, once more reflecting a concern for the control of expenditure.

A major impetus for change in the UK came about following the publication of the Körner reports, beginning in 1982 (Körner, 1982), commissioned as part of a government initiative to overhaul management in the health service. An important outcome of Körner was the identification of a need for a 'minimum dataset', to be used by management for the monitoring and planning of services. In order to capture the required Körner data, hospitals responded by implementing Patient Administration Systems (PAS).

This in turn required a great increase in investment in IT within the health service.

Subsequently, with the publication of the Griffiths report (Griffiths, 1983), there emerged the perception that doctors should be accountable for the expenses associated with the delivery of health care. This led to the Government's Resource Management Initiative (Department of Health and Social Security, 1986), which required that hospitals and Health Authorities should aggregate data from a variety of sources in order to build an accurate picture of the care received by each patient, with the aim of maximising the use of resources. This involved grouping patients by diagnosis type, and then matching the care actually received against the expected care that a patient of that type should receive. In doing so, this exercise necessitated drawing data from all departments that utilised or generated patient-related data, including the PAS, the pharmacy, the pathology laboratories, the nursing system, and so on.

By this time, the first commercially produced integrated systems had become available from the USA, with a full Hospital Information Support System (HISS) being implemented at the Royal Hampshire County Hospital, Winchester, in 1986. While other hospitals watched this development with interest, there grew the realisation that integrated operational systems were feasible and had the potential to bring substantial benefits in terms of efficiency and quality of care. The first national initiatives began to appear for the co-ordination of the various information management ideas that were emerging, in particular with the launch in December 1988 of the HISS Programme by the NHS Management Executive. This had the intention of creating a central pool of expertise that could be drawn upon by hospitals, and of promulgating the advantages of integration.

The most recent major development occurred soon afterwards with the publication of the White Paper *Working for Patients* (Department of Health, 1989). This defined hospitals as the providers of health care for other organisations, such as District Health Authorities, to purchase on behalf of their patients. With this re-organisation, the data collected in Resource Management suddenly became crucial for the accurate measurement of the cost of care, which could be used for the purpose of contracting with the purchasers.

What is most noteworthy is the thread running consistently through all of these developments: health care computing has been dominated by the information needs of management. There can be little doubt that this remains the situation: the Department of Health (Department of Health, 1990) issued

guidelines to hospitals for action to be taken regarding information systems, including the statement that:

*".....the current priority must be to ensure that adequate information is available to enable providers to enter into contracts."*

## **1.2 The motivation for the project**

The inception of the project occurred when the District Health Authorities had a major role in the workings of hospitals, before the implementation of the internal health care market in 1991 and the establishment of the first NHS Trusts. Sheffield Health Authority ran a large central PAS along with computers which stored clinical laboratory results generated by individual hospital systems. In addition, the hospitals were at various stages in their acquisition of nursing systems which were also to be PAS-linked. The authority was concerned with the integration of these developing systems, both at the unit (hospital) and district levels. This was to be a large undertaking, and reports were undertaken to discover the scale of the problems that might be encountered (Jones, 1988). The Authority acknowledged that to integrate these systems at the 'sharp end' of health care practice, on wards or in clinics, would require a degree of commonality of interfaces, which should be characterised by their ease of use and should fit in with the conceptual framework of the principal users. It was in this context that the project was established, in order to explore the issues surrounding the design of integrated hospital information systems from the perspective of the ward-based user.

## **1.3 User centred design**

Large IT projects have traditionally been viewed from what Kammergaard (1990) calls the systems perspective, wherein components are characterised by a set of data types and a set of actions which involve those components. This is indeed the perspective taken by the NHS itself in its Common Basic Specification data modelling programme (NHS IMG, 1990). According to Kammergaard, the disadvantage in using this perspective in the design of systems is that the end users are seen as data processors, and the interface between them and the computer system is seen as another interface between two system components (albeit with its own particular requirements). There is a tendency in the systems perspective to

reduce the jobs of human components within the system to algorithmic procedures, because one is not allowed to consider aspects of a job which cannot be described as data processing. The work of doctors and nurses is very obviously much more than this: the design of the computer system must take account of those non-data processing aspects of ward activity.

Insufficient attention to the users and how they are to interact with the system can have important effects. Sutcliffe (1988) outlines some of the consequences of poor user interface design:

- Increased error rates in data entry and system operation.
- User frustration, leading to low productivity, stress, or system under-utilisation.
- Poor system performance, i.e. problems with its usability may result in it not performing to its specification.
- System failure, because of rejection by its users.

Such problems can be avoided by the consideration of human factors and usability in system design and installation. Shackel (1990) reports that reduced project costs can be a product of such consideration. Gould and Lewis (1985) discuss the principles upon which the design for usability of systems can be based. Their emphasis is on early focus on the users and their tasks: the successful application of these principles is described by Gould *et al* (Gould et al, 1990).

#### **1.4 The need for user-centred design in the hospital ward**

The hospital ward displays a combination of four attributes, any one of which would require careful consideration with respect to its effect on the users' needs. The presence of all of these qualities in one environment makes it imperative to focus on the users for the design of a successful HISS.

- Task complexity: Caring for patients is an ill-defined and complex activity, and information based tasks are intricately linked with patient care. This relationship must be unravelled by detailed analysis of those tasks to provide a system which most concurs with the requirements of the ward staff.
- Work environment: Doctors and nurses work under conditions of considerable stress. Stresses come from a variety of sources, and the introduction of a computer system should not add to them. On the contrary, there is a need to enhance the work environment and not hinder patient care

by imposing further burdens on staff. Hence the usability of the system should be of the highest priority.

- Staff diversity: The ward workforce is varied and includes many transitory and occasional personnel. If the HISS is to become central to the ward activity, then the system must be easy to learn, easy to use, and it must be easy to retain knowledge about its use.
- System complexity: The manual information systems that impinge on wards are highly complex, and transferring these to a fully operational HISS would result in a computer system with a large amount of functionality at the disposal of the ward staff. Several outlying systems, each with its own user interface, must appear as one on the ward. This 'system transparency' must be accompanied by consistency across applications to minimise the learning load on the users.

Despite these particular attributes, the emphasis on information gathering for management purposes reported above has meant that the needs of the people who deliver the health care have been largely ignored. Where recognition of the importance of the user interface is given, it is often simplistic. In a survey of nursing systems, for example (Pluyter-Wenting, 1992), a list of requirements to ensure acceptance of the system merely mentions that "*user friendliness*" is necessary. Sometimes, acknowledgement of the importance of the user interface is cursory; for example, a 138 page report (Benson, 1991) aimed at helping health service managers in the procurement of information systems warrants only half a page on this subject. Moreover, the particular section concerned begins with the words "*Data entry into the computer should be...*", betraying the systems perspective in which the users are held.

There is now, however, a growing awareness that the clinical and nursing staff have been neglected in the move towards computerisation in hospitals. Barnett (1993) articulates the commonly held view that the introduction of computers into health care is treated with scepticism or disinterest by most clinical nurses because the needs of managers, administrators, civil servants and politicians have been foremost, and she goes on to report a shift towards a focus on clinical practice. In a retrospective view of the implementation of nursing systems, the Audit Commission (1992) reported on the lack of commitment shown by nurses, citing various causes for disenchantment:

- Systems resulted in additional work with little proven benefit for the patient.

- Systems were perceived to be of little value to those required to operate them.
- Managers were not seen to make constructive use of the data the nurses entered.
- The pace and timing of implementation were often seen as having been poorly co-ordinated with that of other changes on the wards.

Furthermore, although attempts had been made to engender a sense of ownership by involving interested ward nurses in the implementation, these had been restricted to specifying the detail of the system, and not in "*discussing the way it should be used*". Consequently, only an enthusiastic minority was genuinely committed to the use of the system.

A similar lack of success is reported with respect to clinical computer systems, reflected by Safran (1993) who, noting the small proportion of clinicians to administrators and IT professionals at a recent UK healthcare computing conference, emphasises the need for more involvement by doctors in healthcare informatics, stating that "*...good clinical computing can only happen if physicians are active participants in the process [of developing systems]*". The uptake of computers in hospital consulting rooms, for example, is one percent, as opposed to forty percent for GPs (Benson, 1993). In the analysis of the reasons for this poor uptake by hospital doctors, criticism is yet again levelled at the emphasis on management information at the expense of improving the information systems available to help doctors at the point of care. Reference to the user interface as the factor behind the lack of interest is made by Vincent (1993), who reports that the lack of transparency of links to other systems (PAS, pathology, pharmacy etc.) has been a problem. However, he suggests a more important factor is the perception by doctors that the extra effort required for data entry and retrieval outweighs the potential benefits of using computer systems.

The acknowledgement of the need to re-focus on clinical, rather than administrative needs, is typified by the Integrated Clinical Workstation project (NHS Management Executive Information Management Group, 1993). The user requirements that have been drawn up for this proposed ward based system include many references to the user interface and its importance. However, this move towards a user-centred approach is much less significant than it would seem: the requirements have been derived from questionnaire responses and workshop sessions with hospital consultants. Such clinicians perform a tiny proportion of the information handling in the hospital ward, and the omission of any input from the real users, the junior medical staff, risks a perpetuation of the neglect described earlier. The type

of end user selected for involvement is important. Systems development project teams do include nursing and medical staff, but the author's experience suggests that these personnel tend to be at least sympathetic with the project aims and are keen to make a positive contribution. They may also be in positions of responsibility: it is common to find ward sisters or consultants on project teams. Whether they represent typical end users is highly doubtful. *Typical* users may be less experienced and less enthusiastic. The requirements for the user interface should be derived from an understanding of the real users of the potential system, and of their information needs. The discussion now continues with a consideration of why, from the users' viewpoint, computers have had little impact, and how their information needs might be derived.

### **1.5 The problem of attitudes to computers**

As described above, it is well recognised that the introduction of computers into health care has been slower than might have been expected. Kjerulff *et al* (1989) assert that this is partly because physicians and nurses tend to be somewhat cautious in their attitudes towards computers. There are numerous reasons for such caution. The attitude of health care professionals to computers has been a subject of much research, particularly with reference to nurses (Brodt and Stronge, 1986). Bailey (1990) acknowledges the importance of user satisfaction, warning of the danger that low satisfaction levels can lead to system rejection. The extent of negative attitudes to computers is not certain. Sultana (1990) has found that attitudes can be more negative than positive, although other evidence (Jacobson *et al*, 1989) suggests that, while computer anxiety could be a reason for nurses' resistance to computers, the levels of anxiety levels amongst nurses are not high. Schwirian *et al* (1989) have noted that attitudes improve with experience of computers, and Grobe (1984) has looked at ways of overcoming "*computer cowardice*" observed in student nurses. Several themes emerge from the literature concerning this matter. One is that the attitude and anxiety problem can be overcome by better training of nurses. Another is that involving nurses more closely in system development will give an improved feeling of ownership of the system. There is an abundance of explicit advice to nursing systems managers (Warnock-Matherton and Plummer, 1988; NHS Management Executive, 1990) about the need to involve nurses as a strategy to enhance user acceptance of a new system. Where these approaches to dealing with "*cowardice*" or "*anxiety*" fall short is:

i) They put the responsibility for system approval on the shoulders of the nurses themselves, in that better training and the acquisition of experience are perceived as the means of achieving positive attitudes to computers. No responsibility appears to rest on the shoulders of the system analysts and designers for producing something which is inherently usable, beyond ensuring that 'user friendliness' is taken into account. Users and implementors come to believe that it is obligatory for a new system to bring with it a heavy training requirement; McQuaid (1993) reports on the complexity of the training programme at the Central Middlesex Hospital (and praises the loyalty and commitment of the staff that made it succeed). It is considered necessary to impose many hours of extra training on doctors also: Robson and Joyce (1993) predict that junior doctors at the Greenwich Hospital will need nine hours of training to use the hospital information system, and note that they have yet to find a solution to the problem of training the large number of locums that the hospital uses, stating that:

*"...it is very difficult to provide adequate training, whilst still enabling them to carry out meaningful clinical work."*

ii) The involvement of nurses in system selection and implementation is to a great extent asking them to participate in a *fait accompli*, in that their interaction with the system will be largely predetermined by the nature of the software bought in by the hospital, with the users' contribution being more about fine tuning than participation in design.

Attitudes to computers amongst physicians have been surveyed, most notably by Teach and Shortliffe (1981), and more recently by Young *et al* (1990). These reveal that opinions are in general quite favourable, though the extent of such favour seems highly dependent on the role any computer system might play. Computers are perceived as being most useful in a decision supporting role, while it is significant that ease of use is ranked very highly as a feature of a potential clinical computing system. There is the clear indication of a perceived need for putting the potential system users at the centre of the system design: Young (1990) argues that, for acceptance of a clinical system, the basic characteristics of a doctor's job need examination, in terms of the working environment or framework and the essential or core tasks of the job. It must be pointed out that this refers to physicians at the consultant level; while such sentiments must surely hold for the more junior doctor who works primarily on the ward, there is a dearth of published work on the attitudes of such doctors to computers.

## **1.6 Investigating the ward environment**

Having decided that a user-centred approach may provide a solution to some of the current problems with the introduction of computers into the hospital ward, it is useful to consider to what extent the activities that are carried out by ward staff have been studied. The hospital ward presents a highly intricate environment. Interaction occurs amongst people and between people and information at many levels, in terms of both the personnel involved and of the sophistication of the information exchange. Because of this complexity, studying the activity that occurs on a ward is in itself a problem: it is necessary to restrict the scope of any investigation by providing a focus. The focus which has been lacking in published studies to date is that of information use by the ward staff.

### **1.6.1 Studies in general**

The techniques that are employed to investigate activity in medical environments vary according to the needs of those who commission the study, and the scope of the investigation itself. Work sampling and time utilisation studies are common, and have been used to provide information in a wide variety of situations and from a range of perspectives. Thus Bhat *et al* have performed a time utilisation study from the patients' perspective, and work sampling involving observational studies of direct care has been employed by Mayer *et al*. The aims of a study may be general and primarily descriptive (e.g. Laurente (1987)). Highly specific techniques or goals can be involved: time-lapse photography has been used by Tyson *et al* in an investigation of the activity in a new-born intensive care unit, and the physical design of the ward can provide a focus for an investigation of nurse activity, as reported by Seeyle (1982).

### **1.6.2 Nursing workload studies**

A common focus has been the need for hospitals to operate within financial constraints whilst meeting patients' requirements. Thus much of the effort that has gone into the investigation of hospital wards has concentrated on measuring nurses' workload, and relating this to patient needs. Though there are some common themes in nursing workload methodologies, as discussed by O'Brien-Pallas (1988), most exist in isolation of each other and are tailored to individual hospitals' needs, e.g. Linder (1990), McMichael (1987), Misener *et al* (1987), Worthington & Guy (1988). Those which meet with more widespread use are sufficiently different to produce inconsistent measurements when applied to the same wards, as revealed by O'Brien-

Pallas *et al* (1989). The nursing workload focus is particularly aimed at describing and quantifying the nurse-patient relationship.

Workload studies are of limited value in their contribution to an understanding of information based tasks. These tasks are a subset of the total ward activity. While workload measurement studies do provide data about such tasks, there are associated problems. Firstly, the outcomes of workload measurement studies tend to remain as internal documents within hospitals and do not appear in the published literature. Secondly, the relevant data is dispersed throughout a mass of information, and extracting it is a laborious and uncertain exercise. Thirdly, the grain of detail provided can be poor in terms of what is revealed about the handling of information.

### **1.6.3 Studies of doctors in wards**

Owing to the nurse-patient focus behind existing methods, the involvement of doctors in ward information systems has been largely ignored. Doctors are major players in the ward environment, exchanging data with all other workers at some point in their work. Much of the documentation on a ward is shared between doctors and nurses, even though its use is intended primarily for one group only. An example is the drug card, which is intended for use by nurses in the dispensation of drugs but is written and very frequently referred to by doctors. Thus any study of the use of information on a ward cannot hope to be complete unless the part played by the clinicians is included.

As with nurses, studies of the activities of House Officers have been motivated primarily by the need to determine workload. However, this has been in order to ascertain the degree of overwork, and there has not been the association with financial concerns that has been present in the nursing methodologies. Perhaps because of this, few studies have actually been undertaken or published. Recent work includes that by Katz and Schroeder (1988), Leslie *et al* (1990), Lurie *et al* (1989), Turnbull *et al* (1990), and Upton (1989), while Gillanders and Heiman (1971), and Payson *et al* (1961) provide older, but still pertinent information. Different techniques have been used, varying from blanket observations and timings of House Officers' activities, to self recording by doctors and interviews with doctors about workload concerns. The focus of this work has included night shift work patterns, frequency of bleeper calls, and comparisons between grades. There is a paucity of published studies which focus on the information handled by the doctors who work in hospital wards. In addition, the vital information interchange between doctors and nurses has received little attention. Engström (1988) has related work regarding the co-ordination of the

information given to patients by the two groups, offering essentially narrow patient-centred view, whilst more recently, Tange and Smeets (1993) have carried out a very interesting study that reveals the division of tasks and overlaps between doctors' and nurses' information needs.

## **1.7 Conclusion and thesis outline**

The background to the research work has been described and put into the context of the current situation in hospitals. The need for closer attention to the requirements of the real users of a potential HISS has been identified, and it has been shown that studies of the work carried out in wards has, on the whole, lacked the information based focus that is required for user-centred systems design.

The following chapter reports on an initial study of the tasks of clinical and nursing staff, focusing on the use of information in hospital wards. Chapter 3 goes on to consider the role of task analysis in interface design, and reports on the application of one particular method to an area of ward activity. The resulting specification of requirements was used in the design and trial of a prototype system, in a process which is described in Chapter 4. Chapter 5 describes the evaluation of the prototype, the findings of which are discussed in detail in Chapter 6, concentrating on the impact of the task analysis on the success of the system. Chapter 7 contains an evaluation of task analysis in the overall context of software development, and suggests how it might be further integrated into the development process. The concluding chapter returns to the initial motivation for the research, and assesses the effectiveness of the methods used in the healthcare environment.

# Chapter 2

## Background study

### 2.1 Introduction

The prelude to any analytical work necessarily comprises a period of familiarisation with the environment of concern. In this chapter, the preliminary investigative work that was carried out is reported upon. Subsequently, an outline specification of requirements for a ward based computer system is given.

It was not the sole intention at this stage to collect information, rather to gain insight as to where to focus the work. The aims of the background study were:

- To become familiar with the ward environment, with particular respect to the use of information.
- To identify areas requiring more detailed analysis.
- To identify areas into which the investigation might be extended.
- To produce an outline set of requirements for a ward based system from a user-centred standpoint.

The intention was to concentrate on the information-based tasks carried out by the ward staff, thus centring the investigation on the people who would be the first point of contact with the computer system. Faced with the complexity and richness of activity that is presented in a working ward, there was the temptation to attempt to come to grips with the problem by conducting a data-driven investigation typical of systems analysis methodologies. Indeed, the very first meetings conducted with a senior nurse did concentrate on familiarisation with the documentation that is used. Whilst this did provide a good grounding, allowing the subsequent fieldwork to be undertaken with a fair degree of comprehension, it was decided that, in keeping with a user-centred framework, the core of this stage should comprise an observational study of nurses and doctors carrying out their normal job.

One possible approach to the study was to take a reductionist standpoint by selecting representative staff and performing a high level analysis of their tasks. This would provide a clear, tangible focus and would also yield discrete data for analysis and interpretation. However, both the

daunting breadth of activity that takes place on the ward, and the apparent informality of much of the communication between people meant that such an approach might fail to give a comprehensive or fully accurate view of the workplace.

An alternative approach that has been gaining credence in recent years is to use ethnographic techniques in order to understand the workplace in a social context. Ethnomethodology is a product of the social sciences, and its application to HCI has been pioneered by Suchman (1987). Central to her work is the notion that when people act, they draw upon a set of resources provided by the immediate situation in which they find themselves - a strongly contextual view shared by Winograd and Flores (1986). Whilst Suchman based her ethnographic approach on conversational analysis to interpret people's actions using an existing office computer system, Hughes *et al* (1993) report on the usefulness of more general ethnographic methods to inform the design process as a supplement to more traditional techniques, in the instance of air traffic control rooms. Although this approach is not without its critics, for example Cooper (1991), Somerville *et al*, suggest that there are pragmatic reasons for incorporating sociological techniques in certain situations. The use of such techniques, they argue provides

*"...an understanding of what is really going on in the workplace. Because they [sociologists] establish a rapport with end-users and learn many of the subtleties of their job, they act as a communication pathway between system development and the existing practice of users."*

Although the author did not have the skills to carry out a thorough ethnographic study, it was felt useful to adopt an ethnomethodological perspective at least in part for the purposes of the study. Thus a combination of approaches was employed, in which the outward, visible part of the work comprised a broadly task analytic study of the work performed by individuals during entire work shifts. This semi-formal task analysis was intended to be in part a vehicle for the ethnographic study which ran concurrently; informal opportunistic observations were made on the ward activity, while a rapport was established and maintained with a wide variety of staff, with a view to gaining further, less obvious insights into the working environment.

## **2.2 Methods**

The subjects of the investigation were primarily a specialist surgical ward at the Royal Hallamshire Hospital (RHH), Sheffield, where the background familiarisation and first detailed study were conducted, followed by a period on a general medical ward at the Northern General Hospital (NGH), Sheffield. The work was carried out intermittently over a five month period and involved major inputs from several categories of ward staff, being:

- House Officer
- Ward Sister / Charge Nurse
- Staff Nurse
- Student Nurse
- Ward Clerk

Informal discussions were also held at various times with doctors at the consultant, senior registrar, registrar and senior house officer level, and with other nursing staff.

### **2.2.1 Methods in general**

The two principal methods used were interview and direct observation of tasks. Detailed interviews were confined to the initial part of the work. These were tape recorded and transcribed. The intention of this phase was to provide a foundation for the observational work.

The bulk of the information gathered, and most of the insights gained, came from the observation of the ward personnel carrying out their routine tasks. Observations were performed on selected staff for an entire shift. Communication was kept to a minimum during task performance, and any questions were left until each task was completed, although the occasional willingness of the observed staff to talk about their activity was not discouraged. Table 2.1 gives details of the subjects and occasions of each episode for which observations were recorded formally.

Clearly there were many other possible combinations of role, shift and day type, although experience suggested that the coverage was representative enough to include the great majority of tasks. Observations were recorded according to the set of criteria below:

- Task type
- Type of information involved (i.e. verbal or written)
- Location on ward

- Duration

SUBJECT	SHIFT	DAY PARTICULARS
<b>SPECIALIST SURGICAL WARD</b>		
Sister i/c ward	Evening (13.30 - 21.00)	Theatre day
Staff nurse i/c ward	Morning (07.30 - 16.00)	Theatre day
Staff nurse	Morning	Theatre day
Staff nurse i/c ward	Night (21.00- 08.00)	End of theatre day
Staff nurse	Morning	
Student nurse	Morning	
Student nurse	Morning	
Ward clerk	08.00-16.00	
House Officer	08.00-17.00	Theatre day
House Officer	08.00-17.00	Clinic
<b>GENERAL MEDICAL WARD</b>		
Charge nurse i/c ward	Early (07.00 - 15.00)	
Sister i/c ward	Evening	
Staff nurse	Early	
Ward clerk	06.45 - 13.00	
House Officer	09.00 - 15.00, 21.00 - 00.00	Take day
House Officer	09.00 - 15.30	

Table 2.1 Observed subjects and occasion details

The purpose of this was to determine the extent of the work that involved the handling of information, the nature of the information, whether particular data-intensive tasks were performed in particular locations, and the differences between tasks performed by different nurses. A second motivation for this semi- structured approach was to give authority to the author's presence on the ward, rather than merely 'hanging around'. This provided the opportunity to make more general observations, particularly of those ward staff who were not the knowing subjects of the current session. Many tasks required little of the author's direct attention, so other events could be duly observed and notes taken. The opportunity to talk to other ward staff at such times also proved invaluable.

### 2.2.2 Medical staff

The observations on the medical staff were carried out slightly differently. With as few as two doctors on the ward at one time, the comparative standpoint taken for the observations on nurses, who were present in larger numbers and had evidently different roles, was not necessary. Thus this set of observations was concerned more with identifying the tasks carried out by doctors in the context of their overall job. It was realised very early on that the doctor's work is very data-intensive, with information being used in every location on the ward. Of the four formal House Officer observation sessions undertaken, only the latter two

included detailed task timing and location data: the first two were used for familiarisation.

### 2.2.3 Communications survey

An exercise in collecting data about telephone communications with the ward was conducted over a twenty four hour period on the general medical ward at the NGH. Forms were placed by the telephones at the nurses' station and in the doctors' office, and staff were asked to make a single entry to record the source or destination of each telephone call made or received.

## 2.3 Findings: nursing staff

The findings are described here in terms of the activities observed and the documentation used. Outline findings are described first, then more detailed task-related descriptions follow.

### 2.3.1 Task groupings - nurses

From the observational data, all of the task types that involved recorded data were placed into broader categories, as shown in Table 2.2. The term *active time* used below refers to the total time observed in the performance of discrete, identifiable tasks. The term *recorded data* refers to any instance in which information was read or written, such as in the use of drug cards, care plans, fluid balance charts, and including the nurses' own personal reference notes.

Patient monitoring	IVI therapy Temp / Blood pressure/ Respiration Pump chart	Fluid balance charts Pre/post op check Intake/output charts Glucose level monitoring
Ward administration	Patient Care Hours (PCH) charts Maintain ward diary	Sign out patient Maintain ward plan
Drug administration	Drug round Check controlled drugs	Giving drugs (non-drug round)
Maintain patient notes	Report Write care plan Record patient progress	Write admission sheet Maintain personal notes
Communications	Test requests PCH totals Bed availability Patient transfers	Telephoned lab reports Appointments Requisitions Ward summary

Table 2.2 Grouping of recorded data related tasks into task areas (nurses)

While Table 2.2 includes only those tasks that were observed, it does contain the great majority of the data-related tasks performed on a ward. The

definition of task areas themselves may be open to debate; for example, there is some overlap between areas, especially between ‘communications’ and the other categories, and the decision to allocate tasks to particular areas contained an element of subjectivity based on the perspective used in the initial definition of the categories.

### 2.3.2 Tasks types and the role of the nurse

There was a clear difference in the tasks carried out by nurses in different roles. Most markedly different was the nurse in charge, over 70% of whose time was found to involve recorded data. The great majority of physical, non-data orientated tasks such as making beds, bed baths, dressing changes, etc. were performed by lower level nurses, who were involved in data related tasks for about 35% of their time.

Figure 2.1 gives a breakdown of the data related activities according to the groupings described in Table 2.2. The significance of the drug round to the job of the nurse in charge is very noteworthy. Staff nurses were involved in the administration of drugs, sometimes carrying out a complete or partial drug round, to back up the nurse in charge. A very small proportion of the time was spent in extra-ward communication. This can be attributed in part to the brevity of most communications, and also to the nature of the data communicated. The nurse in charge had a greater burden of administrative tasks, while tasks involving direct patient monitoring were

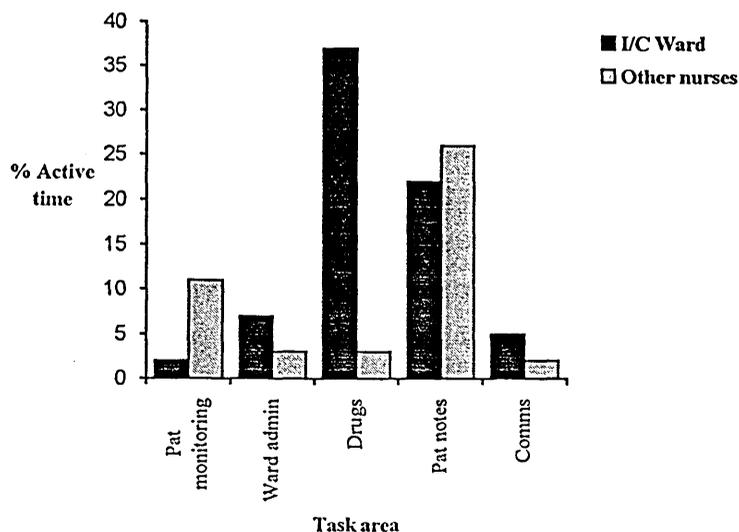


Figure 2.1 Percentage time engaged in main data related task areas

undertaken mostly by the lower grades. Extensive use was made of the patient notes in one form or another by all nurses.

### 2.3.3 Task types and their location on the ward

The locations where these various tasks were performed are shown in Figure 2.2. Included here are observations on the ward clerk (whose work was almost entirely geared around the handling of recorded information).

Most patient monitoring tasks occurred at the bedside, while most administrative tasks were done at the nurses' station. The location of drug-related tasks was dependent on the location of the drug trolley, which was kept at the nurses' station when not being used for the drug round, and at the drug cupboard, which on these wards was adjacent to the nurses' station. Communications were made entirely from the nurses' station, or required staff to leave the ward to take requisition slips, for example, to their destination.

Tasks involving use of the patient notes were much less confined by location. They tended to be carried to where they were needed: the sister's office for report, the bedside to write a care plan, and so on. Their use at the nurses' station was often for convenience - they happened to be stored there.

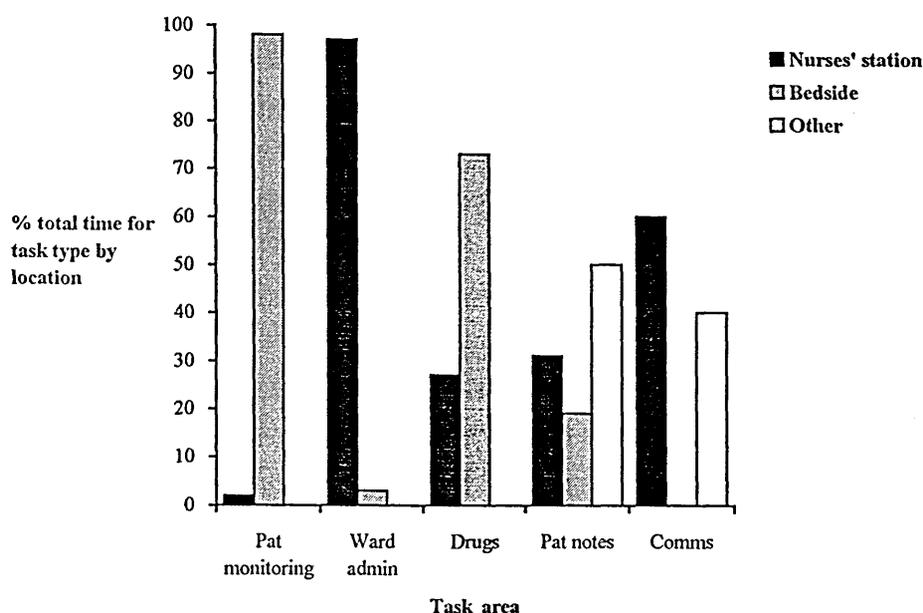


Figure 2.2 Percentage of total time per task type split by location

### 2.3.4 Patient monitoring

This constituted the second most data-intensive task area for the majority of nurses. It was notable for its frequency rather than its duration: the measurement of the various aspects of the patients' metabolism is a (several times) daily routine, made up of many brief tasks. On the whole, it was carried out by the lower grade nurses, with the nurse in charge

contributing most usually in the course of checking the progress of a particular patient of interest.

### **2.3.5 Ward administration**

The completion of PCH charts related to this aspect of ward administration. (The general medical ward was not involved in the use of patient care hours for calculation of staffing requirements, thus this did not feature in the latter part of the study.) On the basis of observations on three nurses who produced them, PCH charts took up 4% of active time.

#### **2.3.5.1 The ward plan**

A ward plan is a display in a prominent position near the nurses' station and was found on most of the wards visited in the course of the study. It lists patients currently on the ward, grouped by bay or room. Other details, such as a consultant colour code, may be included. Reference to the ward plan was very frequent indeed in the two wards of the detailed study: in one, its position also enabled visitors to the ward, such as medical staff, social workers or relatives, to locate patients without needing assistance. It is used at changeover by nurses starting the shift as the first reference to the current set of patients. Bed moves, transfers and discharges are recorded by any member of the ward staff as they happen - checking is done simply by the identification of errors in its current status. Because reference to it is so frequent, the ward plan is rarely inaccurate.

#### **2.3.5.2 The ward diary**

Some form of ward diary or patient log was kept in both wards in the study, and in others that were visited. Differences did exist between the forms they took, the data held, how they were used and by whom. The term '*ward diary*' is used here to encompass all of those documents that provided a day to day record of ward events not covered by other means (such as the nursing cardex). Typical uses of the ward diary are shown below.

- A record is kept of patients who stay on the ward. When a patient leaves the ward, their paper records leave with them: the record is used for back reference, for example when enquiries are made by relatives or staff from other parts of the hospital. This record may be alphabetical or may be a day by day log of who is in each bed in each room/bay. In the former case, admission and discharge dates are recorded along with the patient sticker, which forms the main entry. The destination of the patient (i.e. home, other ward etc) is also recorded. It was not ascertained to what extent this record

keeping was a redundant activity, or whether another department such as admissions could more efficiently act as a repository for such data.

- Details about the patient's treatment may be included, e.g. reminders to perform certain tasks, such as remove a catheter, or take a specimen. On the surgical ward, the nature of the operation undergone, and the post-operative time are recorded. Requests to contact certain personnel such as a dietician may be placed.
- Requests to carry out discharge related tasks are included, such as ambulance bookings and out-patient appointments. Such requests are typically directed at the ward clerk, though nurses may carry them out. On completion, requests are ticked off.
- Reminders are placed for ward specific requirements such as repairs or the need to place requisitions for particular items.
- There are typical diary entries such as reminders of courses to attend, meetings arranged, special events, and so on.

### **2.3.6 Drug administration**

The need for accurate recording of all data relating to the administering and control of drugs makes this area very data intensive. It is a highly collaborative exercise, with much consultation and frequent cross checking of information. Many people are involved, and though the nurse in charge was seen to carry the bulk of the responsibility for administering drugs once prescribed by a doctor, much parallel activity was observed involving multiple use of drug cards.

#### **2.3.6.1 Personnel involved in drug administration**

- Nurse in charge: Figure 2.1 shows the preponderance of drug tasks in the activity of the nurse in charge, occupying 37% of the active time of those nurses observed. Several drug rounds may occur in the space of a single shift, with additional individual patient dispensations in between these times. The net effect of this can be that the job of the nurse in charge seems to consist of the continual dispensation of drugs, punctuated by other tasks.
- Staff nurses: These very frequently administer drugs, and sometimes do a drug round for one or two rooms/bays. In the general medical ward, there was a deliberate policy of delegating the drug round to the staff nurse responsible for that bay. Frequently, an individual patient would receive a single drug extra to the drug round, for example a pain killer or insulin dose. Every instance of this requires access to the patient's drug card.
- Other nurses: Student nurses or other unqualified staff administer drugs after consultation and cross checking by a qualified colleague. This is an

important part of their training, and also eases the workload of the qualified staff. It is important to note that such a consultation again involves reference to the drug card.

- Pharmacy staff: Weekly visits are made to the ward by pharmacy staff to check stock drug levels and to re-order as necessary. Also, the signature of a pharmacist is required for non-stock drugs prescribed.
- House Officers: Their central role in this area is described in section 2.6.4.
- Ward clerk: At the NGH, where requisitions for drugs can be faxed to pharmacy, the ward clerk may be involved in this activity. Writing of requisitions themselves may be carried out by the ward clerk at the request of someone else.

#### **2.3.6.2 Use of the drug card**

As the previous section indicates, most of the ward staff would at some time require access to a patient's drug card. The drug card is kept by the bedside, though it may temporarily reside with the drug trolley. The prime responsibility for the information contained is the House Officer's: nurses record the execution of the instructions it holds. Although only one person uses one card at any one time (except during discussions between colleagues about the patient), several cards may be used simultaneously. An infrequent but entirely possible scenario might be:

- One House Officer is making an amendment to a card.
- Another House Officer is referring to a card whilst updating a patient's notes.
- The nurse in charge is conducting the drug round.
- A student nurse is consulting with a staff nurse about giving an analgesic.
- The ward clerk is faxing a special request through to pharmacy, or the card has been sent to pharmacy for addition of a drug.

The drug card is subject to frequent alterations as a patient's condition changes. Prescribed drugs, dosages, times and frequencies may all be altered. A signature is required for each administration. The portability of the drug card is a vital property. It will follow the patient on ward transfer, or to theatre, where further entries will be made. Access and alterations to the information it contains occur in many places - the nurses' station, at the drug trolley, in the doctors' office, by the bedside, and at any time.

### **2.3.6.3 Controlled drugs**

Maintaining an accurate record of controlled drugs kept on the ward is a time consuming and data intensive activity. Frequent checks are made of the numbers of these drugs, and each administration of one requires an accurate, cross checked written entry in a log. This task is performed either at the drug cupboard, or at the drug trolley: the controlled drug book is the physical data store.

### **2.3.7 Maintain patient notes**

Grouped into this task area are the activities that are related to the upkeep of the nursing record as outlined in Table 2.2. Also included are the end of shift report and tasks involving use of the nurse's personal notes, both of which have links with the nursing record as described below.

#### **2.3.7.1 Planning care**

The writing of care plans took up 5% of the nurses' active time. Wide variations were seen in their usage. In the NGH, the presence of a computerised care planning system meant that care plans were written by necessity at the nurses' station. At the RHH, a variety of approaches was seen within one ward. Care plans were written at the bedside or at the nurses' station.

Care plans were written at various times, although this tended to be when other tasks had been completed. Time had to be found for the production of care plans. This raises the possibility that they were being written retrospectively - a confirmation of what care had been given, rather than a plan of future care. Where the system was manual, several nurses sometimes wrote care plans at once, though this seems to have been due largely to the synchronisation of other tasks and their completion at similar times. The restriction caused by having a single PC did not appear to cause queues. It seems that the nurses adapted to this restriction.

The use to which care plans were put to was also seen to vary. In some instances, they were produced and filed away. In others, they were integrated into the overall patient care, being referred to during discussion with the patient and on writing of the progress notes, and were updated as necessary. This variation was seen within one ward, as well as between wards and hospitals.

Attitude was seen to be a major factor in the use of care plans. This was in turn influenced by other factors:

- Type of ward: Where the patients exhibited a wide variety of conditions, such as on a medical ward, there was felt to be a strong need to produce care plans to match individual requirements. On a ward where patients' conditions were more uniform, such as on a specialist surgical ward, the care from patient to patient did not vary greatly, and the production and use of care plans was considered to be an impingement on the delivery of care.
- Type of nurse: Within a ward where there was great variation in attitudes to care plans; student nurses were seen to place more emphasis on them. An inexperienced nurse can learn about established practices from a careful deliberation of a care plan, while the influence of their training must also be of significance.
- The ward policy: Perhaps resulting from the characteristics of the type of ward, the whole ward policy to planning care could determine the attitude to and use of care plans. Where their positive aspects were emphasised as a matter of ward policy by the senior ward nurses, a favourable attitude diffused to the rest of the staff.

#### **2.3.7.2 Nursing record**

This is the recording of the patient's progress, and involves the evaluation of the care delivered. There was consistency within one ward, where care plans are computerised. Here, the evaluation was done by the bedside, with reference to a care plan printout. In a ward with an inconsistent use of the care plans, the manner of completion of the progress notes varied. Location of the task and reference to the care plan differed from nurse to nurse.

Once completed, the progress notes become a component of the patient's medical record. They are referred to by the House Officer on occasion, for example in the morning in order to catch up on the patient's progress through the night. They may be used at report, more particularly in the medical ward, where afternoon report was given at the bedside, and reference was made to both the care plan and the progress notes.

As with care plans, progress notes are usually completed by different nurses at the same time. This tends to be done towards the end of the shift, when evaluation of the care given is carried out.

#### **2.3.7.3 Report**

The report is the communication of the current state of the patients between staff at the change of shift. It is an essential means of ensuring continuity of care from shift to shift. Although it tended to take place in an isolated location, such as the Sister's office, it was also observed at the

nurses' station, and at the bedside (though a preliminary overview report was still given away from the patients). The nature of the report was seen to be common to all wards:

- The nurses first prepared a list of patients from the ward plan, using anything from a note pad to a blank progress sheet.
- The nurse in charge gave a patient by patient summary of condition, treatment, progress, diagnosis, etc. Patient identification was by bay/room, name, age and sometimes sex. Patients were dealt with in bay/room and bed order.
- Each nurse took notes, the use of which is described in the next section.

The report was also used as an opportunity to pass other information to the whole group, such as the allocation of staff to parts of the ward, where relevant. The source of information used by the nurse giving the report varied: the nursing record, the ward diary (in the case that this was used as a patient record), or the nurse's own summary sheet compiled near the end of the shift, along with the admission sheets.

#### **2.3.7.4 Nurses' personal notes**

These originate from the report. Their use was ubiquitous, at least within the study area. They were used more near the start of the shift, because at this time there was more new information to assimilate. The notes seemed to act as a prompt, or as a means of recording an instruction or information for later reference. After a ward round, the nurses would make updates to their notes in accordance with any change in the treatment required by the medical staff. It was the use of the notes as a running commentary on the patients under the nurses' charge that seemed to be the crux of their usefulness.

#### **2.3.8 Communications**

Communication is used here in the sense of information transfer between the ward and outside bodies such as laboratories or administrative departments. Communication of written data was not found to be a major time consuming part of the nurses' job (Figure 2.1), although most communication was verbal, over the telephone, and thus was not incorporated into the figures from which the graph was derived.

### 2.3.8.1 Types of communications

Table 2.3 gives a breakdown of the communications observed, including telephone calls. It can be seen that the latter formed the great majority of communications, with a substantial minority being from relatives of patients. It is to be noted that there was wide variation between staff: several nurses did no tasks in this category, while at the opposite extreme, one ward sister was involved in 37 telephone calls in one shift, of which 10 were from patients' relatives. Though each communication was of quite short duration, the sheer frequency of calls made communication a major part of the ward activity. Jobs were frequently interrupted by telephone calls, while

Type of communication	Number observed	Percentage of total
Telephone calls:		
Relatives	42	26
Other	100	63
Total of telephone calls	142	89
Written	17	11
Total communications	159	100

Table 2.3 Breakdown of communication types (nurses and ward clerks only)

certain tasks required a series of calls to be made. An example was in the transfer a patient to another ward, which involved a series of calls to the receiving ward, porters and the admissions department.

Communications of data, as opposed to the 'conversational' type exemplified by a relative's call, were seen to consist of three types:

- written - e.g. test ordering, requisitions for drugs
- verbal (telephone) involving recorded data - e.g. telephoned lab reports, PCH totals, ambulance bookings from a memo in the ward diary or an item in the nurse's personal notes
- verbal (telephone) involving data held mentally - e.g. answering an enquiry about a patient's presence on the ward, requesting a porter when a patient is ready for theatre.

Outgoing communications tended to be carried out by the person requiring them, or were delegated to someone else, most notably the ward clerk. Incoming communications were invariably dealt with by whoever was at the appropriate location, usually the nurses' station. Thus the ward clerk and the nurse in charge were greatly involved. Incoming calls often had a disruptive effect on several people: it was common for one person to answer a call, only to have to seek out a doctor or the nurse in charge.

### 2.3.8.2 Breakdown by function

Of the 159 communications reported in Table 2.3, 95 can be categorised as shown as in Table 2.4. This shows that the majority of incoming calls were for information about the ward, while the majority of outgoing calls were for services to be provided.

Direction of communication	Function performed	Percentage of total (n=95)	
Outgoing	Request for services	36	60
	Request for data	14	
	Supply of data	10	
Incoming	Request for data	34	40
	Supply of data	6	

Table 2.4 Communications grouped by type of function - nurses and ward clerks.

### 2.3.8.3 Twenty four hour telephone log

These results of the telephone log, shown in Table 2.5, reinforce those found by observing individual staff. It can be seen that there was a preponderance of incoming calls from relatives, and a large number of requests for services. Written communications were excluded from this set of data, as were many more requests for services (i.e. from laboratories, radiology, porters, etc). Examination of the log reveals that, excluding relatives' calls, at least 35 different sources or destinations were in contact with the ward. This is a clear indication of the complexity of the information needs of the ward.

Source/destination	Incoming	Outgoing	All calls
Relatives	29	1	30
Services	13	13	26
Clinicians	6	7	13
Outside bodies	6	4	10
Other wards	4	3	7
Admissions	2	4	6
Others	3	5	8
Total	63	37	100

Table 2.5 Telephone calls logged over a 24 hour period as a percentage of 139 calls recorded in total.

## 2.4 Findings: medical staff

### 2.4.1 The general perspective

The House Officers and Senior House Officers on the ward perform a variety of tasks which can be viewed in a very general sense from the perspective of a patient from admission to discharge:

- The patient is *clerked* by the doctor, when an initial assessment is made. There are variations to this procedure according to the type of admission.

- Investigations are carried out as required.
- Treatment of the patient is determined on the basis of the patient's symptoms, history, and the results of the investigations as they become available.
- The patient's treatment is modified according to the progress that takes place, the results of further investigations and the guidance of senior colleagues, particularly the consultant. This process continues until the patient is discharged.
- A record is kept of treatment and patient's responses in the medical notes.

Events such as operations are incorporated under the heading of treatment in the above summary.

## **2.4.2 Task areas**

The great majority of tasks observed in the study fell into four categories:

- Investigations - taking samples, ordering laboratory tests and other services, obtaining results.
- Drugs - prescribing and modifying drug therapy according to needs.
- Medical notes - maintaining an accurate and up to date medical history of each patient.
- Consultations - principally talking to patients about their condition or treatment, but also conferences with colleagues, particularly during the consultant's ward round.

### **2.4.2.1 Time spent in different task areas**

Figure 2.3 shows the relative proportions of the House Officers' time spent in the various task areas.

While the largest proportion of time was spent on tasks which were essentially communication with the patient or with colleagues, the significance of the other task areas is noteworthy. Nearly 40% of the House Officer's time was spent on tasks related to investigations or drugs. Both of these have a major data component. When this is combined with the 21% of the House Officer's time spent recording the medical notes, it can be seen that the overall job is very data intensive. In addition, the consultations with the patients and colleagues usually involved reference to recorded data, most frequently the bedside notes, but also the medical notes.

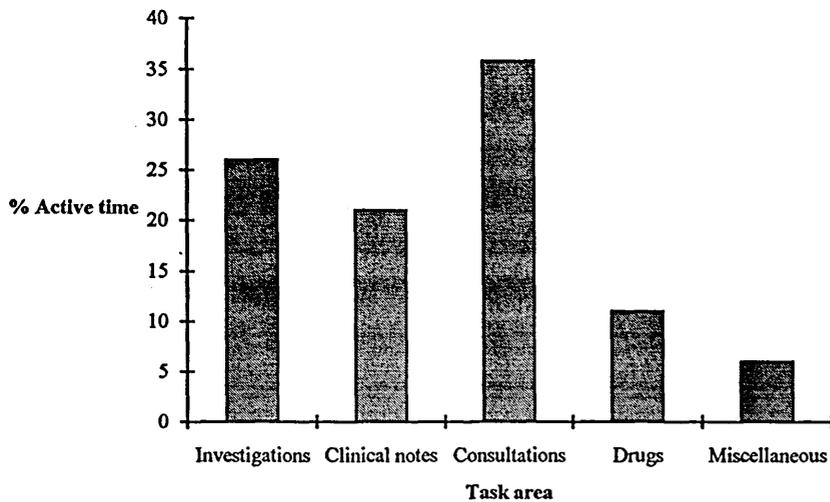


Figure 2.3 Percentage active time in all task areas - House Officers

### 2.4.2.2 Investigations

Tasks related to investigations constitute a central part of the House Officer's job, particularly on a general medical ward. The numbers of the different investigations requested during the periods of observation are shown in Table 2.6.

Investigation requested from	Number requested
Clinical chemistry	21
Haematology	9
Radiology	3
Bacteriology	9
ECG	6

Table 2.6 Destinations of test requests (total = 48) made during 15 hours of observations on one House Officer

The distribution of requests amongst the various departments will vary from specialty to specialty. These figures serve to illustrate the great demands on these departments and the communication needs of the House Officers. Indeed the majority of the telephone calls made by the House Officers related to investigations, as shown in Table 2.7.

Reason for call	Number of calls
Test request	16
Test results	2
Other	8

Table 2.7 Telephone calls made (total = 26) during 15 hours of observations on one House Officer

An urgent request requires more work by the doctor, in that it needs to be backed up by a telephone call. Some House Officers will take the samples for testing directly to the laboratories to ensure prompt service by catching

early test runs. A 'personal approach' in working with laboratory staff was thought to confer favour from the laboratories.

Each test ordered requires the recording of basic patient details; often, but not always, achieved by means of attaching a patient sticker to the appropriate form. Request form filling is time consuming; one House Officer was seen to prepare batches of forms the evening before a shift to save time later. As there is only a limited number of investigations possible, a large proportion of the requests is duplicated from patient to patient. This is particularly true for the routine tests performed on patient admission.

The results of investigations reach the House Officer fairly promptly. Table 2.7 shows that only two special calls for results had to be made. However, the considerable anecdotal evidence about having to chase up for results was supported in one of the surgical ward observations. The need to have all investigations completed in time for theatre resulted in the House Officer visiting relevant departments, collecting test result data, X-ray films and so on. There were delays that led to more telephone calls and repeated visits, with much loss of time and resulting stress as a deadline approached.

#### **2.4.2.3 Medical notes**

Maintenance of the patient's medical notes is an essential part of the ward doctor's role. The observed doctors were seen to be meticulous in their recording of each case. The patient's treatment and progress were logged, along with the clinical evidence on which decisions were based. Hypotheses and the outcomes of lines of reasoning were noted as appropriate.

The results of investigations were copied into the medical notes, though only those results deemed relevant were included. Thus principal blood count figures were entered as a matter of course, as were notable or unusual blood metabolite levels. Changes to and reasons for drug therapy were recorded. The medical notes contain a distillation of the mass of data that is generated by the activity of the nurses and the external service departments. What is contained is the selection of data that has been used as the basis of patient's treatment.

The medical notes are treated as the definitive history of the patient's stay in hospital, and their accuracy is essential. They were updated frequently as each patient was dealt with. This updating would be done where appropriate - many locations in the ward were used. Because of their bulkiness, they were retained in a trolley. This trolley was sometimes moved around the ward, while at other times, folders of notes were removed and taken to the patient. As with so many other documents, their flexibility gave the user the freedom to use them as desired.

#### 2.4.2.4 Consultations

Constituting the largest single task area, these included those activities that brought the doctor to the patient to gather and pass on the information which determined the patient's treatment. Various types of consultation were seen:

- Clerking: the initial assessment by the doctor. The conversational nature of this task is seen as its central feature, and the information gathered was recorded only at the end of the session.
- House Officer's round: The doctor reviews the condition of each patient. This involves intensive use of the bedside notes. Reference was made to the whole array of documentation, from care plans and nursing evaluation sheets, through temperature charts to ECG traces and haematological data. Whilst these references were sometimes cursory, the ready availability of these data at the bedside helped with the assessment of the patient by the doctor.
- Consultant's ward round: This varied according to the consultant and specialty. (On the surgical ward, it also acted as the House Officer's round: the relative simplicity of the surgical ward is discussed in section 2.4.3) In essence, the ward round provides a forum for the discussion of each patient's progress. Inputs come from nursing staff, the House Staff, and senior members of the consultant team. Reference may be made to any part of the array of documentation, particularly the clinical notes, bedside notes and drug cards. The ward staff will update this documentation as appropriate as the ward round proceeds. Although the amount of discussion that occurs is very much dependent on the consultant's approach, there is always a requirement for accurate, recent and easily accessible data.
- House Officer-nurse consultations: These are very frequent and very informal, often involving documentation, particularly the drug card, which is a prime point of contact between these staff.
- Consultations between House Officers: Again, these are very frequent and informal, and in the nature of mutual professional support. In general, House Officers are independent of each other, as they are responsible for different patients, very often under different consultants, although there is a strong link between Senior House Officers and their juniors.

#### 2.4.2.5 Drugs

Decisions to prescribe particular drugs are the House Officer's responsibility. Changes are made according to the patient's responses, feedback from the nursing staff, and input from senior colleagues. Writing

out drugs cards and their amendment is a time consuming aspect of the House Officer's job. The House staff were seen to make great use of the flexibility and ease of access provided by individual drug cards positioned at the bedside. The task of ordering drugs from the pharmacy for patients to take out on discharge is also time consuming, involving the transfer of data from the drug card to another form used as a prescription for the pharmacy. Doctors made frequent references to the British National Formulary (BNF), for information about drug dosages, alternatives or contraindications. A small and compact reference book, the usefulness of its portability was displayed by the fact that some doctors were seen to carry a copy in their pocket. Decisions to prescribe certain drugs are obviously influenced by whether or not a drug is in stock. Access to accurate information of this type was seen to be desirable.

### **2.4.3 Medical versus surgical wards**

A major difference in the role of the House Staff exists between the surgical ward and general medical ward. In a medical ward, the patients exhibited a wide range of conditions. The doctor's approach is an investigative one; the patient is admitted with a list of symptoms, the cause of which may or may not be known. There is a significant portion of diagnostic work to be done by the House Officer, who does not know which test will yield relevant data. Thus many tests are requested, and great importance is placed on obtaining results quickly, and on looking for patterns in the results. The volume of work here is very high, and the pressure is constant. When the ward is on take, patients with any one of a multitude of problems can be admitted, and a doctor can experience a high volume of work for very long shifts.

The surgical ward demonstrated different pressures, as illustrated in section 2.4.2.2. The theatre timetable imposes urgency on the work of the House Staff. The job here is to ensure that the patient is in as healthy a condition as possible for the operation, and then to help the patient's recovery. Investigations and documentation must be completed by a prescribed time, so speed of response from the service departments is important. Doctors spend much time and effort collating information. However, non-theatre days can be very quiet, with a much reduced work load, when the opportunity for study is often taken.

## **2.5 Discussion: nursing staff**

This discussion looks at each task area in turn and relates the findings regarding roles, locations and documentation needs to the requirements for a potential computer system.

### **2.5.1 Patient monitoring**

Taking about 10% of the nurses' time on the study wards, patient monitoring occurred entirely at the bedside. Related tasks such as writing out new charts took place elsewhere. While automating this group of tasks would be prohibitively costly, there could be potential benefits from storing the data generated in electronic form. The documentation produced during patient monitoring is kept by the bedside. Consequently, references to this data are carried out there, but this is not to say that access to it might not be advantageous in other locations.

The nursing value of automating patient monitoring is uncertain: a task such as taking a patient's blood pressure provides an important point of contact between nurse and patient. Information is exchanged between them, and their relationship maintained. Many of the timings obtained for these activities were prolonged because of this phenomenon; automation of patient monitoring may not necessarily improve the quality of care for the average patient, although evidence presented by Hendrickson and Kovner (1990) suggests that bedside terminals do save time and reduce errors. While there is a strong case for such automation in Intensive Therapy Units, where there is often no such interpersonal contact to speak of, it is debatable whether it would emerge favourably from a cost-benefit analysis for normal wards. A real requirement may not be the automation of the collection of data, but the collection of data by a means which, whilst preserving the advantages conferred by current methods, allows the integration of this data with that from other sources.

### **2.5.2 Ward Administration**

The tasks grouped under this heading are involved principally in the activities of bed management and the management of ward staffing. Figure 2.2 showed the prevalence of the nurses' station as the location where these tasks were performed. There is a clear and understandable requirement for such tasks to be performed in a central location. Two types of documentation were extensively used in this area: the ward plan and ward diary. These act as physical data stores and were heavily involved not only in ward administration, but in most ward activities in one way or another. Their inclusion here is primarily to relate them to administrative tasks.

### **2.5.2.1 Role of the ward plan and ward diary**

The heavy use that was made of the ward plan is indicative of a strong positional sense in identification of and reference to the patients. This could form the basis of a central part of the human-computer interface at least as far as patient identification is concerned. Recognition of this is shown by the work of Morris and Cooper (1991) and Frascina (1990) in which the ward as a geographical entity acts as the outermost layer of the interface between the user and the patient information. Ward plans and ward diaries are so widespread, often created by individual wards, that a strong need for a flexible form of recording and retrieving information to assist in day to day running of the ward is indicated. Essentially, the ward plan reflects the bed state. On the other hand, the ward diary provides a means of communication between the ward staff, particularly across time, though the potential improvements in communication between the wards and other parts of the hospital, such as ordering an ambulance directly using a network terminal, might obviate the need for a diary entry.

### **2.5.2.2 Bed management**

Bed management particularly relates to the nurse in charge. Information should be readily accessible for decision making regarding bed moves, bed state, and patient dependency (whether by formal or informal measures). Such decision making is a prime concern of the nurse in charge. Thus a central repository of relevant information is required which the responsible personnel can use as appropriate. This information must be up to date and accurate, implying that data entered into it must be frequent and validated.

### **2.5.2.3 Ward staffing**

The benefit of automatic generation of PCH data is indicated by the fact that completing PCH charts took nearly as long as writing out the care plans from which the charts were derived (5% active time writing care plans, 4% completing PCH charts).

## **2.5.3 Drug Administration**

The administration of drugs and the information handling associated involves much co-operation between individuals. Doctors prescribe drugs, nurses administer them and report back to other nurses or the doctors about the subsequent progress of the patient. Suggestions about frequency, dosage, route, form and type of medication by the nurses to the doctors were all observed. In addition, the need for multiple access to drug data, and the need

for portability of these data indicate particular requirements for the drug component of the ward computer system.

It can be considered that this component comprises two parts, each with implications for the interface requirements:

- **Stock control and maintenance:** This would entail linking the usage of drugs on the ward directly with the pharmacy stock system, allowing for stock drugs to be re-ordered as they were used, and would favour a central point for order entry.
- **Recording drug administration:** This is the function currently met by the drug card. Portability and multiple access would be very important criteria, as would that of security in the context of the signatures that are currently used on the drug card.

These two components should appear to be seamless, in that the action of giving drugs should both maintain a record and generate the data required for stock control. In the current system, the nurses are not concerned with this latter job; there is no reason why they should want to take on this responsibility directly.

A rather more difficult problem would be maintaining the flexibility of the current paper system whilst seeking ways of easing the administrative load involved in record keeping. A paperless record is entirely possible, though the convenience of bedside documents, which provide the flexibility of the current system, would be lost. However, we may question why the drug cards are at the bedside at all. As far as the nurses are concerned, this is a convenient place to put them - they are frequently removed to be used, for example, at the drug trolley. Indeed, they have been seen to be kept at the drug trolley for several hours.

The issue of security is a vital one in drug administration, and is discussed very briefly along with the requirements of the House Staff in section 2.6.4.

#### **2.5.4 Patient notes**

The essence of the tasks in this area is the maintenance of the most appropriate type and level of nursing care. Thus after completion of the admission sheets, the tasks are concerned with planning care according to the patient's needs, evaluating and re-adjusting the care as necessary, and communicating with other ward staff, particularly at changeover, to ensure continuity of care.

There is a natural relationship between several of the tasks in this area. The observed practice of writing the progress notes at the bedside with reference to the care plans demonstrates this. The implication here is that these tasks could be carried out using portable devices to produce care plans and maintain the nursing record. This is making the assumption that computerisation of these functions is in itself desirable. The benefit of computerised care planning for nursing management is not questioned here. Seen from the point of view of the nurses, the situation is not so clear cut. By integrating computerised care plans into patient care more fully, they might be more readily accepted. Thus production of care plans, maintenance of the progress notes, and the production of patient summaries should be part of a unified system. Patient summaries would form the basis of the nurse's personal notes that are used so extensively. The widespread use of personal notes is indicative of a need to have immediate access to a flexible, easily read and updatable information store about the patients in the nurses' care. A computer system should be able to augment this aspect of the nurse's job. Hendrickson and Kovner (1990) report that computer generated patient information distributed to the staff at shift change produced time savings in one US hospital where this was investigated. However, time savings alone are not the only criterion for approving a system. The generation of summaries from a central record would ensure accuracy and consistency between nurses. Also incorporated into this record should be patient specific data held in such places as the ward diary.

What is proposed is a nurses' patient record that can be worked on wherever necessary, but is seen to have a focus at the nurses' station, just as now the nurses work with a disparate set of documentation all of which ultimately resides at one place. The detailed requirements specification for this would need considerable further work.

### **2.5.5 Communications**

It seems entirely desirable to automate as many communication tasks as possible, thus firstly removing from the ward staff a source of frequent interruptions to the flow of the ward activity, and secondly reducing the burden of tasks needed to obtain required services and information. The main consideration is with the degree of control over the communication, and over what is communicated. It is appropriate that the normal activity of the ward should itself generate the necessary calls to outside agencies, but there is a question about how much the ward staff would desire control over this communication. For example, as a patient is made ready for theatre, so recording this on a ward workstation might generate a call to the porters to

come to the ward at the allotted time, thus taking this task out of the control of the nurses. The design of the interface must take such factors into consideration. An illustration of the perceived need to control the information flowing out of the ward was seen during an observation episode when a patient died. Admissions 'should' have been informed of this because a bed had become available. Admissions were not in fact informed until the numerous protocols following a death on the ward had been completed, thus avoiding the complications of a new patient arriving without the bed being available.

The issue of the need for control does not enter into certain aspects of communication. Essential data such as laboratory results should be made available as soon as possible. It is worth noting that 20% of observed communications were concerned with the request for data from or the supply of data to the ward. Networking such data would be of benefit both in terms of its usefulness in patient care, and for time saved and disruption avoided.

## **2.6 Discussion: medical staff**

As in the previous section, a task by task view is taken for a consideration of the requirements for the potential system and its interface to the ward staff.

### **2.6.1 Investigations**

Requests for investigations are made frequently and involve data that is frequently repeated, and consists of a fairly limited set of possibilities. A small time saving per request would result in quite large overall savings. Likewise, the reliable availability of results would usually save little time per request, but there would be a great accumulation of savings. The benefit from the appropriate application of IT to many such small tasks would be multiplied considerably because of the volume of work and the frequency with which the doctor performs these tasks.

### **2.6.2 Medical notes**

Little enthusiasm was shown for any ideas concerning computerisation of this part of the doctor's job. A medical history follows conventions that all doctors understand, and has its own codes and constructs. The lack of enthusiasm could well be due to a lack of awareness of the enabling qualities of computer technology, and to experience of poor systems. Kjerulff *et al* (1989), reporting on the attitude of physicians to computer systems, indicate

favour for systems that assist in medical record keeping, and that the degree of acceptance is positively correlated to the degree of computer experience.

A computerised system for medical record keeping must be seen to provide benefits for the House Staff. The benefits of the current system are the portability of the notes, which can be taken to the patient or not, and their open nature, in that the doctor can enter free text as well as using the conventional medical syntax. An appropriate computerised system must augment this or not be used at all. It must do more than just save time, but also provide support for decision making, using the various sources of data as input. Computerisation of the medical record is a major concern of medical informatics, and its consideration is beyond the scope of this work (see McDonald and Barnett (1990) for a summary).

### **2.6.3 Consultations**

The essence of this task area is contact with the patient. There is a powerful association between the patient and their bedside notes, and the House Staff use this to focus on the patient during consultations. In simple situations this is less pronounced, such as with a patient who is making a good recovery after an operation, but in the investigative environment of the medical ward, the concentration of data in one place is a clearly advantageous. The exact location of this concentration of data need not be the bedside. A computer system could provide a greater concentration of data to help in decision making. The results of investigations could be integrated into a whole patient record along with the results of patient monitoring. Appropriate visual cues could be provided in the form of a ward plan and a patient photograph (see Morris and Cooper, 1991). In addition, location of a terminal in the vicinity of the patient would enable the electronic record to be treated as though it were portable, implemented using portable devices or distributed static workstations.

### **2.6.4 Drugs**

Although the requirements for the House Staff do not differ greatly in this respect from those outlined for the nurses in section 2.5.3, additional requirements can be identified:

- Decision support would be desirable. The House Officer should be notified if adverse combinations of drugs are prescribed.
- Indication should be given if a run of medication were exceeding a pre-determined length of time.

- Central access to a list of the drugs any one patient is taking is considered to be advantageous.
- Prescriptions for discharged patients should be generated in pharmacy from the current drug card, subject to the control of the House Officer.

Providing security by means of a signature is an important part of drug prescription and administration. This will not be considered in depth here: it is a major area of concern in healthcare computing (e.g. Barber, 1993). Solutions to the signature problem do exist, notably by the use of bar-coded identity cards at one pilot HISS site (Kings Mill Hospital, Central Notts Health Authority).

## **2.7 Outline specification of requirements**

The requirements for the ward human-computer interface can be seen at various levels. This chapter has concentrated partly on the desirability, from the perspective of the ward staff, of computerising the ward activities. In theory at least, most information based ward activities could be computerised in some way. With such a wide potential, it is important to assess the possible benefits or otherwise of computerisation. A first set of recommendations can be drawn assuming a base level of computerisation, that is providing an interface between the ward users and existing remote computer systems. A second set of recommendations can be stated assuming a greater degree of interaction and more extensive computerisation.

### **2.7.1 Requirements at the base level**

Given that the existing computer systems are based in various laboratories, pharmacy and other external and administrative departments, then the interface requirements that a ward system should meet are:

- to give an overall view of the patients as they are located in the ward.
- to allow staff to record quickly and accurately changes in the state of the ward.
- to be able to include patient care information with each patient record, in the form of care plans, discharge arrangements, special requirements and so on.
- to automate the transfer of administrative data from the ward to administrative departments and vice versa.
- to automate drug ordering and stock taking, whilst allowing multiple access for dispensation of drugs by ward staff.

- to provide patient summaries which aid in the continuity of care.
- to automate the communication of data between the ward and other departments, under the control of the ward as is necessary.
- to provide links to laboratories and other service departments to automate the requesting of services and retrieval of results and reports.

Given the probable complex functionality of this interface, and the low level of computer experience of the ward staff, further general requirements are:

- the computer system should present tasks in a manner that is intuitive to the ward personnel, and which reflects current practices.
- using the system should require little learning and should be easily remembered.
- the interface should be designed to minimise the possibility of errors.
- the interface should give a high level of user satisfaction.

### **2.7.2 Requirements at the higher level**

The implementation of the requirements listed above would not require a great change in working practices. A further set of requirements can be specified, which would entail greater changes in established practices, and would also envisage a greater level of sophistication in the human-computer interface. These might include:

- a computerised means of taking a medical history, incorporating data from the various computer and paper based sources.
- decision support for the administration of drugs and investigations, possibly based on an expert system component in the interface.
- incorporation of patient monitoring data into the electronic record.

### **2.7.3 Areas for further investigation**

Two of the aims of the study outlined in section 2.1 were concerned with the identification of areas for further work. In order for the continuation work to be feasible within the constraints of the project, certain criteria needed to be met for the selection of a suitable task area:

- The task area should present a problem appropriate to the application of user-centred methods.
- The problem should be well defined in order to maximise the use of the available time and resources.

- The task area should be capable of accommodating a prototype for use in real work conditions.
- The task area should not currently contain a computer system, so that a prototype would be used without prejudice.

Suitable areas for further investigation were the ward administration, drug administration, the maintenance of the doctors' medical notes, and communications with the pathology laboratories. Of these, the latter two best concurred with the overall project requirement to investigate the *integration* of hospital information systems. It was decided, on the basis that it was the smaller, and in the eyes of the medical staff the more pressing problem area, to concentrate the rest of the work on communications with the pathology laboratories.

## **2.8 Conclusion**

The work of doctors and nurses involves the use of information in a wide variety of forms, in a manner intricately linked with the patient care duties that form their primary concern. This chapter has sought to identify the role of information in the hospital ward taken from the perspective of those who use and generate it, and has resulted in a better understanding of the environment into which a potential computer system will be introduced. Finally, it has established areas for deeper analysis, with a view to furthering the investigation into the applicability of user-centred methods.

# Chapter 3

## Interface requirements capture through task analysis

### 3.1 Introduction

The preliminary study of the problem domain has set the scene for the detailed investigation that now follows. In this chapter, a justification will be given for the application of task analysis as a means of capturing the interface requirements for a prototype system to be used in this domain. The detailed methodology employed will then be discussed, and the outcome of the application of the task analysis will be described, culminating in a set of user interface requirements.

### 3.2 The use of task analysis in interface design

For many years, task analysis has been seen as a very important element in the collection of techniques employed by HCI practitioners. This belief in the role of task analysis is most strongly expressed by Diaper (1989):

*"...task analysis is potentially the most powerful method available to those working in HCI and has applications at all stages of system development, from early requirements specification through to final system evaluation."*

Despite Diaper's unequivocal statement of high expectations, the supposed potential of task analysis in interface design is yet to be fully exploited. Task analysis is criticised as being *"...confusing, often not done, or not done well"* (Anderson, 1990), and the benefits of producing task models for designing user interfaces are seen as *"largely speculative"* (Kelly and Colgan, 1992). However, the particular setting of the project, comprising a number of well established and cognitively complex tasks, involving a population possessing very expert domain knowledge, and with an explicit need for highly usable systems, gives the opportunity to test whether or not task analysis can indeed contribute to the design of usable systems, and in doing so test to what extent Diaper's assertion can be justified in a real world situation.

### 3.2.1 A rationale for the application of task analysis

When people use computers, their intention is to carry out tasks more effectively, or to carry out tasks that were not possible before. The tasks that are performed on the ward are therefore of prime relevance to the developers of the new system. There are several roles that task analysis can play in the design of interactive computer systems. These are summarised by Johnson (1992) as follows:

- i) As a means of producing a requirements specification: the analysis should be able to identify the structure and content of the task activities, and can constrain the design of the computer system such that it supports and minimises the effort to perform those tasks without adding superfluous task requirements.
- ii) As a means of providing an idealised, normative model of the tasks that the computer system should support in the given domain. A task model is a hypothesis of how a task is or might be carried out. This can be used as an input to the process of designing a new task using the computer system.
- iii) To provide a set of benchmark tests against which the computer system design can be evaluated. Once there is a complete description of the user tasks, behavioural data from user trials of the system can be interpreted against the normative description of behaviour from the task analysis.

An important aim of task analysis techniques is to gain an understanding of the knowledge that people possess and employ during task execution, to the extent that this knowledge can be described and represented in a consistent form. It is this form of representation that can be subjected to analysis and modelling. The various properties of the user's task knowledge can subsequently be identified, although different task analysis methodologies emphasise different aspects of knowledge.

A consequence of gaining an understanding of the knowledge employed in performing a task is that, provided this knowledge is carried over into the computer system derived from the task analysis, the new task will be easier to learn and remember. Such a transfer of knowledge from the old task to the new is a fundamental theme that runs through HCI, and its importance has been demonstrated by Pollock (1988) in the transfer of skills when changing from one word processor to another.

Clearly, such task knowledge should be taken into account during the design and development of the software that is to be used by the ward staff. Current task analysis techniques have been researched and developed in the academic community; the work reported here seeks to apply some of these

techniques in a very real and complex work environment. The potential benefits of such work will be reflected in the acceptance and usefulness of the system to which the work is applied.

### **3.2.2 Background to task analysis methods**

Task analysis is rooted in post-war research into training and retraining. The motivation for these early developments lay both in the need to train military conscripts in the use of new weapons and weapon systems, and later in the economics of the post-war job market, in which skill shortages and retraining for new jobs had become significant factors. Descriptions of early task analyses (Miller, 1962) included examples concerning the piloting of bomber aircraft. The use of such example tasks reflects the concerns of task analysis at the time, with its concentration on the task performer's perceptual, motor and problem solving abilities, all important in the use of complex machinery. The approach characterised in Miller's work made much use of measuring performance in psychometric terms, and sought to match people who possessed the required abilities to the task that needed to be done. An important limitation of these approaches was that they were constrained by their concern with the analysis of physical, rather than cognitive tasks.

An emphasis on training for tasks rather than matching people to tasks gave rise to Hierarchical Task Analysis, or HTA (Annett *et al*, 1971). This has the advantage of using as its input the observation of people actually performing tasks, and has been successful in identifying where training is needed in such areas as fault finding and process control. However, HTA is a general task analysis method that, even its adherents concede, fails to provide a suitable basis for interface design (Stammers and Astley, 1987). Its use in HCI is promoted by Shepherd (1989), but here the emphasis is still with training. Shepherd gives examples of its application for the production of a user manual, and in familiarisation with a new visual display. There have been attempts to extend HTA in specific situations, for example by Philips *et al* (1988), in the identification of requirements for air traffic control systems. One of their aims was the validation of the analysis by close involvement of the users, and their selection of HTA reflects an important advantage of the technique, in that its representation is quite easily understood by non-specialists. This simplicity of representation, however, has a drawback in that it diminishes its analytical and abstractive powers.

A major impetus to the development of task analysis methods has come with the increase in the use of computers in the last decade. It was recognised that users' conceptual skills and knowledge needed to be

understood in order to design computer systems that adequately automated their tasks, rather than the perceptual motor skills that concerned early task analysts. The discussion will now go on to consider the variety of approaches to task analysis, and their appropriateness to the problem area under consideration here.

### **3.2.3 Selection of a task analysis method**

In the process of establishing which approach to take in applying task analysis, it is of paramount importance to recognise the *purpose* of the analysis. It is the first of the roles of task analysis that were described in the previous section that provides the principal purpose for its application in the context of this research: in order to obtain the basis for a design, the structure and content of one of the ward activities described in Chapter 2 needs to be identified. Thus, the most appropriate task analysis method would be the one that would most facilitate this identification. The selection of the task analysis method to be used in the project would largely depend on this general criterion.

In recent years, there has emerged a multitude of different forms of task analysis directed at the description of human interaction with computers, or with obtaining requirements for such interaction. These vary greatly in their scope, complexity, granularity and usefulness. At one extreme lie the methodologies which view users and their tasks from the social/organisational standpoint, such as ETHICS (Mumford, 1983), Open System Task Analysis (reported in Eason, 1989), and User Skills Task Match (Fowler *et al*, 1988). These acknowledge the importance of users in information systems, and are primarily participative methods aimed at helping users identify desirable qualities in future systems. The level of analysis offered is too coarse grained to be effective in revealing the kind of task information sought here, and such methods do not usually feature under the heading of task analysis applied to interface design. At the other extreme lies the Keystroke Level Model, (Card, Moran and Newell, 1980) which is aimed at predicting performance of expert users carrying out given tasks with a proposed interface. This type of analysis is too fine grained to reveal high level task structures, and more importantly is only of use once a computerised system of some kind is already in place, or there is already a detailed design that can be used as a basis for predictive modelling. In between these two extremes are the task analysis methods which are aimed at giving an understanding of knowledge intensive tasks: these are the methods considered as potentially the most relevant to the requirements of the project.

There have been several different attempts to establish criteria upon which to base the selection of a task analysis method. Bellotti (1990) offers a set of matrices for assessing the applicability of HCI techniques. However, as with many of the techniques it aims to assess, in many ways Bellotti's framework lacks the clear definition that would enable it to be put into practice. Often cited is the review by Wilson *et al* (1988), who compare eleven knowledge-based task analyses, using four characteristics of the techniques:

- i) The type of knowledge represented, for example, ideal as against non-ideal knowledge.
- ii) The extent to which the dynamics of tasks are expressed, such as the effects of the performer's goals and intentions.
- iii) The degree to which they specify cognitive limitations on the performance of the task.
- iv) The practicality of their use.

Furthermore, the authors group the techniques into four blocks, depending on the intended target area of the analysis. These are:

- The knowledge content of real world tasks.
- The prediction of difficulties from a given interface specification.
- Users' conceptual structures.
- Users' cognitive activities.

Whitefield *et al* (1991a) comment that comparison of techniques alone is not enough when making a suitable selection. They suggest a different set of criteria for the assessment of task analyses based on the effectiveness of three of their aspects, namely:

- i) That of the task analysis *product*, i.e. the representation of the task that the analysis generates.
- ii) That of the *notations* employed in the analysis, with respect to its completeness, coherence, and suitability for the analyst.
- iii) That of the *procedures* by which the method is carried out, with respect to the same sub-criteria as above.

The subdivisions of the general criteria allow quite a detailed assessment of a proposed task analysis. The advantage of this scheme is that the criteria have a greater degree of practical applicability, although it lacks the more absolute measures employed by Wilson *et al*.

A starting point for the selection was taken from the groupings given by Wilson *et al* regarding the intended target area of the analysis. The group including External-Internal Task Mapping Analysis (Moran, 1983), the Task Action Grammar (Payne and Green, 1986), and the GOMS models (Card *et al* 1983) were rejected as inappropriate because they depend on an existing specification or a computer system for their application. Also rejected on this basis, although not grouped in the same review, was the Cognitive Complexity Theory of Kieras and Polson (1985). By contrast, the group which most matched the needs of the project was that which comprised the techniques aimed at the analysis of the knowledge content of real world tasks. Of those reviewed by Wilson *et al*, Task Analysis for Knowledge Descriptions, or TAKD (Johnson *et al*, 1984; Diaper and Johnson, 1989), and the Command Language Grammar, or CLG (Moran, 1983), along with Knowledge Analysis of Tasks, or KAT (Johnson and Johnson, 1991) met the requirement of being targeted at the analysis of real world knowledge based tasks.

A choice between these techniques could be made by transferring to the criteria proposed by Whitefield *et al*. CLG was rejected on the basis that, whilst it is strong with respect to its notational support, it would pose problems with respect to its usefulness for system development. A study of CLG (Sharratt, 1987) revealed that designers found it difficult to use its 'product' (i.e. the outputs of the method) and its use did not lead to better designs. Such difficulty with its use ranks the method poorly against the effectiveness criteria set out above particularly with respect to its suitability for the analyst.

The choice between TAKD and KAT was made chiefly on the grounds of how suitable the method would be for the analyst. There are many similarities between the two, which is partly a consequence of the fact that KAT has been developed from TAKD. The former has a greater level of sophistication, and much work has been done to give it a theoretical foundation (see Johnson, 1992). However, TAKD has the greater maturity, with several reportedly successful applications (Diaper, 1990; Johnson, 1985; Warren, 1993). Whilst examples of the application of KAT are also available (Johnson and Nicolosi, 1990; Johnson, 1989; Wilson *et al*, 1992), at the time that the decision was made, TAKD was the better documented method (Diaper, 1989b). It also has the clearer notational support, and is procedurally very complete and coherent. A final and crucial element in the decision to apply TAKD as the analytical technique was the availability of software support.

It is acknowledged that the usability, and thus the wider acceptance, of task analysis techniques would be improved by the availability of dedicated software tools (Johnson and Johnson, 1989). Although Johnson's group has proceeded in the direction of developing a sophisticated user interface development environment (Markopoulos *et al*, 1992), their work does not offer the direct support for task analysis given by the smaller scale Liverpool University TAKD (LUTAKD) toolkit (Diaper, 1991a). Given that one of the project aims was to identify possible approaches that might be generally adopted for analysis in the ward environment, then it was felt to be more appropriate to use a method, with any associated software support, that might have continued applicability in the hospital setting. The conclusion of the selection process was, therefore, that TAKD, with the use of the LUTAKD toolkit, should be utilised.

### **3.3 Outline of TAKD**

It is not necessary to give a full account of TAKD, as this is amply covered by Diaper (1989b), and to a lesser extent by Dix *et al* (1993), while its theoretical basis is explained in Diaper and Johnson (1989). However, an outline of the methods and notations used is essential for reference in this work.

#### **3.3.1 The basis of TAKD**

The TAKD method uses a modified framework for HCI activities devised by Long (1986; 1989). Long's aim in devising a framework was "*to develop implementable specifications of human-computer interactions for a desired performance of work*". The framework (Fig 3.1) contrasts the real world of everyday objects and experiences with the representational world; the representational world aims to facilitate the understanding and change of the real world. Intermediary representations are used to mediate between these two worlds. In HCI, there are transformational activities concerned with acquiring knowledge about users and their tasks, and also with the application of knowledge to design. Thus, from an analysis, we may, via an intermediary representation, generalise about the real world and add to our understanding of it (i.e. producing a science representation). From this understanding, we might 'particularise' our understanding to produce a prototype system, which is the 'application representation' in the model. Following on from an iterative process of refinement, or 'synthesis', we will bring this application representation closer to the real world and complete the set of transformations, thereby fulfilling the aims of the framework.

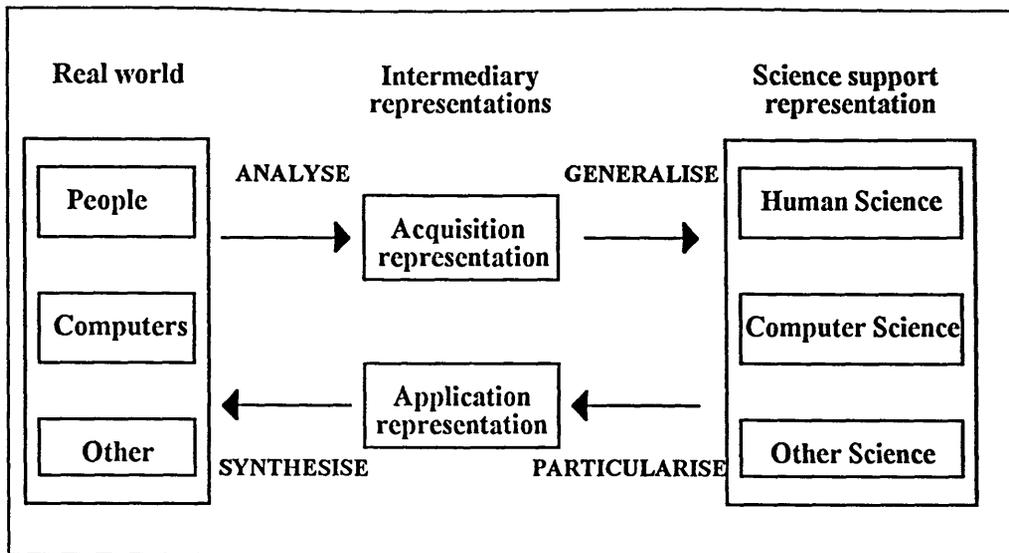


Figure 3.1 A model of HCI science support (after Long, 1989)

TAKD provides a means of generating acquisition representations that can be used as a basis for the generation of application representations, providing a mapping between the real world tasks of people and the (initially prototype) computer system.

The TAKD method produces a set of application representations at increasing levels of generality, until all the aspects of the task (that have been subjected to the analysis) are re-described in a common format, or grammar (described more fully in the next section). This achieved, the totality of these grammars may be subjected to analysis and interrogation. In addition, the process by which they are generated is itself productive: it involves a great degree of interpretation and analysis of the observed behaviours in terms of the actions performed and the objects acted upon.

### 3.3.2 The TAKD method

The principal stages in TAKD are now described. [See Diaper, 1991a; Diaper, 1991b and Addison and Diaper, (1990) for a detailed guide and heuristics on the use of the method] Although what follows suggests a linear progression through the method, in fact a great degree of iteration occurs. The completion of a particular stage may prompt the analyst to re-visit a previous stage, with a consequent review of the analysis.

#### 3.3.2.1 Data collection

Whilst the method used to collect the data used in the analysis is not prescribed in TAKD, the quality of the data collected is of primary importance to its validity and success. TAKD is aimed at the analysis of real world tasks, and a variety of techniques may be employed for the analyst to

glean task information upon which to base the analysis. Clearly, the approach that is taken in the data collection will impinge on the reliability and nature of the findings. Diaper (1989a), argues for the use of task observation as the principal data gathering method, although he warns of the many problems associated with inappropriately planned and executed observations. Two prominent problems are:

- i) The behaviour of the subject is altered by the presence of the observer. This is inescapable, although the effect can be reduced by appropriately planned observations, and by reducing the intrusiveness of the observer to the minimum possible.
- ii) Observations on a task performed in an artificial setting will have less validity than those performed in the work setting. The fidelity of the observations is diminished the more the observed task is removed from its original setting (which can be defined in more than simply locational terms, as described by Stammers (1989)).

There are alternatives to observation, which mainly involve verbal or written protocols. These are suitable for situations in which, to cite Bainbridge (1990), the outcome of thinking does not emerge in observable action. However, the task that was selected for analysis had clearly observable outputs (see the next chapter). Furthermore, it can be argued that verbal protocols are unreliable because people have difficulties articulating how they perform their tasks. An expert's performance of the individual steps of a task forms part of a co-ordinated whole, which is controlled at the cerebellar level. The act of articulating each step as it is performed requires cerebral control and actually impedes the performance of the task. (Try to walk while describing in detail each movement of the legs to illustrate this effect). Because of such factors, TAKD strongly encourages the observation of expert workers performing real tasks, with minimal intrusion from the observer. Video-recording is the preferred method, but this is not considered essential. Additionally, it was not deemed either appropriate or ethically desirable on the part of the hospital authorities to use a video camera in the proximity of patients.

Whilst observations constitute all of the data input to the analysis itself, the context for its application is gleaned from supplementary data collections and observations. This is an exercise in knowledge acquisition and involves the use of techniques shared by designers of expert systems. Rather than expand on these here, reference is given to full accounts of

knowledge elicitation by Cordingley (1989), and Shadbolt and Burton (1990).

### **3.3.2.2 Construction of the activity list**

From the recording (video or otherwise) of observed behaviours, a list is produced comprising individual task steps, essentially comprising a task protocol. Here, subjective judgements have to be made about the granularity of the analysis. These judgements are made in the light of the purpose of the analysis, and the understanding of the task environment that the analyst has accrued. Each line of the activity list must contain an action and an object acted upon, and may include the duration of the step, or specific values associated with the step, or even the analyst's comments.

*[The LUTAKD software provides a word processor for this part of the method, although it is basic, and in practice a more sophisticated one may be used.]*

### **3.3.2.4 Selection of specific actions and specific objects**

One action is selected in each line of the activity list, along with its associated object. The object may be physical, but in most applications of TAKD, it is likely to be informational, i.e. an item of data. The output of this stage is two lists, one for the complete set of specific actions, and likewise for the specific objects.

*[Although the LUTAKD toolkit includes a dedicated specific action and object selector that allows line by line selection, in practice it is possible, and far easier, to place these in brackets as the activity list is written, provided that decisions about the selections have already been made.]*

### **3.3.2.5 Construction of the Task Descriptive Hierarchy (TDH)**

This is the principal analytical stage of TAKD. All available knowledge about the tasks is drawn upon to build a hierarchy of general (generic) and specific actions and objects. The hierarchy is begun with several high level generic actions, placed under a topmost, dummy node. Nodes are added to build a description of the task in terms of these actions and objects. Higher nodes are more generic, and therefore more important, than specific ones. Objects tend to appear at the lower end of the hierarchy. This top-down task decomposition is done in conjunction with a bottom up analysis, in that the final part of the TDH construction is the addition of the specific objects to the lowermost nodes. Thus, as the TDH is built, attention

has to be given to the specific objects, all of which must eventually be attached.

Decisions about the importance of different aspects of the task are reflected in the naming and vertical positioning of the nodes. Many subjective decisions need to be made for this. It is the construction of the TDH that forces the analyst into thinking about the tasks both in general and in detail, and into looking for underlying structure. The importance of the analyst's understanding of the task environment is vital for this, as are the quality of the data collection and explicitness of the activity list.

*[Here, the software is extremely supportive. The TDH editor tool allows construction and easy manipulation of the TDH. Moving, copying and renaming nodes is trivial, freeing the analyst to experiment with and assess different TDHs, concentrating on the analytical process rather than being handicapped by what would otherwise be a laborious paper or word processing exercise.]*

### **3.3.2.6 Generation of the Knowledge Representation Grammar**

The TDH is re described in the form of a Knowledge Representation Grammar (KRG). Each different path through the hierarchy results in a different KRG sentence, and the node names become the 'words' in the sentence. Owing to the fact that each line of the activity list has one specific object, and that specific objects lie at the bottom of the TDH, it means that the activity list is re-written in the form of KRG sentences, i.e. the path to each specific object is described in terms of the nodes above it.

Low level detail about the task, which is described at the bottom of the TDH, is removed by the process of 'generification'. In this, low level nodes are deleted from the TDH, giving a more general view of the task. Depending on which part of the task is of interest, generification can be carried out at different levels in different parts of the TDH. The output of this process is a number of generic KRG sentences. High level generic KRG sentences are considered to be more important than lower level ones, because they reflect the importance decisions that were taken in the construction of the TDH.

*[Generation of the KRGs would be an arduous and error prone exercise by hand, but is fully automated by the software tool. The analyst is presented with a complete set of KRG sentences at every level of generality.]*

### **3.3.2.7 Generation of the Task Sequence Representation**

Temporally related sequences of activity list lines can be blocked together so that a task sequence representation, the Sequence Representation Grammar (SRG) may be generated. This gives sequences of KRG sentences between blocks, so that temporal relationships between KRG sentences may be uncovered.

*[Although LUTAKD makes SRG generation very simple, the output was so vast that it was considered too unwieldy, giving every sequence of every KRG, at every level of generality, resulting in an unmanageable set of data.]*

## **3.4 The application of TAKD to an area of ward activity.**

This section reports on the findings arising from the application of TAKD in two hospital wards, one at the Northern General Hospital (NGH), and the other at the Royal Hallamshire Hospital (RHH), Sheffield. Following on from the introductory work reported on in Chapter 2, it was decided that a detailed analysis should be conducted into one functional area in both hospitals. The area selected was the ordering of investigations and retrieval of results from the Haematology and Clinical Chemistry departments. Data were collected for both ordering and result reading, although only the former function was subjected to detailed analysis. It is critical to the achievement of a successful analysis that both its scope and aim are defined beforehand. The aim of the analysis was to gain sufficient understanding of the tasks concerned in order to derive a design specification for a clinicians' interface to an ordering system for haematology and clinical chemistry tests. The scope of the analysis proper was restricted to the filling in of request forms.

### **3.4.1 The problem area**

Doctors working on the wards, usually House Officers and Senior House Officers, request investigations from the pathology laboratories. Request forms are required to contain various demographic details about the patient, identification of the consultant, the names of the ward and the requesting doctor, and test specific data including required investigation, specimen, and clinical details relating to the case so that the laboratories can make an informed interpretation of the test results.

Laboratory staff direct forms and specimens to the appropriate section for the tests to be performed. Here the results are screened by various automated and manual means. Anomalous results and those of less common tests are interpreted in the light of the clinical details which have been

reported. Other data is taken into account in this process, such as the age, sex and location of the patient, e.g. maternity ward. The problem area to be addressed by the design is described in Table 3.1 below.

Doctors	Laboratory staff
Time consuming task.	Reception and other laboratory staff spend much time telephoning ward for missing details.
Highly repetitive data entry.	Results may not go back to correct ward/doctor because of inaccurate details on form.
Low skill requirement for majority of task.	Tests destined for different labs are entered on the same form, so time is spent making
Highly specialised knowledge needed for selection of tests and inclusion of pertinent clinical details.	duplicates of request forms.
Clinical details perceived as extraneous to the request - they are for the laboratories' use.	Clinical details may be absent, excessive or
Several forms have to be completed for many transactions because of the lab organisation.	irrelevant.

Table 3.1 The problem area

### 3.4.2 Methods

The methods used consisted of several stages. There was a period of data collection that led to the definition of the problem area given above. The latter part of the data collection was used to gather observational data that was input to the analysis proper. Finally, the LUTAKD software was utilised in order to perform TAKD itself, resulting in the production of a set of outputs from which the interface requirements were drawn.

#### 3.4.2.1 Data collection

The data were collected over a two month period, involving four junior doctors and twelve laboratory staff. All of these personnel were interviewed, while the doctors were observed completing seventy seven request forms. A variety of approaches was used in the collection of data, varying according to the stage in the knowledge acquisition process, and also to the type of data sought.

The methods were, in chronological order:

- i) Semi structured interviews with doctors about the process of request form filling, conducted at the beginning of the data collection. Four junior house officers were interviewed, two from a surgical ward at the Royal Hallamshire Hospital, and two from a general medical ward at the Northern General Hospital.
- ii) Informal interviews with a range of staff from twelve laboratories, concentrating on the use of the data on the request forms, and based on the

'life history' of a request form and the information contained; the knowledge elicited in this process was essential to put the task analysis into context. It was fundamental to the underlying theme of the research, i.e. the integration of hospital information systems: the effects of one system on the other needed to be exposed - the analysis of the doctors' tasks would be meaningless in isolation of the effects of those tasks on other systems.

iii) Direct observation of form filling *in situ*, with the recording of the text entered and sequence of data entry on the forms; all observations were made on doctors whilst actually working and recorded on duplicate forms. Fifty two forms were recorded in a general medical ward in the NGH, and twenty five in a specialist surgical ward at the RHH. The personnel involved were those doctors who took part in the interviews, and data were collected over a two week period. Data that were not specific to the investigations being requested were recorded in a general sense (for example, patient name, doctor name, date). Other data were recorded verbatim (for example, the clinical details and the actual investigations requested).

Additional experience was gained during the 'familiarisation' period of general observations that led to the definition of the scope of the analysis, providing essential domain knowledge.

#### **3.4.2.2 Application of TAKD stages**

##### **i) Activity list construction:**

The data recorded on the request forms, interpreted in the light of the interview transcripts, were used to produce a list of the activities constituting the task of requesting a test (see Appendix A1.1). Each form recorded was treated as a different instance of the task, so the activity list comprised separate descriptions of each form completed.

##### **ii) Selection of specific actions and objects**

In each line of the activity list, the objects being acted upon were selected. It was decided that in this task, specific actions were of no interest, as only two actions were involved, namely writing text or sticking on labels.

##### **iii) Construction of the Task Descriptive Hierarchy (TDH) and Analysis of Knowledge Representation Grammars (KRGs)**

It was decided that separate analyses should be run through for the two different hospitals. The same TDH, with minor modifications, was used because of the inherent similarity in structure between the task of form filling in the two wards. However, there were sufficient differences to merit separation of the data input to the analysis: the frequencies of particular generic KRG sentences were seen to differ between the wards, and merging

the activity lists would have resulted in the loss of detail in the outputs. Nevertheless, in the results section below, most are presented in combined form, and only where differences between the wards merit it are the distinctions shown.

### 3.4.3 Results

TAKD produces outputs of two distinct but equally valuable kinds. Firstly, there are the 'formal' outputs, being the Task Descriptive Hierarchy and Knowledge Representation Grammar sentences [and Sequence Representation Grammars]. These are tangible, and to varying degrees measurable. They allow for descriptive reporting of the tasks analysed. Secondly, there are much less tangible outputs, which derive from the process of performing the analysis itself. These are insights into the task and the task environment which become apparent particularly during the construction of the TDH, and lead to the generation of questions, and to the evolution of a framework for the analysis and indeed the design itself. This section reports the findings of the analysis after deliberation of all of the outputs. It makes reference both to the formal TAKD terminology, and also shows what the methodology was instrumental in revealing.

After initial experimentation, two TDHs were constructed. The first focused on the number and type of items recorded on individual request forms, and will be referred hitherto as the first pass TDH (Appendix 2.1). In this, three major nodes were identified: *state*, *request*, and *report*. These corresponded to the actions of marking the request with the identity of the patient and requesting clinician, requesting a particular service from the laboratory, and informing the laboratory of the clinical condition of the patient respectively. The second, or final TDH, (Appendix A2.2) evolved from the first pass TDH as it became apparent that the first attempt did not satisfactorily represent the relationship that clearly existed between many of the forms. The final TDH focused on this relationship, using different transaction types as high level generic objects.

The term *test* here refers to a single investigation ordered by a doctor to be carried out by a laboratory. The term *transaction* refers to a doctor ordering any number of tests for a patient on any one occasion. *Activities* refers to individual actions recorded, represented by a single line in the activity list, such as filling in one field on a form, or one item where several are entered in a field. It corresponds to the frequencies of KRG sentences, or combinations of sentences.

### 3.4.3.1 Type of data entered

Table 3.2 shows the results of an analysis of the KRGs representing the entry of different types of data. Results for each ward are given separately in Table 3.2(a) before the totals for each type of data are shown. Note that the actual KRG sentences are referred to using a shorthand notation, so that KRG ' 3 refers to what would be KRG """"3 using the notation in Appendix A3. Owing to the fact that the TDH for the surgical ward was the more simple and shallow hierarchy, a lower level of generification was sufficient to provide a useful removal of detail for the analysis (4' for the RHH, but 7' for the NGH).

There was a dichotomy between data that were specific to a particular investigation, and data that related to the patient in general. Those entries that were common across request forms could be considered to be non test-specific entries. They did not vary according to the investigation requested. Those that differed from form to form could be considered test specific, and might vary according to the investigation requested. Tables 3.2 (a) and (b) show the preponderance of general, non-specific data that were entered, in that two thirds of all the data entries were not specific to an individual test

Doctor details	KRG	Freq	Patient details	KRG	Freq	Dates	KRGs	Freq
NGH	' 3	74	NGH	' 4	122	NGH	' 1,4,7,	56
	' 7	2		' 8	5		12,15,37,	
	'11	26		' 12	50		50,53,56	
RHH	' 3	32	RHH	' 4	15	RHH	' 1,4,	20
	' 6	2		' 7	1		8,11,23,	
	' 10	16		' 11	18		26,29	
Total		152	Total		211	Total		76
Clinical details	KRG	Freq	Investigations	KRG	Freq	Specimen reqs	KRGs	Freq
NGH	' 2	55	NGH	' 1	105	NGH	' 2,8,13	39
	' 6	3		' 5	4		38,51,54	
	' 10	23		' 9	34			
RHH	' 2	5	RHH	' 1	51	RHH	' 2,5,9,12	19
	' 9	16		' 5	5		18,24,27	
				' 8	22			
Total		102	Total		221*	Total		58

Table 3.2(a) KRG analysis for type of data entered

\* This total includes KRGs totals for date and specimen entry, which were to be found in lower level KRG sentences. Thus the total KRG frequency for Investigations was reduced to 87 by the subtraction of these sub-totals.

request. During requests that spanned more than one form there was repetition of the entry of data that was extraneous to the core of the task itself, other than in its use for identification purposes. Thus the patient and doctor details, along with the date, were entered more frequently than was necessary. The use of patient, which included ward and consultant information, in the RHH reduced the proportion of such entries slightly (to below 60%) in the surgical ward.

		Total KRGs	% KRGs	Overall KRGs	Overall %
Non test specific entries	Patient details	211	31	439	64
	Dates	76	11		
	Doctor details	152	22		
Test specific entries	Clinical details	102	15	251	36
	Investigations	91	13		
	Specimen requests	58	8		

Table 3.2(b) Type of data entered on request forms, derived from Table 3.2(a).

### 3.4.3.2 Transactions and types of investigations

Table 3.3 shows that most transactions involved the completion of more than one form. Thus, given the findings that most data were non test-specific, there was a major duplication of effort when multiple forms were completed. When considered in terms of the actual number of data entries made, it can be seen that three quarters of all data entries were associated with multiple test ordering. This overhead of non test-specific data entry constituted the principal time consuming element of ordering tests. Transactions usually involved the ordering of more than one test, as shown

Forms per patient	Transactions	Percentage	N° KRG sentences	Percentage
1	23	47	258	37
2	25	51	384	56
4	1	2	49	7

Table 3.3 Transactions and KRGs shown against number of forms per patient

in Table 3.4. A substantial minority involved ordering three or more tests. The combinations of tests ordered is detailed in Table 3.5. Here it can be

Tests per transaction	Transactions	Percentage
1	21	43
2	18	37
3	7	14
4	2	4
5	1	2

Table 3.4 Number of tests ordered per transaction

seen that the combination of requests for a urea & electrolyte report, (U&E) and a full blood count (FBC) constituted by far the largest single test grouping. Such 'routine' tests are carried out on most admissions, with requests for these tests as single orders also very prevalent. Indeed 88% of all transactions involved one or both of these investigations, while 22% of transactions did not involve these tests at all. Not shown in the table are requests for the specimen required for the test. All requests (except for haematology in NGH) require this data item. In all but three of the fifty four forms involved (ie 94%), this was venous blood (VB).

Combination	Transactions	Percentage
FBC & U&E	17	35
U&E	10	21
FBC only	7	14
Other single	4	8
FBC & U&E with other	8	16
U&E with other	1	2
Other with other	.2	4

Table 3.5 Combinations of tests ordered

### 3.4.3.3 Clinical details

A significant difference was found between the entry of clinical details between the two wards, reflecting the common view of the difference between medical and surgical cases. The analysis considered clinical details from a number of aspects. Table 3.6(a) shows the number of items comprising the patient condition entered per form. The first pass analysis separated the current therapy from the patient condition; Tables 3.6(b) and 3.6(c) re-incorporate these data, showing the number of clinical details entered per form distinguished by type of ward. While the majority of forms included only one line of information, a large proportion of forms in the medical ward (44%) registered several items. This in itself indicates that there was a degree of complexity to the information that was communicated to the laboratories. For example, in half of the forms where more than one item was recorded, it was information about current therapy that constituted the additional data (KRG '6 in the first pass analysis). Evidence for the supplementary role of reporting the current therapy was re-inforced by the fact that only once was this data given in the absence of the patient condition. The relative simplicity of patient care in the surgical ward is reflected in Table 3.6(c), where it is seen that there was never more than one

KRG sentences	Frequency	KRG sentences	Frequency	KRG sentences	Frequency
r'28	18	r'24	9	r'19	1
r'29	25	r'25	14	r'20	6
r'30	3	r'26	1	r'21	3
r'31	1	r'27	1	r'22	4
r'32	1			r'23	1
One detail	48	Two details	25	Three details	15

Table 3.6(a) Patient condition: Number entered per form; KRG analysis, first pass TDH.

Note that this gives KRG sentences for patient condition only. The next two tables are derived from the incorporation of current therapy details, and provide more meaningful data.

Number of clinical details per form	Number of forms	Percentage
1	29	56
2	17	33
3	6	11

Table 3.6(b) (Medical) Clinical details: Number entered per form

Number of clinical details per form	Number of forms	Percentage
0	3	12
1	21	88

Table 3.6(c) (Surgical) Clinical details: Number entered per form

KRG sentences	Frequency	KRG sentences	Frequency	KRG sentences	Frequency
r'20	6	r'21	3	r'19	1
r'22	4	r'23	1	r'26	1
r'24	9	r'27	1	r'30	3
r'25	14			r'31	1
r'28	18			r'32	1
r'29	25				
Statement	76	Query	5	Suggestion	7

Table 3.7(a) Clinical details: Certainty associated with details entered; KRG analysis, first pass TDH.

Certainty	KRG sentences	Percentage
Statement	76	86
Query	5	6
Suggestion	7	8

Table 3.7(b) Clinical details: Certainty associated with details entered; summary.

item reported, and sometimes there were none. Further detail is explored in Tables 3.7(a) and 3.7(b). Here it is seen that most items were entered as statements about the patient, i.e. they were reports about the patient's clinical condition, diagnosis, or current therapy. However, the doctor frequently communicated a suggestion or query (21%) to the laboratories. Table 3.7(b) again shows the comparative simplicity of the surgical ward, in that most details were statements about the status of the patient in relation to the surgical operation.

In the case of the 26 multiple form transactions (Table 3.3), there was a relationship between the details on the different forms. In the surgical ward, all eight multiple-form transactions contained identical clinical details. Table 3.8 shows that in the medical ward 63% of these transactions contained identical details, while in the other instances there was an overlap between forms. It is interesting to note that no transactions observed involved entirely distinct clinical details: there were no instances of the possible KRG (*request (multiple tests (multiple forms (specific data (report (distinct))))))*), while the related KRG 3 (*request (multiple tests (multiple forms (specific data (report (common))))*) occurred with a high frequency.

Details	Transactions	Percentage
Identical	17	63
Overlapping	9	37
Distinct	0	0

Table 3.8 (Medical) Clinical details: Relationship between details for multiple form transactions.

#### 3.4.3.4 Task sequences

[*The SRG tool was not used to produce the data reported here. Rather, the sequences recorded on the request form copies themselves provided a sufficient, manageable source of information.*] The sequences of sub-tasks were seen to be highly dependent on the layout of the forms used. The predominant tendency was to follow the forms from top to bottom and from left to right, with 31 out of 77 forms (40%) adhering precisely to this sequence. Identification of the patient was the first action in 62 forms (80%). A point of great interest lies in where diversions from the 'standard' occurred. Table 3.9 shows the occurrences of the more significant deviations from the 'standard' sequence. It can be seen that the selection of the investigation was more frequently brought forward than pushed back in the sequence. Conversely, entry of the clinical details was given a lower priority, with a large proportion of all deviations accounted for by this sub-task being pushed further down the sequence.

Deviation from 'standard'	Number of occurrences	Percentage of all deviations
Investigation brought forward	14	24
Investigation pushed back	11	18
Clinical details brought forward	10	17
Clinical details pushed back	24	41

Table 3.9. Deviations from 'standard' sequence of form filling involving investigations and clinical details.

### 3.5 Implications for the design of the interaction

Here, the results described above are interpreted in the light of the broader picture obtained through the analysis as a whole, and a discussion is given to provide a rationale for the design of a possible computerised test ordering system.

#### 3.5.1 Entry of non test specific data

##### a) Patient details

There is a need to identify the patient, both for the doctor in assigning the test to the correct patient, and in ensuring that the laboratory has sufficient data at hand to make a fully informed interpretation of the test results. However, the patient details should be a once-only entry on admission. The system should assign all such data to a transaction once the doctor has identified the patient within it. Current use of patient stickers does alleviate the load considerably, but they are not always available, and, depending on the sticker design, there are additional items which need to be repeatedly entered by hand.

##### b) Doctor details

Identification of the requesting doctor is a requirement for each transaction. A signature could be associated with a log-on code, or at least reduced to one manual signature per transaction; the entry of the doctor's bleep number is easily automated via log-on.

##### c) Date and time of request

Date stamping transactions is a standard feature of automated systems. A problem arises in that doctors will at present prepare request forms a day in advance and write the following day's date. This occurs primarily because form filling is so time consuming that doctors may complete forms during quiet periods before they are needed; by simplifying the requesting process, such a practice would not be necessary. A second problem involves wards which employ phlebotomists to take samples. A doctor working at night may issue a request for the phlebotomist to complete

the next day. There is a need for the design to include a function to allow for this.

Certain investigations also require a time stamp : this could be provided by default with that selection, or again if phlebotomists are employed an option to enter a future time could be given.

### **3.5.2 Test selection**

The notion of forms and numbers of tests per form, and the problem of incorrect combinations of tests on the same form disappear when the ordering is seen as a transaction. A single encounter with the computer provides the opportunity to select whatever combination of investigations is required.

The high frequency of occurrence of requests for FBCs and U&Es, both alone and in combination, points to the need to have these as the principal permanent options in the ordering system interface. The selection of other tests is sufficiently infrequent to warrant their inclusion in a separate functional area, e.g. as a sub menu.

Entry of the specimen requested can be automated, because most investigations are associated with only one specimen type. Where there is an option, a menu may be offered.

### **3.5.3 Clinical details**

There is an important design choice to be made here. No part of the requesting procedure lends itself more readily to free text entry than the reporting of the clinical details. It may be appropriate to leave it thus, with all of the clinical details relevant to each test requested associated with the transaction as a whole. This would affect the general requirement to simplify ordering in different ways. Two points can be made in its support:

- Free text entry is simple and allows the doctor complete freedom to report whatever is deemed desirable, using any chosen terminology and abbreviations.
- Even though use of the keyboard is slower than handwriting, the requesting process will have been so streamlined by other improvements that it would be acceptable for this part of the new system to be slower than its manual counterpart.

However, there is a case for selecting a different input method:

- Given that keyboard use is time consuming, (the very factor doctors perceive as problematic with test requesting), there should be some effort to design a data entry system which produces greater time savings.
- Opting for free text entry is a denial that there is any underlying task structure, and makes no use at all of any findings from the task analysis regarding the entry of clinical details.
- Free text entry ignores the specific requirement to communicate to the pathology laboratories only those clinical details which are relevant to the investigation requested. There should be a means of linking particular items with requests destined for different laboratories.

The analysis indicates that there is the potential to automate the entry of most of these details. Table 3.7(b) shows that 86% of details are statements. These mainly report the principal diagnosis, which will for the majority of patients change little or remain constant throughout the stay in the hospital. Medical patients have a more unstable diagnosis, changing as the results of investigations are obtained. (The term used by clinicians is the *working diagnosis*.) Thus there is the possibility of a once-only entry of this information, with the possibility of modification if this were warranted. The revelation from the analysis that multiple forms never have completely distinct clinical details has been very important here, because it shows that where different laboratories are being given details, there is common data being entered. Often, it was the patient's current therapy that made up the details that were additional to this common data. This suggests that there should be an option to include the current therapy on a request. The entry of the current therapy onto the patient's record would be once-only, or it could be drawn from other parts of the system if the patient's drug regime were also computerised. The relevance of a particular therapy depends upon the investigation ordered, and the determination of which detail should be transmitted to which laboratory could be resolved within the interface software; e.g. 'heparin' would only be associated with tests going to haematology, and not to clinical chemistry.

Automatic inclusion of the working diagnosis would also be desirable in the surgical ward, where current practice in most cases involves only reporting whether the patient has undergone surgery or not. Interview data has revealed situations in which a lack of basic clinical data in the laboratories has caused delays and requests for additional information, which would have been prevented by such inclusion.

In view of the discussion and the findings reported earlier, it is proposed that the entry of clinical details should comprise:

- i) the working diagnosis as a default.
- ii) the current therapy as an option.

Options for the source of these data are:

- They could be selected, at request time, from pre-written lists of the predominant diagnoses and therapies occurring on the ward.
- They could be entered on admission/clerking and updated as necessary.

iii) a query / suggestion prompt, with a free text area

iv) a free text area, which would be available for use in the minority of cases not covered by the above.

### **3.5.4 Sequence / priority implications**

The sequence findings support the impressions gained from interviews with clinicians about the relative significance of various parts of the request forms. A hierarchy of significance may be proposed, which leads directly to possibilities for the interface design:

1. Patient identification.
2. Stipulation of investigation(s).
3. Entry of clinical details.

The request screen should reflect this hierarchy in the layout of the data displayed, whilst the tendency to bring forward the stipulation of tests suggests that there should be the facility to select them before the act of identifying the patient.

## **3.6 Specification of requirements for a ward based system**

1. Identification of the patient draws up patient name, age, sex, date of birth, hospital number, consultant and ward.
2. The system should permit the performance of transactions as identified in the final TDH, in that selection of the patient enables the user to request as many tests as are required for that patient.
3. The screen layout should reflect the three node structure of the first pass TDH, namely *state*, *request* and *report*.
4. The screen layout should have patient identification data as most prominent, with the test ordering function following and the clinical details area subordinate to this.

5. The interface should not prevent the user from selecting tests before the patient has been explicitly identified.
6. The screen should offer permanent options of FBC and U&E.
7. A menu should be available containing the other principal tests according to the ward.
8. A sub menu should be available containing the names of less common investigations.
9. A date and time override facility should be available to stamp the transaction for a future request (e.g. for a phlebotomist to complete).
10. The specimen should be recorded automatically according to what is appropriate to the investigation. Where there is a choice possible, an option menu should be presented.
11. Each request should be accompanied by the working diagnosis, which may be amended as necessary.
12. An option should be offered to include the current therapy with the diagnosis. Where a number of therapies are current, a menu is should be presented for selection.
13. An option should be offered to make suggestions or queries, with a free text area for completion.
14. A free text field should be available for other clinical detail types.
15. Logging on should identify the doctor, marking the request with this identity and the bleep number.

### **3.7 Conclusion**

The intention of applying task analysis to an area of ward activity was as a means of obtaining a set of requirements for the human-computer interface of a prototype system. It has been shown that TAKD was successful in this. However, the requirements must be incorporated into the design of the prototype, so that they, and by implication the task analysis, may be validated. This chapter has terminated with a straightforward definition of a specification of requirements for the interface. The following chapter reports on the design process that was undertaken in the development of the prototype derived from this requirements specification.

## Chapter 4

### Design and Implementation of the Prototype

In this chapter, the outcome of the application of TAKD is related to the design and implementation of the prototype system. It is important to note that it does not seek to give a comprehensive description of the process by which the entire system was developed. Rather, it is the input of the task analysis to the design of the interface which is focused upon.

#### 4.1 A framework for the design

The list of requirements given at the end of Chapter 3 does not in itself specify the framework or the paradigm for the interaction that will embody those requirements. There exists an intellectual context within which the design of the prototype must take place; this context determines how the requirements are to be implemented. Artifacts in computing, as in the greater world of technology, are not created within a vacuum. Rather, they are the product of a multitude of influences which come to bear on the problem that the inventor (or designer) seeks to solve. This is illustrated by Carroll *et al* (1991), who relate past technological advances to the evolution of artifacts in HCI. Using the steam engine as an example, they argue that no one inventor was responsible for its emergence, but that it was the product of an extended process of development and redevelopment. Likewise, advances in HCI have been made on the back of existing artifacts and in the light of experience. Design is always guided by what already exists: thus, the process of designing the prototype was guided by an array of factors that need to be elucidated here.

A suitable starting point for the design process is given by Norman's model of interaction (Norman, 1988). Norman proposes that people's actions have two aspects: *execution* and *evaluation*, each of which consists of several approximate stages:

- Execution is concerned with *doing* and comprises:
  - i) A *goal*, which is the intended state to be achieved.
  - ii) An *intention* to achieve the goal.
  - iii) An *action sequence*, which is a set of internal commands.

iv) *Execution*, when the action sequence is performed.

- Evaluation is concerned with assessing whether the goal has been achieved.

v) Our *perception* of the world informs us of the effect of the execution.

vi) The perception is *interpreted* according to our expectations.

vii) The interpretation is *evaluated* by comparison with our goals and intentions.

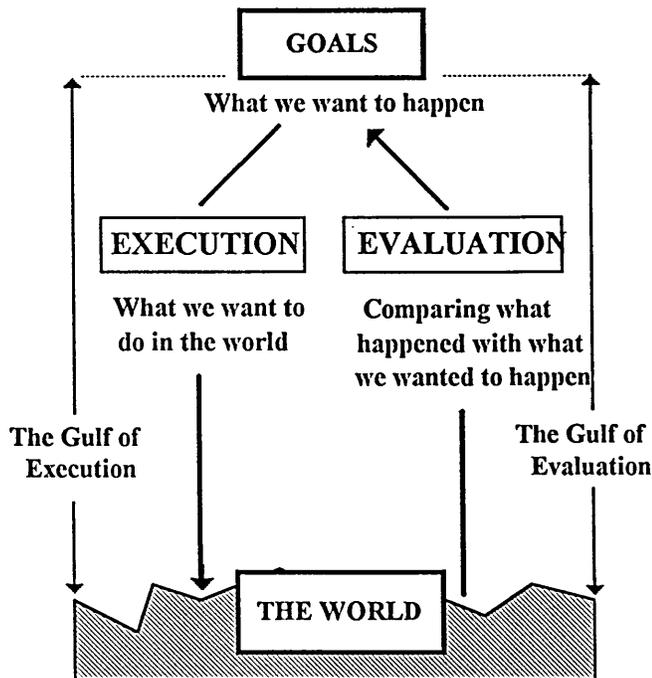


Figure 4.1 The Action Cycle (from Norman, 1991).

There is bound to be a mismatch between the user's internal goals and the availability and representation of information about the system, because of the different languages that describe the two components of the model; the computer user's goals are expressed in terms of tasks, whereas the state of the system is expressed in terms of computational behaviour. Norman (1991) describes these mismatches as *gulfs* (see Figure 4.1), wherein the gulf of execution refers to

*"...the difficulty of acting upon the environment (and how well the artifact supports those actions)."*

Thus it is the distance between what the user wants to achieve and the extent to which the system permits it. Conversely, the gulf of evaluation is

*"...the difficulty of assessing the state of the environment (and how well the artifact supports the detection and interpretation of that state)."*

In other words, it is the disparity between what the user expects to see in the state of the system and what it actually shows.

The model may be related to the design of the interface thus: we can see that an artifact that permits actions which correspond closely with the user's intentions is allowing the user to achieve a goal with less effort - it is reducing the gulf of execution. Whereas, an artifact that presents the state of the system in a form that is readily interpreted in terms of the user's goals and intentions is allowing the user to more easily understand the effect of actions on the system - the gulf of evaluation is reduced. The design of the interface should, by minimising these two gulfs, both match the user's task needs and be easily understood in terms of those needs.

## 4.2 The design goals

Given the broad aims set out in the section above, the more specific goals to be achieved by the design can be addressed. Both the background work described in Chapter 2 and the detailed study described in Chapter 3 point emphatically to the need for a system which displays a very high degree of usability (a concept that is discussed at length in the next chapter, both in general terms, and with particular reference to evaluation).

The design goals may be illustrated by means of a scenario in which a junior doctor has her first encounter with the system. Already under pressure due to her workload and continuing study requirements, she has been asked to use a computer to carry out a task she already performs with expertise on paper. Rather than imposing an extra learning requirement on her by relying on training, or a help system to instruct her in how to use the system, it is intended that the interface will be so designed that its use will be intuitively obvious to the doctor. It should be as close as possible to a 'walk-up-and-use' system (Polson *et al*, 1992), such as a bank cash point machine, and offer very high error avoidance and recovery levels. This would be a severe test for the efficacy of the application of task analysis to the design of the interface.

## 4.3 The interaction style

With a framework for the interaction in place, consideration is now given to more specific influences that impinge on the design process. Perhaps the most significant determinant of the nature of an interface is the interaction style that is applied in its design. Walker (1990) and Dix *et al* (1993) discuss how different interaction styles have developed as technology

has changed, enabling the creation of novel forms of human-computer dialogue. Given the range of hardware and software that is available, the scope for design is extraordinarily wide. However, the selection of the most appropriate interaction style is one of the first steps in constraining the design. Thereby, it directs the designer in identifying an appropriate design environment (or tool) from the large array that exists.

An interaction style reflects a particular character for the dialogue between the user and the computer, wherein both the nature and degree of user's control over the system, and the feedback given by the system, may vary greatly. Interaction styles are not discrete entities, and there is much overlap between them. However, a useful classification of styles that applies to most common systems is given by Shneiderman (1987):

- Menu selection
- Form fill in
- Command language
- Natural language
- Direct manipulation

The criteria for selecting the most appropriate interaction style may be taken from the Norman's framework described earlier: there should be an effort to reduce the gulfs of execution and evaluation. Different interaction styles lend themselves more readily than others to this effort. Table 4.1 gives a rationale for the selection of a style of interaction most within Norman's framework for interface design.

Interaction style	Gulf of Execution	Gulf of Evaluation
Menu selection	Well-designed menus make execution of some tasks easy, but style is restricted and may be cumbersome.	Depends upon complexity of menu structures. Overall state of system may be unclear. Navigational problems may occur.
Form fill in	Inappropriate where choices are limited, making task harder than necessary. Data entry syntax needs to be learned.	Feedback about the user's actions is delayed.
Command language	Very open to error. Carries excessive learning requirement.	Effect of actions on system very difficult to see, if evident at all .
Natural language	Inappropriate where task is well defined. Does not tell user what actions are supported.	Difficulty with assessing extent to which action has altered system state, as this depends upon quality of input.
Direct manipulation	Actions and choices supported by system may be made very explicit, with minimal syntactic requirement.	User's effect on system may be instantaneously evident. System state may be explicit at all times.

Table 4.1 A rationale for the use of direct manipulation as a style of interaction within Norman's framework.

Direct manipulation, because of its immediacy and clarity of feedback, and, given a good design, its great potential for matching the user's task requirements, appears to be the most apt style within the framework. The style itself contains a multitude of components, not all of which are required to fulfil Norman's criteria. Moreover, because of the indistinct boundaries of the various styles, an interface that reflects predominantly one style may contain elements of another. Nevertheless, with direct manipulation giving the overall character to the interface, the strengths of the incorporated styles may be utilised whilst avoiding some of their weaknesses.

Heuristic support for the rationale above is provided by Shneiderman, who gives as the advantages of the direct manipulation style of interaction:

- Visual presentation of tasks
- Ease of learning
- Ease of retention
- Facilitation of error avoidance
- High subjective satisfaction

Considering many of the particular characteristics of the ward environment, these advantages may be considered to be highly favourable, and lend further weight to the decision to adopt this particular interaction style.

#### **4.4 Selection of a prototyping tool**

Given the constraint of a particular interaction style within which to build the prototype, selection of the most suitable design tool was possible. In recent years, many different user interface design tools and environments have appeared. Various factors were considered in the process of selection:

- Flexibility, to allow sufficient freedom to realise alternative design options.
- Ease of use of the design environment itself.
- Ease of programming the interactivity and functionality.

Performance and the hardware and operating system platform were considered less important criteria for selection, because of the intended throw-away nature of the prototype.

The author's own experience with Hypercard and Hypertalk led to the selection of Plus (Spinnaker Software, 1991), a Hypercard clone for the PC environment. This software easily met the first three criteria, and being PC

based, lent itself easily to portability to the hospital location, with straightforward linkage to peripheral devices that would be necessary in the trial and evaluation that were to follow. While its performance was not good, the author's knowledge of the software was sufficient to devise means of overcoming most of the problems in this respect.

## 4.5 The Design

The process of design is, according to Fischer *et al* (1991) "*characterised by creativity, judgement and dilemma handling, rather than by objective scientific methods*". This is not to say that design is not informed. It is, in essence, the creative process that occurs once all of the information available about the problem is in place.

Apart from the knowledge that the designer has about the problem domain itself, many other sources of guidance may influence design decisions. Principal amongst these are design rules. These are rules that the designer may follow in order to increase the usability of the software, and are derived from past experiences of other designs. They may be rooted in empirical evidence, psychology, ergonomics, or other sources, and their value lies in that they may be applied on trust by the designer, who may lack the expertise of those who devised the rules. Rules may be divided into *standards*, which have limited applicability and high authority, and *guidelines*, which are more general, but lack the authority of standards.

Further influences on the design come from the nature and limitations of the design tool used, as discussed previously. Inevitably, there will be cultural influences that will work subliminally as options and decisions are considered. These will be based on the designer's previous exposure to computer systems, on his or her graphic design experiences (passive or active), and on broader influences such as aesthetics.

The account of the design that follows excludes two major factors. Firstly, it does not give details about those parts of the prototype that were not directly concerned with the outputs of the task analysis. Secondly, there is no reference to any design rules, as none were overtly used during the design process. The intention of this was to drive the design as much as possible from the outputs of the task analysis, although, as it is argued above, the creative process that was undertaken was subject to many other influences.

A rapid prototyping approach was taken during the design, with frequent peer group observations and testing in the departmental research office. Continual discussions about design choices and directions helped to

prevent apparently bad decisions becoming too deeply embedded in the prototype. It must be noted that this contemporaneous evaluation was not allowed to affect the specification of those task analysis-derived features of the system. Its role was to provide feedback about the realisation of the specification in the form of a design.

The following sub-sections deal with each item in the requirements specification in turn, giving a rationale for the design decisions that were arrived at. Where several options were considered and trade-offs needed to be made, the rationale is presented in tabular form. The screen designs themselves, showing all of the features described in the following account, may be found at the end of this chapter.

#### 4.5.1 Specification 1: Patient identification

*Identification of the patient draws up patient name, age, sex, date of birth, hospital number, consultant and ward.*

Criterion to be met	Design options	Trade-offs
Identification of patient must be easy.	List of current patients.	Easy to program. <i>May take longer to find patient.</i>
	Patients shown in ward plan layout.	Possibly quickest way to locate patient. <i>Complex to program.</i> <i>Must be updated with every bed move.</i>
Selection of patient must require minimal effort.	Menu.	Very quick. <i>Depends upon integrity of list.</i>
	Typing selection into data field.	No need to search for patient. <i>Data entry is slow, needs validation.</i>
No ambiguity about which patient has been selected.	Only details about selected patient visible after selection.	Reduced cognitive load. <i>Extra step required in case of error.</i>
	Both particular details and all patient identities remain visible.	Increased screen clutter. <i>Easier to undo.</i>

#### Design decisions:

There is to be a permanent list of current patients, from which the user selects with a single mouse click. The list is hidden after selection and is replaced by demographic details for selected patient. A button is available to take user back to the patient list.

#### 4.5.2 Specification 2: Availability of tests for selection

*The system should permit the performance of transactions as identified in the final TDH, in that selection of the patient enables the user to request as many tests as are required for that patient.*

Criterion to be met	Design options	Trade-offs
Affordance of printing all forms with one command.	Explicit information to indicate behaviour of system by inclusion of a prompt or label.	Less likelihood of inefficient use of system. <i>Information may not be needed, or will become redundant with time.</i>
	Behaviour implicit in interface by a) not segregating tests choices according to destination lab and b) inclusion of a button that allows selection of tests that go to different laboratories.	Smaller cognitive load during use. <i>Affordance may not be apparent to user.</i>

#### Design decisions:

All tests available for selection are not grouped according to laboratory, and there is the inclusion of one button that allows selection of FBC and U&E tests together, even though destined for different laboratories.

#### **4.5.3 Specification 3: Overall screen layout.**

*The screen layout should reflect the three node structure of the first pass TDH, namely state, request and report.*

#### Design decisions:

The 'state' node is implemented in the top left of the screen, as a window entitled *Patients* comprising the patient list, replaced by *Selected Patient*, comprising the selected patient's administrative details after selection. The act of selection constitutes the entire effort needed to 'state' all of these details.

The 'request' node is implemented at the top right of the screen, in a window entitled *Investigations*. Within this area are all of the available tests that can be requested, and a storage area to record selections as they are made. Included here is the current date and the command button to set future dates and times. Although these were grouped under 'state' in the task analysis, it was decided that it was more appropriate to group this function within the requesting area of the screen; automation precludes the need explicitly to state the date, unless a particular request requires it.

The 'report' node is implemented as a window entitled *Clinical Details* below the *selected patient* window, and is only visible once a patient has been selected. Its proximity to the patient data should allow for easy cross reference between the clinical details and relevant demographic data, such as the date of birth.

#### 4.5.4 Specification 4: Layout Priorities

*The screen layout should have patient identification data as most prominent, with the test ordering function following and the clinical details area subordinate to this.*

##### Design decisions:

These three functional areas are prioritised by following the convention of left to right and top to bottom, as described in the previous section.

#### 4.5.5 Specification 5: Sequence priorities

*The interface should not prevent the user from selecting tests before the patient has been explicitly identified.*

Criterion to be met	Design options	Trade-offs
Tests available without prior patient selection.	Hide inappropriate functions until patient selected.	Invisibility of inappropriate functions prevents errors and reduces screen clutter. <i>Modes must be introduced which may cause confusion as options appear and disappear.</i>
	Show all functions and give feedback by error messages and/or greying out.	Control is more in the hands of the user. <i>Possible user frustration at attempts to execute unavailable commands.</i>

##### Design decisions:

A combined approach is taken. All functions relevant to the requesting of tests are available at all times *except* for the button to *print request*, which only becomes visible on selection of a patient. Greying out of inappropriate commands only occurs when the user enters a mode other than test requesting, i.e. when adding a patient, amending a patient's details, and also when setting the date.

#### 4.5.6 Specification 6: Permanent test options

*The screen should offer permanent options of FBC and U&E.*

Criterion to be met	Design options	Trade-offs
Tests should require minimal effort to locate and select.	Individual buttons for these tests.	Very easy to locate and select. <i>Takes up more screen space, more movement of mouse needed.</i>
	Place tests at head of menu of less common tests.	More compact. <i>Tests less pronounced.</i>
Tests should not appear as pre-selections.	Place tests at head of menu of less common tests.	Appear like other unselected tests. <i>Tests less pronounced.</i>
	Individual buttons in unselected state.	Prominence for ease of selection. <i>May appear to be pre-selected on first encounter with system.</i>

#### Design decisions:

Three buttons in an unselected state are positioned at the top of the screen area set aside for storage of selected tests. Topmost button allows for selection of both tests with one mouse click.

#### 4.5.7 Specification 7: Common tests menu

*A menu should be available containing the other principal tests according to the ward.*

Criterion to be met	Design options	Trade-offs
Locating required tests should be as easy as possible.	Limit number of items.	All items visible at all times, reducing effort for selection. <i>May need to exclude some frequently requested tests.</i>
	Include all frequently selected tests.	Most common tests all located together. <i>May require scrolling menu which will increase search time and effort.</i>
	Tests listed alphabetically.	Ordering of menu will be clear. <i>Does not reflect groupings of common combinations.</i>
	Tests ordered by frequency of selection.	Natural groupings and selection frequencies reflected in menu. <i>Menu structure may not be apparent to inexperienced doctors.</i>

#### Design decisions:

There is a non-scrolling menu of the most commonly occurring tests, ordered by frequency of selection.

#### **4.5.8 Specification 8: Infrequent tests menu**

*A sub-menu should be available containing the names of less common investigations.*

##### Design decisions:

A single button below the principal tests menu leads the user to see the minor tests menu. The tests visible on clicking the *More tests* button are the most common of the minor choices, and are arranged by frequency; all other tests, visible on scrolling down the menu, are arranged alphabetically. Menu disappears when mouse pointer leaves menu rectangle.

#### **4.5.9 Specification 9: Date and time facility**

*A date and time override facility should be available to stamp the transaction for a future request (e.g. for a phlebotomist to complete).*

##### Design decisions:

The current date is shown at the bottom of the *Investigations* window. A button above this field allows the user to set a future date and time. Upon setting, the new date and time appear in the date/time field.

#### **4.5.10 Specification 10: Recording of specimen**

*The specimen should be recorded automatically according to what is appropriate to the investigation. Where there is a choice possible, an option menu should be presented.*

##### Design decisions:

Entry of the specimen is entirely automated. However, the problem of a choice of specimens has not been addressed.

#### 4.5.11 Specification 11: Working diagnosis

*Each request should be accompanied by the working diagnosis, which may be amended as necessary.*

Criterion to be met	Design options	Trade-offs
Entry of the working diagnosis should require little effort.	Present user with menu of commonest diagnoses according to ward.	Data entry is much quicker. Medical wards have very wide variety of diagnoses - would require complex menu structure.
	Free text entry.	More laborious. <i>Allows subtlety and freedom of expression of paper system.</i>
Amendment of the working diagnosis should be facilitated.	Working diagnosis field should be permanently open for amendment.	Less effort required to make changes. <i>Increased risk of corrupting patient database.</i>
	Field should be read-only unless user specifies that changes are to be made.	Increased effort for user. <i>Patient data less likely to be corrupted.</i>

A free text entry field is available for the working diagnosis. This is read only, unless the user selects a *Change Details* button, which permits editing of all patient details. Return to read-only mode is brought about by saving changes.

#### 4.5.12 Specifications 12 - 14: Additional clinical details

*An option should be offered to include the current therapy with the diagnosis. Where a number of therapies are current, a menu should be presented for selection.*

*An option should be offered to make suggestions or queries, with a free text area for completion.*

*A free text field should be available for other clinical detail types.*

##### Design decisions:

Three buttons are located below the working diagnosis field:

- The *Current Therapy* button reveals a list of drug treatments that the patient is on. If there are none, a dialogue box prompts the user to enter the therapy. This is added to the patient record.
- The *Query* button opens a dialogue box for entry of a query.
- The *Note* button opens a dialogue box for free text entry.

Information entered by means of the latter two selections is not added to the patient record.

#### **4.5.13 Specification 15 - Logging on**

*Logging on should identify the doctor, marking the request with this identity and the bleep number.*

##### Design decisions:

A single password entered at the login screen allows the user to proceed to the test requesting interface. Request forms are marked with the name and bleep number of the doctor according to the password. There is a three minute time-out which returns the system to the login screen if no activity is detected by the system.

#### **4.5.14 Other aspects of the design**

There were several other functional aspects of the prototype that have not been covered. Their inclusion came from two sources:

- i) Supplementary data collection carried out after the task analysis revealed omissions in the analysis, due mainly to the comparative infrequency of certain entries on the request forms. Thus, in the bottom left of the screen, a bank of three buttons was added to allow the user to specify certain less common criteria, such as an urgent request, or a request for a patient located in a ward away from the doctor's normal base.
- ii) The use of a computer for the completion of request forms produced emergent needs, relating to the use of the technology itself. Thus, in the bottom right of the screen was a bank of buttons for:

- Adding and deleting patient from the database.
- Printing forms.
- Making amendments to a patient record.
- Navigation between the patient list and individual records, and to exit the system.

Although all of these parts of the prototype were essential to its completeness and usefulness as a tool for the users during the trial period, their inclusion was not as a result of any particular need identified by the task analysis. While this is of interest and importance to the debate about the requirements analysis in general, a description of the derivation of these design features lies outside the scope of the research work.

PATIENTS		INVESTIGATIONS	
AA1111 John Wayne	↑	<b>FBC &amp; U&amp;E</b>	RBS
WW3333 Peter Piper		<b>FBC...</b>	LFT
RT6543 Geoffrey Chaucer		<b>U&amp;E</b>	TFT
KH9820 Rudolph Valentino			CEP[1]
			CEP[2]
			CEP[3]
			Calcium
			Digoxin
			Free T4
			ESR
			Ferritin
			Film
			Amylase
			INR
			KCCT
			Serum Folate
			Vitamin B12
		Set Date / Time	<b>More</b> ↓
		Tue Aug 16	
		Add patient	+
		Remove patient	-
		Exit	→
!! URGENT !!			Outlier

Figure 5.2 Patient selection screen

SELECTED PATIENT				INVESTIGATIONS	
Name		Hosp No		FBC & U&E	
Peter Piper		WW3333		FBC	
Sex	Date of Birth	Ward	Consultant	U&E	
M	5/6/54	P1	DRC	RBS LFT TFT CEP[1] CEP[2] CEP[3] Calcium Digoxin Free T4 ESR Ferritin Film Amylase INR KCCT Serum Folate Vitamin B12	
CLINICAL DETAILS				Set Date / Time	
Working	Sneezing			Tue Aug 16	
Diagnosis				More	
	Note		Query	Include Therapy	
				On Anticoags On Diuretics	
!! URGENT !!					Outlier
Print Request					
Change Details					
Show Patient List				John 333 Pete 543 Geof	
Exit					

Figure 5.3 Individual patient details screen

## **4.6 Conclusion**

A framework has been applied within which it has been possible to reason about the design of the prototype. Importantly, it has been shown how this design has in large part been driven by the outputs of TAKD. In the following chapter, the process of evaluating the impact of TAKD on the prototype is described.

# Chapter 5

## Evaluation

### 5.1 Introduction

The production of the prototype system is the culmination of the series of processes discussed in the preceding sections. The effectiveness of those processes is now assessed, central to this being the evaluation of the prototype, with particular reference made to the role played by TAKD in the development of its design. In order to ascertain whether task analysis has made a significant contribution to a good design, the evaluation must aim to show whether the design is a good one, and how good are those parts of the design which are derived from the task analysis.

The importance of evaluation, as outlined by Downton (1991), is that it *"provides a mechanism for injecting objectivity into the process of assessing a design"* or more pertinently by Dix *et al* (1993), that the role of evaluation is to *"assess our designs and test our systems to ensure that they actually behave as we expect and meet the requirements of the user."* When the word *evaluation* is applied to interactive systems, it is generally used with respect to the usability of that system. If the contention held here is that the application of task analysis leads to designs which are more usable, then the evaluation must aim to demonstrate not only how usable the system is *per se*, but also how much of this usability is due to the application of task analysis.

A definition of usability is necessary in order to establish the aims of the evaluation more clearly. While early definitions of usability were based on the ease of use of systems (Miller 1971), later developments attempted to ascribe further components to it. This approach is retained by Gould (1988), who lists these components as:

- System performance
- System functions
- User Interface
- Reading materials
- Language translation
- Outreach programme
- Ability for customers to modify and extend
- Installation

- Field maintenance and serviceability
- Advertising
- Support-group users

This list represents a broad sweep of aspects of the development and installation of a system that have an impact on its success. Whilst this is helpful in the heuristic sense, it does not in itself give us an understanding of what makes a system usable.

Eason (1984) presents a more contextual view, incorporating the relevance of the nature of the user, task, system and environment. These factors interact with one another to determine whether or not a system will be used successfully. He suggests that the interplay of three variables results in a reaction from the user, in that the system will be used to a greater or lesser extent. These variables and their components are:

- System functions
  - match between user's task and functionality provided by system
  - ease of use
  - ease of learning
- User characteristics
  - knowledge that the user applies to the task
  - discretion as to whether to use system
  - motivation to use system
- Task characteristics
  - frequency of task performance
  - openness, or modifiability, of the task

The measure of usability in this scheme is the extent to which the system is used. A limitation of this approach becomes evident when one seeks to evaluate usability, because, as Booth (1989) points out, the act of evaluation requires that the system be used. Unless evaluation is left until after implementation, at the risk of great cost, it must be carried out well before the design has been finalised.

A framework which has evaluation measures built in is most prominently expounded by Shackel (1986, 1991). In this explicitly quantitative approach, he defines a set of operational criteria for the specification and measurement of usability in terms of the system's effectiveness, learnability, flexibility and the attitudes it engenders in the users. For each of these criteria, it is specified that numerical values should be ascribed to particular aspects of usability. For example, *effectiveness* should be measured:

- at better than some required level of performance
- by some required percentage of the specified range of users
- within some required proportion of the range of usage environments.

This, and similar empirically based work, such as that carried out by Gould and Lewis (Gould and Lewis 1985), (Gould 1988), have led to the emergence of an engineering approach to usability (Whiteside *et al* 1988). Usability goals are set for a software product on the basis of user and task analyses, and the achievement of those goals is assessed through the design cycle by the evaluation of prototypes or system simulations.

Recent work as exemplified by ESPIRIT project 5429, the MUSiC project (Corbett, *et al* 1993), echoes Eason's emphasis on the environment in which systems are used, whilst aiming to develop metrics for usability. Context of use is central to the MUSiC methodology. For example, context guidelines are included to enable usability evaluators to determine the contextual issues which may affect the product under consideration. Upon this basis, the methodology then proposes a set of measures of usability that can be applied according to the context.

There is now widespread and growing use of the ideas encapsulated by the general concept of usability, typified by the Usability Now! programme (Preece *et al* 1990), and definitions of usability have been standardised in ISO 9241 part 11. This gives definitions for usability as:

*"the effectiveness, efficiency, and satisfaction with which specified users can achieve specified goals in a particular environment"*

and for usability attributes as

*"the features and characteristics of a product which influence the effectiveness, efficiency, and satisfaction with which specified users can achieve specified goals in a particular environment"*

Though such definitions are necessarily broad, there is also a need for more understanding of what, in detail, constitutes usability. There is an identified need for clarity of definition: Dillon *et al* (1993) report that, while there is general awareness of usability within the European IT industry, understanding of it remains superficial. They suggest that the development of

metrics and standards may be a pragmatic way forward for the promotion of user-centred methods in industry.

Despite a growing consensus about the meaning of usability, its definition is not static. Some pressures for redefinition come from changes in practice. Tetzlaff and Mack (1991) comment that the usability approach to design exists within an ever changing framework, so that methodologies are not given time to consolidate. Laboratory based observation (Tyldesley, 1988), which was so prominent in usability engineering, is being superseded by methods that aim to give an understanding of the setting in which computers are used. Other pressures come from empirical work. For example, Jordan *et al* (1991) offer experimental evidence to suggest that there are additional components to usability that reflect users' performance over time.

## 5.2 Usability and Functionality

A dichotomy which has existed for many years has been whether or not to include the functionality of system within the scope of its usability. (Functionality, it may be argued, is synonymous with *utility*, or *usefulness*). In some definitions of usability, functionality is clearly excluded, such as by Bennett (1984) and Shackel (1984). This does meet with criticism, for example from Booth (1989), who considers that even though a system may fulfil Shackel's criteria for usability, if it does not match the users' goals in their everyday work, it may not actually be useful. Grudin (1992) argues that, for historical reasons, these two aspects of computer usage are considered separately, and that they should be considered logically together. The usability engineering school does acknowledge the importance of functionality, in that "*usability and functionality are linked inseparably in design and implementation*", (Whiteside *et al* 1988), but in so doing imply their separateness. Dix *et al* (1993) make this explicit, stating that evaluation tests the 'usability and functionality of an interactive system'. However, the phrase "*achievement of specified goals*" which forms part of the ISO definition given earlier may be interpreted as the inclusion of functionality within the definition of usability, concurring with Booth's (1989) proposed amendment. An early definition given by Gould and Lewis (1985) also supports this:

*"any system designed for people to use should be easy to learn...., useful, that is contain functions people really need in their work, and be pleasant and easy to use."*

This is the view that will be taken here.

## 5.3 Evaluation Methods

The selection of the methods used in an evaluation is dependent on a multiplicity of factors. Recently, attempts have been made to place these within a framework in order to provide a methodological basis for this selection. Sweeney *et al* (1993) classify usability evaluations in terms of the approach to the evaluation, the type of evaluation, and the stage within the product life cycle when the evaluation is done. Whitefield *et al* (1991) suggest that evaluations can be categorised according whether or not the computer and user are present during the evaluation, i.e. are they *represented* or *real*? These issues are addressed below in the context of two important criteria that determine how the evaluation is to be carried out. Firstly, what is the purpose of the evaluation and secondly, how suitable are the available evaluation methods?

### 5.3.1 The Purpose

There were two distinct aims in the evaluation of the prototype. Firstly, for the purposes of the collaborating body, there was a need to identify areas for refinement and alteration in order to improve the system. The evaluation was effectively to be the trial of a prototype system that was to be developed further, and was thus, in Hewett's (1986) terms, formative. Secondly, within the confines of the project, the prototype represented an implementation, based on the use of TAKD: in this sense, the evaluation should also be summative, in that it should measure the impact of task analysis on the usability of the prototype.

#### 5.3.1.1 Usability of the prototype

Of the usability criteria given by Shackel (1986), those of *effectiveness* (incorporating system functionality) and *learnability* were considered to be paramount in this evaluation.

##### i) Effectiveness

As the prototype was intended to replace an existing paper-based system, then its usability should be assessed in part with respect to that system. The problems that were identified in the current system should be alleviated by the prototype:

- Time: production of request forms using the prototype should not take longer than the current method.

- **Completeness:** the information on the forms should be complete with respect to the requirements of the laboratories.
- **Clarity:** the information on the forms should have a high standard of legibility.

## ii) Learnability

As discussed in Chapter 4, there should be a minimal learning requirement for the system. Thus the learnability goal was to achieve error free performance at first use, the extent of the achievement of these goals would provide formative data for refinements to the prototype.

### 5.3.1.2 The impact of task analysis on the usability of the prototype

The evaluation should include measures to show how much the task analysis has contributed to the level of usability revealed in the previous section. In order to ascertain what the contribution of the analysis has been, the users' tasks carried out with the system should be compared with the same tasks carried out with the paper-based system. The mapping between the two can be taken as the extent to which the task analysis has contributed to the design. By combining this evidence with the usability data, assertions about the impact of the task analysis on the usability may be made.

### 5.3.2 Suitability and selection of the evaluation methods

An evaluation method is a procedure for collecting the data that are relevant to the operation of the system. The classification of methods described by Whitefield *et al* (1991) provides a basis for a discussion of the possible approaches to the evaluation. The categories given are:

- **Analytic** - involving the prediction of user performance on the basis of formal or semi-formal interface descriptions.
- **Specialist, or Expert** - in which expert users review the system on the basis of their own experience.
- **Observational** - in which data are collected from observing users and how well they perform using the system to carry out their work tasks.
- **Experimental** - (categorised by Whitefield *et al* as the formal extreme of observational methods) in which the users' performance with particular aspects of the system is tested in a highly controlled manner.
- **User review** - in which surveys, interviews and questionnaires are employed to gather data about the users' opinions and attitudes regarding the system.

No one method can provide all of the required data. In actuality, several methods may be utilised in combination because there are many aspects to usability (see Vainio-Karsson and Orring (1990) for an example of such typical practice). The criteria which had to be met in the selection of the methods to be used were:

- High involvement of the real users.
- Evaluation of the prototype in the work setting.
- Use of the prototype for real work.

The suitability of each category of method can be assessed against each of these criteria.

#### **5.3.2.1 Analytic**

These methods are used early in design and can test specific aspects of usability. They range from the simplistic, such as the Keystroke Level Model (Card et al, 1980), to the more sophisticated, such as the Command Language Grammar (Moran, 1981), Task-Action Grammar (Payne and Green, 1989), and indeed TAKD. With respect to the selection criteria, they are unsuitable in that there would be no user involvement in the evaluation. Also the tasks would have to be specified rather than arising from the natural demands of the work context, which would not be testing the assertion that the design incorporates an accurate task model.

#### **5.3.2.2 Specialist**

Such an evaluation method requires the production of a report on the system by people experienced in design or human factors. They will put themselves in the position of inexperienced users and attempt to predict usability problems. The form of the evaluation may be a cognitive walkthrough, which is a theory based, semi-formal technique (Polson *et al*, 1992), or a less formal heuristic evaluation, as expounded by Nielsen and Molich (1990). As with the analytical methods above, these suffer from the lack of involvement of the real users. Equally importantly, the proposed evaluators do not have the domain knowledge upon which the prototype is based, so their view of the system cannot be the same as the target users. This is not to undervalue the contribution that expert evaluation can make, but in essence, it is for complementary use. Indeed informal peer evaluation was a constant feature during the design of the prototype.

### 5.3.2.3 Observational

This was considered to be the most appropriate method of evaluation, partly because of the wealth of data that it generates, but mainly because it completely satisfies the selection criteria given above. The richness of the data produced by the application of observational methods is unattainable by other methods. In addition, if the data is collected in the work setting, then its relevance to the application domain is self evident. Observations may easily be carried out in the workplace, thus satisfying the need to include contextual factors in the evaluation. In their account of their experiences of usability engineering, Whiteside *et al* (1988) give a good account of the importance of the work context and how workplace observation is essential for gathering data about the effect of context on usability. Many see observation as a powerful source of insight which can drive design. For example, according to Henderson (1991), observation is intrinsic to the development process, while Monk and Wright (1991) propose that the rationale for invention in interface development comes from observations of the use of existing systems.

### 5.3.2.4 Experimental

Experimental evaluation methods can be used to great effect; a widely cited example is that of Card *et al* (1978), who produced rigorous evidence for the benefits of employing various pointing devices. Eason (1984) urges the development of field experiments as a means of providing rich data for the evaluation of systems, although he does acknowledge the problems presented by the variability of field conditions. Such reservations are taken further by Thimbleby (1990) in his chapter on science, where he warns against the inappropriate application of experimental methods.

The experimental approach was discounted here on several grounds. Most important was the restriction on the number of experimental subjects. The prototype was designed for use by a single consultant firm, which would contain as few as two clinicians who would be active in the ordering of pathology tests. Knowledge about the patient is crucial in the execution of the task; thus the task should be performed with regard to existing patients whom the doctor knows. To involve more doctors would require an increase in the number of patients' details held in the system. This in turn would require changes to the interface that would have been induced by the needs of a particular form of evaluation rather than being pertinent to the needs of the users and task.

A second factor in the rejection of this method of evaluation concerned the need to control the experimental environment. The stated

requirement that the system be used for real work introduces a large number of unpredictable nuisance variables. An experimental evaluation would bring about a reduction in the authenticity of the performance of the task. The motivation of the users was in part dependent on their ability to use the prototype in their work. It was not considered appropriate to jeopardise this situation.

Finally, there was an ethical issue involved in the rejection of these methods. By definition, the testing of an hypothesis would require some use of a system that was suspected of being inferior in the areas undergoing comparison. It was not considered fair to subject the users to deliberate impediment in their work, given the pressures of their jobs and the nature of that work.

#### **5.3.2.5 User review**

Survey methods are usually aimed at obtaining measures of users' attitudes. As discussed in Chapter 1, the factors that have been identified as most influential to physicians' attitudes to computers are ease of use and functionality. Provided then that the criteria of effectiveness and learnability are met to a satisfactory level, favourable attitudes could be expected to follow. Therefore the users' attitudes were not given a high priority in this evaluation. A survey method was used however to validate the findings of the task analysis with respect to its impact on the design, an exercise that included largely attitudinal measures.

### **5.4 The prototype trial**

Any account of the trial of the prototype must be closely linked with the process of evaluation that was carried out. This process is described in detail in the next chapter, while a description of the logistical aspects of the trial of the prototype is given here.

The target user group was a firm (i.e. team of doctors led by a consultant) on ward P1 at the Royal Hallamshire Hospital. This ward is a general medical ward, which, as described in Chapter 2, is characterised by the wide variety of patients it receives, and by the investigative approach required of its clinical staff. Furthermore, the speciality of firm selected was diabetology, which is well known for the complexity and severity of patient conditions with which it deals. The selection of such a treatment-intensive group of patients for the trial was intentional, in order to maximise the use of the prototype in the time available. Initially, passwords were allocated to two senior house officers and one junior house officer. However, three days after

the start of the trial, the junior house officer was replaced temporarily by another junior colleague, bringing the number of different users to four. Two more junior house officers from another general medical firm became involved owing to the substantial number of their patients on the same ward and their interest in the trial, bringing the total number of users to six.

Contact was made with the principal user group several weeks before the trial, and the motivation for the project explained. In the week preceding the trial, the users were timed for the manual completion of request forms during normal work (see Appendix C5). The evening before the trial, all of the firm's current patients were entered onto the patient database by the author, including all data except for the clinical details. Thus the users were presented with a system in which all of their patients were already present, although of necessity the first request for each patient activated a prompt for the addition of the missing data. The doctors were asked to use the prototype without the aid of any instruction or training.

The system was housed in a room normally only used for the treatment of day patients. However, it was centrally located, being near the nurses' station and adjacent to a room where the doctors and phlebotomists prepared the equipment for taking specimens, and also where doctors left their completed request forms for the phlebotomists to pick up.

Owing to the requirements of the evaluation, there was a substantial amount of additional equipment adjacent to the PC, as shown in Figure 5.1. The trial lasted for three weeks, of which the first ten days involved the use of additional hardware. This was removed when sufficient video data had been collected, and for the second part of the trial, only the PC, monitor and printer were present.

The purpose of the additional equipment was to obtain a video record of the use of the prototype. It entailed logging of the screen output directly onto video tape for later analysis and was achieved using a digital to PAL converter. This mediated between the graphics card of the PC and two other output devices: digital signals continued to be supplied to the VDU, while an analogue signal was supplied to the VCR for video recording of the screen display.

Concurrently, sound recording was provided by the directional microphone near to the mouse pad. This recorded the sound of mouse clicks as well as the user's vocalisations. No 'think aloud' protocol was taken because of its likely interference with the speed of performance. As no video camera was involved in the data collection, the time stamping of events had to be achieved with an on-screen counter in the prototype, measuring to one tenth of a second.

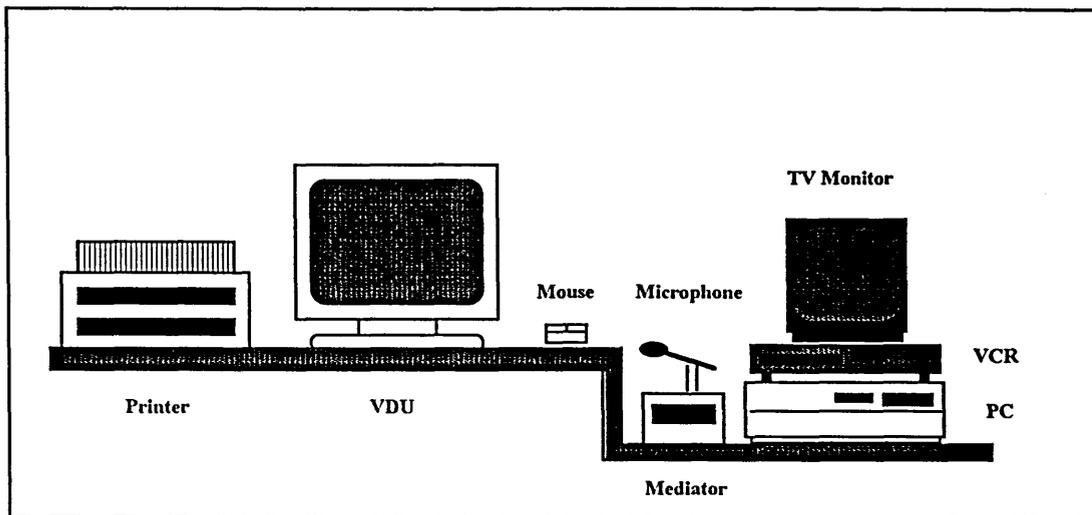


Figure 5.1 Arrangement of equipment for recording of user activity.

This method of recording user activity was preferred to traditional video recording because:

1. It was less intrusive and intimidating to the users.
2. The definition of the recording was far superior to that which could be achieved by recording the VDU screen with a camera.
3. There was no satisfactory positioning for a video camera in the location that had been put aside for the trial. The space being occupied had to be kept to a minimum, as the room was still being used for occasional patient treatment.

## 5.5 Design of the evaluation process

The evaluation process was designed to:

- Capture data about the use of the prototype in real work.
- Record the time taken to perform each task and sub-task.
- Record any problems with the use of the system and capture the context in which those problems occurred.
- Validate the contribution made by task analysis to the design by eliciting the users' opinions about the prototype.

A combination of techniques was used to collect the observational data.

### **5.5.1 Video recording**

This was the principal source of data for the evaluation, and was carried out as described in section 5.4.

### **5.5.2 Direct observation**

This was used only as a supplement to the video logging. When unexpected behaviour occurred, this was noted and the first opportunity was taken to question the relevant subjects after they had finished using the system. If this was immediate, then the VCR was kept running to record the ensuing conversation. Otherwise, the relevant section of tape was played back using the TV monitor to prompt the user as questions were put. In this case, a separate audio cassette recording of the responses was made.

### **5.5.3 Software logging**

The trial period was considerably longer than necessary for collecting sufficient data for most aspects of the evaluation. This was exploited by using a software log to record each request that was made using the system over the whole trial period. It was not a full log of the interaction with the system, but a more simple record of the data sent to the printer, the intention being to provide census data on the types and combinations of investigations being requested. By recording the overall time for each transaction, whether video recorded or not, the log also gave an increased sample size for measuring the average task completion time.

### **5.5.4 Questionnaire**

A set of questions was given to the doctors at the end of the trial period. The questionnaire was adapted from the Software Usability Measurement Inventory (SUMI) (Porteus and Kirakowski 1992), which is a product of the MUSiC project. Where the SUMI questionnaire groups its items on various different aspects of usability, however, this questionnaire was based on the set of requirements given in Chapter 3. The questionnaire was constructed firstly by listing fifteen assertions, either derived directly from the requirements specification, or that support the application of TAKD. Then, for each assertion, a pair of antithetical statements was devised (Table 5.1). Statement pairing in this way was intended as a check against bias towards validation of the assertions. Each statement was then numbered randomly from one to thirty, and the resulting list checked to ensure that no statement pair was closer than three items apart. Close pairings were dealt with by re-allocating one of the pair at random within the block of statements the appropriate distance away. The questionnaire was

	Assertion	Item pair
1	<i>The overall design is consistent with the identified (three node) task structure.</i>	I know where to look to find particular information. The general layout bears little relation to how I request tests.
2	<i>The layout corresponds to the three top level nodes in the first pass TDH.</i>	Related types of information are clearly grouped together. The general layout of the screens could be more logical.
3	<i>The implementation is a good application of the identified task structure.</i>	I have to move the mouse around too much to make a request. I have no problem going from one part of the task to another.
4	<i>The notion of a transaction as the unit task is desirable.</i>	It is good that all the desired tests can be requested at one go. I would like more control in the printing of each individual form.
5	<i>There is no need for batch ordering of tests.</i>	I often order the same batch of tests for several days ahead. It is good that the system allows ordering for only one date at a time.
6	<i>The TA has correctly identified the most common tests.</i>	I have difficulty finding the most common investigations. The more common the test, the easier it is to select.
7	<i>The TA has correctly prioritised the tests.</i>	I agree with the order in which the tests have been placed. I would prefer all the tests to be in straight alphabetical order.
8	<i>There is a perceived need to order tests in advance.</i>	It is important to be able to order tests in advance of the date. required. I prefer to write my request forms on the day the sample is to be taken.
9	<i>There is a perceived need to stipulate the sample time.</i>	There is no need for a facility for setting the time as well as the date. Certain investigations require that the sample collection time be stipulated.
10	<i>The working diagnosis should be the default clinical detail.</i>	It is convenient to print the working diagnosis with each request. A patient's clinical details change frequently.
11	<i>There is a valid trade-off between ease of reporting and relevance of clinical details.</i>	I would prefer to be able to report different clinical details to different labs. My priority with clinical details is that they should take little effort to report.
12	<i>The analysis of clinical detail reporting has revealed the task structure.</i>	The row of buttons below the working diagnosis is not useful. The system should allow me to enter more than a working diagnosis.
13	<i>There is a necessity for the labs to have full details.</i>	There are too many patient details displayed. I think the labs would be satisfied with the patient data this gives.
14	<i>The TA accurately identified the elevated importance of test selection in the task sequence.</i>	It is confusing that I am allowed to select the tests before the patient. This system allows me the flexibility to do things in the order I want.
15	<i>The TA correctly identified what could be automated.</i>	The computer makes form filling less repetitive Little effort is required once the patient has been selected.

Table 5.1 Assertions and associated antithetical statement pairs.

administered with a five point Lickert-type response scale (see Appendix E).

## **5.6 Methods for analysing the data**

The data that were collected comprised:

- A video recording of the use of the prototype, with fifty seven logged transactions performed by all of the six trial users. The transactions involved the requesting of tests, and the addition and removal of patients from the system.
- A log recorded by the prototype software including all those later transactions that had not been video recorded. This log comprised the data recorded on the request forms.
- A set of questionnaire responses. Four of the six trial users returned the questionnaire.

Various forms of analysis were performed on the collected data. These are now described.

### **5.6.1 Video log of the interaction**

#### **i) TAKD**

The video log was used as the basis for the re-application of TAKD. An activity list was produced from fifty seven transactions carried out using the prototype (see Appendix C2). The time taken for each action was read from the recording of the on-screen timer. Specific objects were all assigned both a name (as the object acted upon), and a time. The final TDH (Appendix A2.2) was used as a template for the construction of the new TDH in an attempt to discover the extent of the mapping between the task in its manual and automated forms. The resulting KRGs were interpreted in a variety of ways, which are explained fully in the following chapter.

#### **ii) Critical incidents and breakdowns**

Qualitative analysis of the video log was carried out by looking for behaviours which stood out from the background. This is based on work by Wright and Monk (1989) concerning the elicitation of data from users. They define a critical incident as behaviour which is sub-optimal with respect to the intentions of the user and functionality of the system. The idea of a breakdown in the use of the computer is taken from Winograd and Flores (1986), and is said to occur when the user loses the task focus and becomes conscious of the computer itself through some problem arising from the interaction. Critical incidents can be identified by unexpected behaviour, and

breakdowns need to be marked by the user's verbalisation about the system at the time of breakdown. (If nothing is said, then the occurrence of a breakdown can at best only be guessed at.)

### **5.6.2 Software logging**

#### **i) Validation of the original data collection**

The record provided by the software log was compared against the data collected at the beginning of the analysis stage, and against the supplementary data collection that was carried out in the final stages of the design of the prototype.

#### **ii) Task timing**

The log provided overall task times which could be compared against the manual task completion times (Appendix C5).

### **5.6.3 Analysis of the questionnaire**

The five points in the response scale were scored as follows:

Strongly agree	+2
Agree	+1
Undecided	0
Disagree	-1
Strongly disagree	-2

The scores for each question from each respondent were totalled. In order to extract the degree of agreement or disagreement with the assertion, the score for the negative item from each item pair was multiplied by -1, the scores for the pair then being added together. This gave a score for the assertion; negative scores negated the assertion, positive scores gave support, with the absolute score indicating the degree of agreement or disagreement. Interpretation of these scores was made in conjunction with the other findings of the evaluation.

## **5.7 Analysis of the data using TAKD**

This section details how the video data were interpreted to provide the input to the re-application of TAKD. Subsequently, it describes how the outputs of this were subjected to further analysis.

### **5.7.1 Construction of the transaction log**

The video recording was indexed on the basis of individual transactions performed by the doctors. A transaction was taken to be an (intended) order for laboratory tests for a patient for a given date, or an

addition or removal of a patient from the system. The resulting transaction log (see Appendix C2) contained the points on the tape where the transaction began and ended, the doctor name, the patient name (in order to more easily identify the transaction during playback), the transaction type, and any additional points of interest. The end of a transaction was taken to be the point at which the system returned the user to the patient list, i.e. after printing, or on saving or deleting a patient's details.

### **5.7.2 Construction of the activity list**

Each transaction was then studied in detail, and an activity list produced on the basis of the details of the use of the system. Activities were differentiated according to which screen object was selected. A small number of generic actions was identified. The first three were by far the most common.

#### **i) Select**

This was clearly indicated by a movement of the mouse pointer towards a screen object, followed by clicking on that object, be it a list item or button.

#### **ii) Consider**

Often, the pointer would be seen to 'hover' over an area of screen, without a selection being made, the positioning of the pointer indicating the current focus. (It is acknowledged that this would not always be the case, and that the user's attention could be on another part of the screen. However, there were very few 'idle' periods when the pointer was not moving, indicating that the mouse movements gave a good reflection of the user's focus of attention.) Such behaviour sometimes occurred over non-selectable areas, such as the patient details section. At other times, it took place over a list and an item passed over several times would then be selected. It was also more prevalent with some doctors than others.

#### **iii) Enter**

This constituted the entry of data into the patient record, usually on addition of a new patient, and infrequently on amendment of the patient details.

#### **iv) Search**

This was identified with reference to lists that were scanned but where no selection was made. Scanning a list was evident by a clear up and down movement of the pointer over the list. Searching followed by selection was

classed as selection alone, with the search time being incorporated into the selection time.

v) Confirm

A particular form of selection, this referred to a click in a dialogue box, or more rarely the selection of a button, to confirm a command before execution.

vi) Undo

Actions were undone by particular button or dialogue box selections in particular contexts.

It was inevitable that some subjectivity was involved in differentiating between some of the above actions, particularly where the user's intentions were inferred. However, a very rich picture of the interaction was provided by the inclusion of sound, and the incorporation of the evaluator's understanding of the situation and knowledge about the individual user. Also, interpretation of the subsequent actions was used to infer the intentions of the preceding ones. This wealth of contextual data was used to corroborate the decisions taken in the allocation of names to events.

### **5.7.3 Selection of Specific Objects**

Once the generic actions had been identified, selection of the specific objects was straightforward. These would be button names, or list items. The actual list selection was specified as the object in the case of investigations, because these choices were of special interest in validating the data collected in the analysis stage. The time taken for the action on each specific object was recorded as part of the specific object itself.

### **5.7.4 Construction of the TDH**

The first pass TDH (Appendix A2.1) was taken as a template for the construction of a new TDH. All of the nodes which related only to the manual system were removed, such as the addition of the sticky label, entry of the doctor's signature, etc. Then the remaining hierarchy was adapted to accommodate the new task structure. Entirely new sections were appended to this revised TDH, namely those that described adding and removing patients, for setting future dates and for printing forms. These sub-sections were not subjected to detailed analysis, as the design of these parts of the system had little input from the original analysis. What was important was that they were represented and could be referred to as generic actions.

### **5.7.5 KRG analysis**

The KRGs that were of most interest were those that related to aspects of the prototype that had the greatest input from the analysis, while other aspects were treated in a more general way. Appendix A3.1 shows the KRGs selected, each being ascribed to a Task Type number, along with a mnemonic for ease of reference. Task Types 1 and 2 were high level KRGs and referred to maintenance of the patient list. Task Types 3 to 7 were lowest level KRGs that referred to the different test selections that were offered. Task Type 8 was the peripheral act of quitting the system. Task Types 9 and 10 related to the clinical details, whilst 10 and 11 were 'consideration' actions. Task Type 12 was a high level KRG that referred to all actions concerned with setting the date, Task Type 13 referred to patient selection, and Task Type 14 related to the use of the print function. Finally, Task Type 15 was the little used 'special case' selection, referring to use of the 'urgent', 'outlier' and 'phone' buttons.

For each of these task types, three metrics were applied. Firstly, time spent performing each task type was totalled, from the timings allocated to each specific object. These totals were then expressed as a percentage of the total time that the system was used. Secondly, the frequency of the KRGs themselves was expressed as the percentage of all the KRGs recorded. The third metric was the task quotient, which was calculated by dividing the KRG percentage by the total time percentage for each task type. The reason for the inclusion of this last value was to give a single measure which recognised both the frequency with which an action was performed, and the time taken to complete that action. This would permit the comparison of one task type with another, with frequency effects removed. For example, a task type which took only a small proportion of the overall time might still be over-difficult, which would be reflected in the fact that it would occupy an even smaller proportion of the total KRGs.

### **5.7.6 Statistical Analysis**

#### **5.7.6.1 The Data**

The data produced in the KRG analysis (Appendix C3) was subjected to a statistical analysis which utilised general linear modelling to investigate the potential effects of a set of factors characterising each task on the time (in seconds) taken to complete that task. The factors of interest are shown in Table 5.2. It should be noted at this stage that the data are considerably unbalanced with respect to the various factor combinations. For example, there was no guarantee in the method of collecting the data that each doctor

would perform each Transaction Type within each Task Type equally often, as would have been the case had a designed experiment been employed. Furthermore, many factor combinations are not represented in the data at all - for example, there may be no observation of a particular doctor carrying out a particular transaction within a particular task. Since many such factor combinations are not represented, the data are said to be *sparse*.

Factor	Description	Levels
Task No.	The activity list number, unique to each specific object, provided a crude temporal measure, as the activity list was principally ordered by time. This could be used to test if performance improved over time.	521
Transaction No.	Equivalent to the blocking in the activity list, this again could be used to test if performance improved over time.	58
Task Type No.	This was the number allocation described in the previous section, and was included to look for differences in performance between task types.	14
Transaction Type No.	Four transaction types were distinguished, i.e. a basic request, a request on a patient newly admitted, a request on a pre-admitted patient (see section 4.6) and a patient removal. The significance of these transaction types on performance was sought.	4
Position in sequence	The user would perform a number of transactions during a visit to the system. This parameter recorded the position of each transaction in that sequence, and was included in order to detect changes through the sequence.	3
Doctor occasion	This counted how many transactions each doctor carried out, and was used to detect performance changes for individual doctors over time.	15
Doctor No.	Each of the six users was allocated a number, to seek out performance differences between doctors.	6

Table 5.2 Factors subjected to statistical modelling.

### 5.7.6.2 The SAS Package

All statistical analyses were performed on SAS Version 6.03, running on a Novell network. The general linear modelling procedure PROC GLM was employed to construct the various statistical models of interest, perform the relevant analyses of variance and calculate corresponding adjusted means.

### 5.7.6.3 Preliminary Modelling and Data Analysis

Two problems were foreseen in modelling the data. The first concerned the nature of the dependent variable - the response time (in seconds) assigned by a doctor to each specific object. It was anticipated that such a variable might exhibit a non-normal distribution, possibly with the standard deviation increasing with the mean. A variance-stabilising power transformation of the data often provides a solution to problems of this kind (Box and Cox, 1964).

It was also anticipated that even the powerful SAS package would have difficulty in fitting all possible factorial effects, for two reasons. Firstly, the factors of interest would generate a large number of factor combinations,

each of which could yield a different mean response. This would in turn produce a large memory requirement, especially when modelling factor interactions. A second, related problem concerns the imbalance and sparseness of the data already mentioned, which would greatly complicate the statistical modelling process that SAS would have to perform.

Preliminary modelling involved fitting the main effects only of the relevant factors to the raw response times, with a view to performing residual analyses to investigate deviations from normality. It was quickly found that the Task Number and Transaction Number factors contributed very little to an explanation of the data. On further consideration, it was decided that these factors were not task related, and that, in particular, *Doctor Occasion* would provide a more relevant and detailed measure of performance change over time than would either of the above factors. This was because the Doctor Occasion factor would relate performance changes over time to individual doctors. Consequently, the factors Task Number and Transaction Number were dropped from this and all subsequent analyses.

The main effects of the remaining factors were now fitted to the raw response times. A plot of the ensuing residuals against the corresponding fitted values, and a normal probability plot of the residuals can be found in Appendix C4. Clearly, the variability of the residuals appears to increase with the fitted values, and the normal probability plot deviates markedly from linearity. Consequently, the assumptions of constant variance and 'near normality' which are essential for the validity of the analysis of variance are clearly violated.

Raw waiting or response times are often found to exhibit properties consistent with an underlying gamma distribution - in particular, the standard deviation of such data is often proportional to its mean. The appropriate power transformation is to take the logarithms of the response times. However, this would clearly lead to problems when a response time of zero was reported (since the logarithm of zero is minus infinity). Since data were reported to an accuracy of 0.1 seconds, a zero could represent any time between 0 and 0.05 seconds. Thus a value of 0.025 (the mean of 0 and 0.05) was substituted for any zero prior to taking logs.

The above main effect model was fitted to the log response times, and residual plots were obtained (see Appendix C4). These residuals exhibit approximately constant variability, regardless of the fitted value, whilst the associated normal probability plot shows an approximately linear profile, supporting the near normality of the data. Consequently, all further analysis was conducted on the log response times.

## **5.8 Conclusion**

A very mixed approach has been taken to the evaluation of the prototype, with the aim of producing the richest possible set of data for assessing the success of the analysis and design methods that have led to its use. The next chapter gives an account of the outcome of the application of these evaluation procedures.

# Chapter 6

## Results of the evaluation

The outcomes of the data analysis performed in the evaluation are described here. The results of the application of TAKD to the evaluation are given first, including those from the analysis of variance. Subsequently, a description is given of the three critical incidents and eight breakdowns revealed in the video log. The scoring of the questionnaire is then given, before finally going on to the contents of the software log, and a comparison of task timing.

### 6.1 KRG analysis

An overview of the major uses of the prototype is shown in Table 6.1. All uses of the system concerned with test requesting *per se* have been grouped together. The remaining uses are those concerned with maintaining the integrity of the patient list, namely the addition and removal of patients.

KRG sentences	Mnemonic	Task type	Total time (s)	% Total time	No KRGs	% KRGs	Task quotient
<sup>6</sup> 3	remove patient	1	74.8	2.5	26	4.9	0.51
<sup>6</sup> 4	add patient	2	1337.1	44.7	119	22.5	1.99
All others	test requesting		1579.2	52.8	384	72.6	0.73
			2991.1	100.0	529	100.0	

Table 6.1 Summary data: overview of major uses of system.

It is to be noted that the percentage total time for adding patients was quite high, and that for all the time spent using the system, only 52.8% was actually spent in the process of requesting tests. The amount of time spent in adding patients to the system was disproportionate to the corresponding percentage of KRG sentences, which formed only 22.5% of the total. This was reflected in the high task quotient for adding patients.

Table 6.2 gives detailed results for the different components of the test requesting part of the system. All the percentages in the table are based on this type of use only, i.e. the list maintenance functions are excluded from the calculations. Most prominent in terms of percentage time are the *print* and *order ahead* functions, but as these two comprised quite a high percentage of the KRG sentences, their corresponding task quotients are not

large. *Patient selection* has a higher task quotient, while the two that stand out most clearly are the *enter report* and *select minor list* actions. The latter value is particularly high, showing that the time taken to perform the sub-task was out of proportion to the number of times it was performed. *Enter report*, being a data entry operation, was more likely to be a time consuming sub-task.

KRG sentences	Mnemonic	Task type	Total time (s)	Total time %	No KRGs	% KRG sentences	Task quotient
25,27,31	select minor list	3	130.1	8.2	6	1.6	5.27
26,28,32,35	select major list	4	163.8	10.4	53	13.6	0.76
29,30,38	select double button	5	33.4	2.1	11	2.9	0.74
33,34,39,40	select FBC	6	13.7	0.9	7	1.2	0.48
36,37	select U&E	7	47.0	3.0	12	3.1	0.95
<sup>2</sup> 2	leave system	8	35.9	2.3	13	3.4	0.67
<sup>4</sup> 9	enter report	9	141.2	8.9	11	2.9	3.12
<sup>4</sup> 10	consider report	10	25.2	1.6	7	1.8	0.88
<sup>4</sup> 17	consider investigation	11	153.8	9.7	34	8.9	1.10
<sup>5</sup> 9	order ahead	12	282.9	17.9	76	19.8	0.91
<sup>5</sup> 11, <sup>5</sup> 12	patient selection	13	217.1	13.7	43	11.2	1.24
<sup>6</sup> 5	print	14	330.6	20.9	108	28.1	0.74
<sup>6</sup> 1	special case	15	4.5	0.3	3	0.8	0.36
			1579.2	100.0	384	100.0	

Table 6.2 Detailed results for the different components of the test requesting part of the system

Whilst tests in the major list were the predominant choice from the other possible test selections, there was little difference between the task quotient values between them. The task quotient for U&E selection is raised, the possible reasons for which will be discussed later.

## 6.2 Statistical analysis

Table 6.3 shows the analysis of variance that resulted from fitting the factors Doctor, Position, Task Type, Transaction Type and Doctor Occasion to the log response times. Because of the imbalance of the data discussed previously, none of the main effects were mutually orthogonal. Therefore

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Doctor	5	7.3102	1.4620	1.95	0.0849
Position	4	1.1324	0.2831	0.38	0.8248
Task Type	12	86.6150	7.2180	9.62	0.0001
Transaction Type	2	2.8301	1.4150	1.89	0.1528
Doctor Occasion	15	10.7465	0.7164	0.95	0.5026
Error	481	360.8735			0.7502
Total	520				

Table 6.3 Analysis of variance results, including *position* as an independent variable

SAS Type III sums of squares (wherein each effect is adjusted for all other potential effects) are presented.

Ideally, the Doctor factor should be modelled as a random effect. In models of this kind, each factor's main effect is ideally tested against an error term that involves the interaction of that factor with the random factor (see, for example, Winer (1971) and Montgomery (1991)). However, attempts to include the interactions of Doctor with each of the other factors in turn resulted in an "out of memory" error being returned by SAS. Similar problems were encountered when attempting to include other two-factor interactions in the model. The analysis depicted in Table 6.3 above thus represents the best practical compromise that could be achieved in analysing the data.

Returning to the table, it is clear that Task Type has a very highly significant effect on the log response time ( $p = 0.0001$ ), whilst there is slight evidence that the log response time varies between individual doctors ( $p = 0.085$ ).

Since Position was so insignificant ( $F = 0.38$ ,  $p = 0.825$ ), it was removed from the model, which was re-fitted with the remaining factors. It was also noticed that Transaction Type 1, *remove patient*, had only one Task Type associated with it, and was performed by only one doctor. It was consequently judged that the inclusion of this Transaction Type in the analysis would provide virtually no useful information, and would furthermore complicate the analysis and its interpretation. All observations for this Transaction Type were thus deleted from the data. The results of the ensuing analysis were as follows:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Doctor	5	7.1827	1.4365	1.90	0.0925
Task Type	12	88.1338	7.3445	9.73	0.0001
Transaction Type	2	3.3442	1.6721	2.21	0.1103
Doctor Occasion	15	11.0478	0.7365	0.98	0.4800
Error	460	347.2686			0.7549
Total	494				

Table 6.4 Analysis of variance results, excluding *position*.

As before, only Task Type was statistically significant, and again, it was highly so ( $p = 0.0001$ ). Thus we have very strong evidence that the mean log response time (and thus the mean actual response time) differs according to Task Type.

Both Doctor and Transaction Type achieved approximately 10% significance ( $p = 0.093$  and  $p = 0.110$  respectively). Although this falls below the conventional 5% level required for statistical significance, these

results can be taken as a weak indication of possible effects, although further investigation would be necessary to confirm these results (or otherwise).

The following three tables give estimated mean values of the log response times for the Task Type, Doctor and Transaction Type factors. Note that these are not simple arithmetic means, nor should they be. For example, different Task Types may have different numbers of observations from the various doctors and from the various Transaction Types. The reported means (the SAS "least-squares" means, Table 6.5) are adjusted to take account of this imbalance, and estimate what the mean log response time for each Task Type would have been if each doctor and transaction type were equally represented in the data. The results for Doctor and for Transaction Type can be similarly interpreted.

Table 6.5 shows that there are slight differences between the performances of the doctors. This reflects the significance value obtained for the effect of doctor on performance time in the analysis of variance. In Table 6.6 it can be seen that there is wide variation between the LS mean values for Task Types. It may be difficult to infer differences between many of the values from around the middle of the range, but it is reasonable to do so for

DOCTOR	LSMEAN (ln time)	Doctor
1	1.14	A M
2	1.18	L W
3	1.33	R H
4	1.52	A F
5	1.20	S W
6	1.55	R W

Table 6.5 Least Squares Mean values for Doctors

TASK TYPE	MNEMONIC	LSMEAN (ln time)
2	add patient	1.79
3	select minor list	2.99
4	select major list	0.86
5	select double button	0.57
6	select FBC	0.51
7	select U&E	1.52
8	leave system	0.63
9	enter report	2.54
10	consider report	1.35
11	consider investigation	1.23
12	order ahead	0.90
13	patient selection	1.38
14	print	0.92

Table 6.6 Least Squares Mean values for Task Types

TRANSACTION TYPE	MNEMONIC	LSMEAN (ln time)
1	Request only	1.25
2	Add patient	1.56
3	Pre-admitted patient	1.16

Table 6.7 Least Squares Mean values for Transaction Types

hose at the extremes. Thus Task Type 3, selection from the minor list, has a considerably higher value than selection of the FBC button at the lower extreme. Similarly, Task Type 9, *enter report*, was significantly more time consuming than selection of most of the tests. A large discrepancy was evident between the times for the selection of the U&E button and the other (non-minor list) selections. Table 6.7 shows only a slight difference between the mean times for the Transaction Types, again as reflected in the F ratios given earlier, with *add patient* as the most time consuming of the three.

## 6.3 Critical incident and breakdown analysis

### 6.3.1 Critical incidents

#### Critical incident 1

**Transaction No:** 11,12,17

**Doctor:** AM

**Transaction Type:** Remove.

**Critical incident:** Selection of patient before selection of remove button.

**Description:**

The user intends to remove a patient, and selects a patient first. He then has to select *Show patient list*, before returning to correct screen. He then proceeds optimally.

The above three transactions reveal an inconsistency in the way in which actions on patients are initiated. Users may select tests before or after selecting the patient, but this flexibility is not available when removing a patient. This suggests a change to allow the removal of the patient after selection.

#### Critical incident 2

**Transaction No:** 31

**Doctor:** LW

**Transaction Type:** Add patient

**Critical incident:** Adding therapy

**Description:**

The user is entering details for a new patient, whilst talking about a different patient to a colleague. She clicks on the *'Include Therapy'* button which is greyed out, as the screen is in write mode. This results in a prompt to *'Save Details First'*. The OK button in the prompt box is ignored, and the user

clicks on the 'Current Therapy' label, which results in a beep from the computer. She then clicks on *OK* in the prompt box. This allows her to click in the label area twice more, without incurring the warning beep. There is no response from the system and she selects 'Save Details' to go into select test mode, selects the requisite tests, and then clicks on 'Include Therapy'. She opts not to enter anything in the resulting dialogue box, and prints the form.

She failed to achieve her whole objective. Her aim (discovered on questioning the following day) had been to enter a therapy by revealing the pop-up menu that would have been shown by activating the current therapy field. Immediately before this incident, she had used the correct method to enter the consultant, which required the same sequence of operations. In the next transaction she added a therapy without any problem.

This incident, in the light of the user's success in performing the same operation both prior to and after this case, may be attributed in part to the distracting effect of her conversation with her colleague. However, the problem arises from a more fundamental issue concerning the reporting of the clinical details, and is discussed fully in section 6.7.2.5

### Critical incident 3

Transaction No: 36-39

Doctor: RH

Transaction Type: Request

Critical incident: Selection of multiple tests

Description:

The user prints each separate form off and re-selects the same patient rather than ordering all of the required tests at one go.

This incident shows the user performing the task with a device-dependency which was relevant to the paper system. Not only was she the only user to do so, but also was repeating behaviour she had displayed six days earlier (see Appendix C1), in a set of transactions that were not video-recorded. At the end of that previous occasion, she was told that the system would deal with multiple forms. On her next use of the system two days later, she performed optimally, but reverted another four days further on, as recorded here. Her subsequent use of the system showed optimal use again. Her view of what constitutes a transaction may be different from the designer's; the cues that the system will cope with multiple forms have been insufficient. Her reaction on first being told that the system would deal with printing separate forms was "*It's clever, isn't it?*"

This user was least at ease with the system, and displayed the least exploratory behaviour. She most frequently amended or completed the forms by hand. Unfortunately, she was also one of the users who did not return the questionnaire.

## Critical incident 4

**Transaction No:** 18, 73  
**Doctor:** LW, SW  
**Transaction Type:** Request.  
**Critical incident:** Entry of current therapy as a working diagnosis.  
**Description:**

The users enter a patient's current therapy as the only clinical detail, but rather than using the *Include Therapy* button, and selecting from the list of common therapies, they type the information into the working diagnosis field.

Whilst it is clear to them that a therapy is not a working diagnosis, there is no consequence to their reporting the information in this way, as the request form will include the data they wish to communicate in any case. What is critical here is that they do not use the facilities offered by the system to report a current therapy. This is not unexpected, as inclusion of the current therapy requires a fairly complex sequence of actions, whereas straightforward typing may be slightly more time consuming, but requires less mental effort.

## 6.3.2 Breakdowns

### Breakdown 1

**Transaction No:** 43  
**Doctor:** AF  
**Transaction Type:** Request  
**Breakdown:** Problem with proceeding to next request.  
**Description:**

This is the user's first encounter with system. The user has selected *patient* and *tests*.

*User:* *Now do I exit, is that it?*

Pointer over exit button.

*TF:* What do you want to do, now?

*User:* *All I want to do is a KCCT. That's it. [The test]*

*TF:* You don't want to leave the system. You haven't finished what you're doing.

*User:* *Oh no, no. I want to do another patient.*

*TF:* What do you think is the next thing you want to do?

*User:* *Do another KCCT on patient called [name]. I should show the patient list.*

Pointer is placed over *Show Patient List*.

*TF:* Have you finished exactly what you're trying to do?

*User:* *Well that's, I just I want that blood, that printing.*

*TF:* Ah, so you want to print it?

*User:* *Well, ah, I thought it just printed it off last of all, you see.*

Selects print

*Now can I move on to the next patient?*

Pointer is over *Add Patient* button

*Ah, can't list .....until ... patient print.*

Patient list now showing. User proceeds to next patient.

This breakdown demonstrates the opposite to the critical incidents occurring in transactions 36 to 39. In the latter, the user's model of the system was very limited. Here, the user expects the system to do more than it does, i.e. that it logs each transaction and that printing is done after all

there are no more tests to order. *Closure* for this user would occur when he had completed that particular batch of requests. The designer's intention was that closure would be achieved by printing the forms for the selected patient. A simple remedy would be to include a *Next patient* facility that permitted the kind of transition this user was seeking. However, this would not afford any greater information to the user about when was the appropriate time to *Print*, and there would be a cost in that the screen would be more complex. Given that this was the user's first encounter and that minimal assistance was needed in order for him to construct the correct system model, it could be argued that some instruction would be appropriate. It would follow that the prototype could not then claim to be a walk-up-and-use system, although even these employ prompts and instructions (e.g. ATM machines). In addition, the previous critical incident would be avoided by this approach, but not by the remedy required to avoid the breakdown reported here.

## Breakdown 2

**Transaction No:** 48  
**Doctor:** AF  
**Transaction Type:** Request, order ahead  
**Breakdown:** Problem with proceeding to next request  
**Description:**

This is the user's first encounter with the date function. He has requested tests for tomorrow. He then selects the *Date/Time* button again, to set the date for following day. He selects *Further Ahead* and sees the *How many days?* dialogue box.

*User:* So, one day's tomorrow so

*TF:* You only get one date at a time. You can't do....If you want today's, you print today's. If you want tomorrow's you have to go out and print tomorrow's.

*User:* Oh, alright, so I've got to cancel that, have I? (*How many days?* dialogue box).

*TF:* Yes.

User cancels box, then cancels Set Date/Time screen. Clicks 'Print Request' with today's date showing.

*TF:* You can see that now it's just today's.

*User:* That's tomorrow's.

*TF:* Well, what you're going to get is the date that's on there now.

*User:* But I asked for tomorrow's.

*TF:* You cancelled it.

*User:* Oh, did I? Right.

User cancels Print confirmation dialogue box.

*User:* So what I want is in red, .....set date and time.

Selects Tomorrow, OK, Print.

*User:* Now I've got to show the patient list again? Ah, it's done it itself. Got to put it in again? I do that.

Selects patient again.

This breakdown has a similar origin to the previous one, in that the user expects the system to be able to store requests for different days, followed by a batch printing. The problem encountered in the last breakdown had been overcome, as the user used the system several times more without difficulty (transactions 44 and 46). This breakdown, however,

showed that his knowledge about the system model learnt previously was not transferred to the use of the date function. If the notion of a *transaction* does exist in the user's mind, it is reasonable to suppose that this includes all dates as well as tests for a particular patient. Support for the importance of multiple date transactions abounds in this evaluation. Thus this particular breakdown could be avoided by adding a facility for multiple date transactions.

### Breakdown 3

**Transaction No:** 52

**Doctor:** AF

**Transaction Type:** Request

**Critical incident:** Searching for major test, fails to see unselected button as an option.

**Description:**

The user has selected the patient, and one test from major list. This is his first use of *FBC/U&E* buttons.

*User:* Where's the U&Es ?

TF: (Doesn't hear clearly). See if you can find them.

User scans major list twice, then looks in minor list.

TF: You can move down this one by clicking those arrows, or in the grey space. [Instructions on use of scrolling field]

*User:* Give us a clue.

TF: There probably is..... Click on it again.

User clicks on *More* button.

I said you can move through this by clicking on the grey space or on the arrows. It's quicker to go on the grey space. Is what you want there?

*User:* Well, I want urea and electrolytes. It's just got urea really.

TF: You mean.....

*User:* Sodium, potassium, the lot.

TF: You mean U&E.

*User:* Yeah.

Looking at minor list.

*User:* It's not here is it, it's definitely not there.

TF: No. Can you see it anywhere else ?

User clicks on minor list again.

*User:* Go on, give us a clue.

TF: Well, what's been selected so far?

*User:* Just digoxin.

TF: How can you tell?

User points to selected test, then moves pointer over *U&E* button:

*User:* That's er, er, just means you have to do it again here [U&E button] ?

TF: Try it.

User selects *U&E*

TF: Does it look as if you've selected it now?

*User:* What, cos they're, are they always up there? [FBC etc].

TF: Yes.

*User:* Oh, alright, I see. Because they're so common.

The potential for a misunderstanding of the principal test button was realised in this breakdown. This user had previously requested eleven tests, none of which involved these buttons. The root of this problem lies in the disparity between the test frequency findings derived from the original

analysis and the frequencies with which different tests were requested during the evaluation period. The user had not noticed these buttons, although after being informed, he had no further problem with this.

#### Breakdown 4

**Transaction No:** 57  
**Doctor:** SW  
**Transaction Type:** Request ahead  
**Breakdown:** Attempt to order for second day.  
**Description:**

The user has just selected for today, and has printed off. Clicks on *Set Date/Time, Tomorrow, OK, U&E*, and then looks for *Print Request* button, but finds *Add patient*, where *Print Request* had been.

TF: Are you looking for a patient?

User: *Oh, I see. You have to go back into the same patient. That's a shame. That would be a good idea if it stays within a..... So, I want to huff that, do I?*

User clicks on Exit.

User: *Oh no.*

Logs in. Selects patient, then selects test, and prints.

User: *It would be nice if it would stay in so you could do a whole week's.*

Selects patient again, *Set date/time*, points at times (1-12).

User: *This is for this month is it, or, on the 8th ?*

TF: Do they look like months? [Evaluator's misunderstanding of what the user has said.]

User: *Oh, is that months? Could be the beginning of the month I'm in. I don't know, you'll have to tell me then.*

TF: Is there a clue as to what the numbers mean? I can see one.

User: *I don't know what this [column of times] means.*

TF: What about the column to the right of that?

User: *Am, pm? Oh is that time? Is that supposed to be the time when you do the blood test? Oh, so you have to go further ahead.*

Selects Further Ahead.

*And I was on Tuesday already, or does it start from the Monday ? One day ahead.*

Chooses one day ahead.

*It's still on Tuesday so you have to go two days ahead.*

Selects one day ahead. Clicks *OK* in *Date/Time* area, then *OK* in *How many days* dialogue box, then *OK* in *Date/Time* again. Selects *Print Request* without having selected tests. Gets *No tests have been selected* message. Then proceeds to complete requests, up to 5 days ahead for this patient. *Note SW's questionnaire response about moving the mouse excessively.* User checks printed forms:

User: *Wednesday, I've missed the Thursday. I must have jumped a day. The best thing to do is to use the next one.*

Overwrites today's date by hand, and adds the date for the omitted Thursday.

The source of this confusion lies in the failure to identify batch ordering of tests as an important requirement. A greatly simplified method for ordering tests ahead is the clear need that is indicated. Also, it could be inferred from this breakdown that the time-setting function has been given too much emphasis (although, as discussed later, its importance is perceived differently, partly according to the doctor's experience).

## Breakdown 5

**Transaction No:** 63  
**Doctor:** SW  
**Transaction Type:** Add patient + request  
**Breakdown:** Inclusion of current therapy.  
**Description:**

The user includes current therapy when adding patient details

**User:** *Heparin, warfarin. Does that go on the form at the bottom somewhere? Oh, I'll see when it comes out.*

**TF:** What goes on the form is what you see in red.

User prints form without *Include Therapy*

I take it that you don't want to put on the form that they're on heparin and warfarin.

**User:** *Ah, do you have to put that on each one?*

**TF:** I did say that what is in red is what goes on the form.

**User:** *So where is that current therapy. How do you get that on the form?*

**TF:** I'll leave it to you to find out.....The next time you go in, see if you can.....

**User:** *If it's not obvious, just let us know. Include therapy*

Finds button.

*Ah, it is easy. What's the Note then?*

Points at *Note* button.

*If you want to write something extra, a Query.*

Points at *Query* button.

**TF:** If you want to enter a query.

**User:** *It's just the way to write more on the form.*

User selects *Include Therapy* to show the two therapies that he has recently entered.

**TF:** What is red goes on the form.

**User:** *So how do I get that on there then? That's not in red.*

**TF:** See if you can work out what to do.

User scans over *Telephone* and *Outlier* buttons.

**TF:** So how do you select a test from the main list?

**User:** *Oh, you have to click on them again. Selects both therapies from list. That's a waste of time to be honest. If they're on it, you just want it on the form. You might, that's er, I mean you know, Include Therapy, you might as well just put it on, just like in here. I could just write it in there (points to list of therapies), apart from you can click on it it's quicker. I think that, if you're still in the changing process, that's something that could easily.....you might as well just put it on if you're typing it in. It implies you want it on.*

There is a clear problem with the inclusion of the current therapy. The user expects that any information that they include in the patient details will be printed. This would be a sensible amendment to the system. The origin of the fault lies in a very early idea that all of the drugs that the patient was receiving would form part of the patient record that the system would draw from. Only a few of these would be relevant to any particular test request. Thus a menu system was devised for the inclusion of the current therapy. However, the limited nature of the prototype obviated the need for such a system.

## Breakdown 6

**Transaction No:** 95  
**Doctor:** RW  
**Transaction Type:** Add patient + Request.  
**Breakdown:** Inclusion of current therapy with clinical details.  
**Description:**

User enters a new patient, including two current therapies. She proceeds to order tests. When asked, she confirms that it was her intention to report the therapies on the form.

TF: They're not going on at the moment.

User: Oh, it doesn't matter. Oh, they should be.

TF: If you want it on, can you see what you have to do?

User: Em, Include Therapy.

User selects *Include Therapy*.

TF: Can you see how to put them on?

User clicks on the two list items.

This echoes the breakdown and its causes described in transaction 63 above.

### Breakdown 7

Transaction No: 121

Doctor: AM

Transaction Type: Request

Breakdown Change clinical details.

#### Description:

User clicks in *Working Diagnosis* field in order to make an amendment.

User: Now how do you change that? I know. Change Details.

Selects *Change Details*. Then uses *Query* button, before changing mode (by selection of *Save details*), and using *Query* button again to enter a query. Confirmed that his intention was to add a temporary note with that request only.

The disparity between the designer's view and the user's view of the task are evident in this breakdown. The user wishes to add a query, but regards this as a simple appendage to the working diagnosis. The designer's view is more structured, and the system forces the user to employ a construct (the *query* as a separate entity) that is alien to the doctor. Furthermore, the modality of the system forces a second breakdown; the user attempts to edit a read-only field, which initiates the other breakdown.

A solution to both of these problems would be to leave the text fields permanently editable, with a prompt to save changes given in the event of any editing, or to replace the *Query* and *Note* buttons with an explicit *Temporary Note* text field.

### Breakdown 8

Transaction No: 123

Doctor: AF

Transaction Type: Request

Breakdown: Problem with proceeding to next patient.

#### Description:

User selects test, then sets date for *Tomorrow*. He then re-selects the test from the menu, intending to order for another day ahead, in actuality de-selecting the test. He then selects *Set Date/Time* again, and notices that the previously set date disappears:

User: Has it just cancelled that Tomorrow when I ordered it?

TF: It doesn't store them up.

User: You've got to print it every time?

TF: Yes.

User resets date for tomorrow. He fails to notice that he has deselected the test. He selects *Print Request*, and obtains *No tests have been requested* message.

User: *No tests have been requested. What's that mean?*

Clicks *OK*. Re-selects test. Then sets date again, even though it is showing the required date. Proceeds to completion satisfactorily.

This is the same user as in transaction 43, with a similar cause of breakdown. The user assumes that the system will store requests up, and print as a batch for all patients. In this particular case, amending the system to allow for batch ordering for several days ahead should prevent this.

## 6.4 Analysis of the questionnaire

Replies to the questionnaire were received from four out of the six doctors who participated in the evaluation. Table 6.8 shows the individual scores for each question, from each respondent, grouped according to item pairs. Table 6.9 shows the overall scores for the individual questionnaire items. It can be seen that, in general, there was agreement with the items in support of the assertions, and there was disagreement with those items that negated the assertions. Usually, as in the case of item pairs 1,2,5,6,7,8,12,13 and 14, there was a close match between the degree of agreement and disagreement. Item pairs 3 and 4 showed the same pattern with a less even balance. Item pairs 10 and 11 showed strong agreement, but lacked a correspondingly strong disagreement, whilst item pair 9 seemed to generate little collective

Item pair	AF	LW	AM	SW
1	1,-1	1,-1	1,0	1,-1
2	1,-1	1,0	1,-1	1,-1
3	1,-1	2,-1	2,-2	<i>1,2</i>
4	1,-1	<i>2,1</i>	1,-1	1,-1
5	2,-2	2,-1	1,-1	1,-2
6	1,-2	1,-1	1,-1	1,-1
7	2,-2	1,0	<i>-1,-2</i>	<i>1,1</i>
8	2,-2	2,-1	1,-1	1,-1
9	-2,2	2,-1	1,0	1,-1
10	<i>2,2</i>	<i>2,1</i>	1,-1	1,-1
11	-1,2	<i>2,2</i>	-1,0	<i>1,2</i>
12	<i>-2,0</i>	-1,0	0,1	<i>1,1</i>
13	2,-2	2,-1	1,-1	1,-1
14	-1,0	1,-1	1,0	1,-1
15	-1,1	<i>1,2</i>	<i>1,1</i>	<i>1,1</i>

Table 6.8 Individual responses grouped per item pair. The first of each pair of scores is for the item that supports the assertion. Contradictory response pairs, i.e. scores that are not opposite, are in italics.

	Item pair	Score
1	I know where to look to find particular information.	4
1'	The general layout bears little relation to how I request tests.	-3
2	Related types of information are clearly grouped together.	4
2'	The general layout of the screens could be more logical.	-3
3	I have no problem going from one part of the task to another.	6
3'	I have to move the mouse around too much to make a request.	-2
4	It is good that all the desired tests can be requested at one go.	5
4'	I would like more control in the printing of each individual form	-2
5	It is good that the system allows ordering for only one date at a time.	-6
5'	I often order the same batch of tests for several days ahead.	6
6	The more common the test, the easier it is to select.	4
6'	I have difficulty finding the most common investigations.	-5
7	I agree with the order in which the tests have been placed.	3
7'	I would prefer all the tests to be in straight alphabetical order.	-3
8	It is important to be able to order tests in advance of the date required.	6
8'	I prefer to write my request forms on the day the sample is to be taken.	-5
9	Sometimes it is required that the sample collection time be stipulated.	2
9'	There is no need for a facility for setting the time as well as the date.	0
10	It is convenient to print the working diagnosis with each request.	6
10'	A patient's clinical details change frequently.	1
11	My priority with clinical details is that they should take little effort to report.	6
11'	I want to be able to report different clinical details to different labs.	1
12	The system should allow me to enter more than a working diagnosis.	-2
12'	The row of buttons below the working diagnosis is not useful.	2
13	I think the labs would be satisfied with the patient data this gives.	6
13'	There are too many patient details displayed.	-5
14	This system allows me the flexibility to do things in the order I want.	2
14'	It is confusing that I am allowed to select the tests before the patient.	-2
15	The computer makes form filling less repetitive.	2
15'	Little effort is required once the patient has been selected.	5

Table 6.9 Individual item scores, obtained by totalling individual questionnaire responses

	Assertion	Score
1	The overall design is consistent with the identified (3 node) task structure	7
2	The layout corresponds to the 3 top level nodes in the original TDH	7
3	The implementation is a good application of the identified task structure	8
4	The notion of a transaction as the unit task is desirable.	7
5	There is no need for batch ordering of tests.	-12
6	The TA has correctly identified the most common tests	9
7	The TA has correctly prioritised the tests.	6
8	There is a perceived need to order tests in advance.	11
9	There is a perceived need to stipulate the sample time.	2
10	The working diagnosis should be the default clinical detail.	5
11	There is a valid trade-off between ease of reporting and relevance of clinical details.	5
12	The analysis of clinical detail reporting has revealed the task structure.	-4
13	There is a necessity for the labs to have full details	11
14	TA accurately identified the elevated importance of test selection in the task sequence.	4
15	The TA correctly identified what could be automated.	7

Table 6.10 Assertion scores, obtained from totals of adjusted item pairs scores

opinion amongst the respondents. Finally, item pair 15 produced two positive responses, an inconsistency suggestive of a poor, non-antithetical pairing.

The scores shown in Table 6.10 indicate general agreement with the assertions, with a small number of notable exceptions. With the maximum possible score being 16, it can be seen that there was strong approval for both the amount of data included in the system (assertion 13), and of the facility for ordering tests in advance (assertion 8). Only two assertions were opposed: assertion 5, regarding the omission of a batch ordering facility, was strongly opposed, whilst there was less intense disagreement with assertion 12. This latter case was of interest, because it revealed a discrepancy between the supposed task structure underlying the reporting of the clinical details and the perception of the task by the users; this will be returned to later. It should also be noted that some of the scores should be viewed with caution with respect to reservations about the item pairings described earlier, particularly for assertion 15.

#### **6.4.1 Contradictory responses**

##### Item pair 3:

*I have no problem going from one part of the task to another.*

*I have to move the mouse around too much to make a request.*

Doctor SW stated a problem with ordering ahead. His main use of the system was for batch ordering, when he did several days' tests at a time for his patients. His criticism of the ordering ahead function was expressed in terms of the excessive movement of the mouse that this required.

##### Item pair 4:

*It is good that all the desired tests can be requested at one go.*

*I would like more control in the printing of each individual form.*

One doctor expressed a desire for more control in the printing of forms, which was inconsistent with the other replies from the other doctors. The reason for this has not become clear.

##### Item pair 7:

*I agree with the order in which the tests have been placed.*

*I would prefer all the tests to be in straight alphabetical order.*

The responses from Dr SW are inconsistent, in that he both agrees with the ordering of the tests, but would prefer them to be alphabetically listed. Dr AM was able to clarify his responses verbally, in that his disagreement with the ordering was based on two very common tests being low down the ranking.

Item pair 10:

*It is convenient to print the working diagnosis with each request.*

*A patient's clinical details change frequently.*

There was a difference of opinion between the clinicians here: Doctors AF and LW agreed with both items in the pair, whilst AM and SW replied that the clinical details do not change frequently. Whilst the inconsistency in the replies may partly have been a reflection of the inexperience of the respondents, it is more likely that its cause lay in the fact that the items were not antithetical to each other.

Item pair 11:

*My priority with clinical details is that they should take little effort to report.*

*I want to be able to report different clinical details to different labs.*

Again, two doctors agreed with both items in the pair; this is probably another example of a poor pairing, as agreement with both statements does not present a conflict.

Item pair 12:

*The system should allow me to enter more than a working diagnosis.*

*The row of buttons below the working diagnosis is not useful.*

There seemed to be a general ambivalence about the buttons associated with the working diagnosis. Use of these objects was very rare, so that, perhaps, no strong opinions had been formed. It is clear that there seemed to be a consensus against the entry of more than a working diagnosis.

Item pair 15:

*The computer makes form filling less repetitive.*

*Little effort is required once the patient has been selected.*

Three doctors agreed with both statements. This is the worst case of a poor item pairing. By replacing "little effort" with "considerable effort", the pairing would have been improved.

## 6.5 Software Log Analysis

Analysis of the software log was carried out with respect to the frequencies with which the different tests were ordered, the combinations of tests ordered, and the number of tests and printed forms per transaction. Comparison could then be made with the corresponding findings from the original data collection. The log contained a record of all of the requests made using the system, including those not video recorded. (Some additional

data were taken from the video record, transactions 33-41, because this part of the log was lost following a system crash.)

### 6.5.1 Test frequencies

A major discrepancy was revealed between the test frequencies observed in the analysis and those observed in the use of the system. Both the analysis and the supplementary data collection (see Appendix D1) gave strong indications that the combination of FBC and U&E would be the predominant choices. Although these two were still commonly requested using the prototype, two other tests, INR and KCCT, both alone and in combination, were also heavily requested, as shown in Tables 6.11 and 6.12. Even disregarding the INR and KCCT, the proportion of transactions containing the FBC & UE combination was reduced from a half to just above one third. A wide variety of other tests made up this shortfall, usually in combination with either an FBC or a UE.

Test	Frequency	Percentage
UE	84	24.3
INR	75	21.7
KCCT	56	16.2
FBC	47	13.6
Other, major list	70	20.2
Other, minor list	14	4.0
TOTAL	346	100.0

Table 6.11 Frequencies of tests requested

Transaction contains:	Frequency	Percentage
UE (without FBC)	36	27.9
FBC & UE	29	22.5
INR & KCCT	22	17.1
INR (without KCCT)	17	13.2
FBC (without UE)	13	10.1
Other combinations	11	8.5
KCCT (without INR)	8	6.2

Table 6.12 Combinations of tests requested

### 6.5.2 Transactions

A distinction should be drawn here between the transaction as it was first defined in Chapter 3, and the transaction as it appeared in the use of the system. The original definition was that a transaction comprised a request for any number of tests for a patient. In the evaluation, a transaction has been taken as the collection of events between the selection of a patient and the printing of the required request forms (or the selection of the next patient if the transaction was of a list maintenance type). This divergence is due to the implementation of the *Set date* function, which required re-selection of the patient for each new date. As Table 6.13 shows, this distinction has a major bearing on any assessment of the users' interaction with the prototype. Henceforth, the original form will be termed the *logical* transaction, and the implemented form will be termed the *prototype* transaction. Thus:

**Logical transaction:** any number of test requests for a patient made at a given time.

**Prototype transactions:** the set of events between patient (or test if earlier) selection and printing of the request forms.

Tests per prototype transaction	Transactions	%	Tests per logical transaction	Transactions	%
1	81	42.4	1	35	27.6
2	88	46.1	2	43	33.9
3	7	3.7	3	12	9.4
4	8	4.2	4	16	12.6
5	4	2.1	5	4	3.1
6	0	0.0	6	11	8.7
7	2	1.0	7	2	1.6
8	0	0.0	8	2	1.6
9	0	0.0	9	1	0.8
10	1	0.5	10	1	0.8
TOTAL	191	100	TOTAL	127	100

Table 6.13 Number of tests requested per prototype and logical transaction.

As would be expected, the number of tests per prototype transaction was more skewed towards the lower end, with only 11% of transactions comprising more than two tests. A different perspective is given by the distribution for the logical transactions, with approximately 40% of tests being ordered in transactions of three or more. When comparisons of the prototype transaction figures are made with the original analysis, some similarities become evident. For example, 43% of the originally observed transactions consisted of one test only, compared with 42% for the prototype transactions; 80% of the original transactions contained one or two tests, compared with 88% for the prototype transactions. Comparison with the logical transactions is less favourable, although this is to be expected as the analysis revealed only one transaction that involved a batch order.

Forms per prototype transaction	Frequency	%
1	152	77.2
2	39	19.8
3	5	2.5
4	0	0.0
5	1	0.5
6	0	0
TOTAL	197	100.0

Table 6.14 Number of forms per prototype transaction.

Forms per logical transaction	Frequency	%
1	54	42.5
2	43	33.9
3	18	14.2
4	8	6.3
5	2	1.6
6	2	1.6
TOTAL	127	100.0

Table 6.15 Number of forms per logical transaction.

In Table 6.14, it can be seen that the number of forms per prototype transaction is generally very low: transactions involved a single form on 77% of all occasions. When batch ordering is considered (Table 6.15), a very different picture emerges. There was a large number of logical transactions

involving multiple forms, with about one quarter consisting of more than two forms, and an important minority (nearly 10%) containing four or more. This latter distribution tallies more closely with the findings of the analysis than the distribution shown in Table 6.14. The heavy skew towards single form prototype transactions, and the disparity with the findings of the analysis, is largely accounted for by the frequency of requests for the INR and KCCT. These two tests are performed by the same laboratory and thus are entered on a single form. Requests for these tests, separately and in combination, accounted for 15% of all the single form logical transactions, and 38% of all single form prototype transactions.

### **6.5.3 Task completion times**

The software log recorded the time that elapsed between the selection of the patient and the re-appearance of the patient list on the VDU screen. This time therefore included the period required by the system to transmit data to the printer. Excluded from this value was the time taken by the user to gather and sign the forms, and any period spent waiting at the printer. It proved impossible to measure these latter times consistently, as occasionally the user would be working on the next request while printing took place, or did not sign the forms at all, or would be in discussion with a colleague and thus extend the procedure. A few measurements were attempted early in the trial period, and these times are given as a guide to the variety of typical values.

Appendix C5 shows the average time taken per form completed. It was considered that this would be the most useful measurement to compare against the manual system. A selection of times for prototype transactions was used to calculate the mean. Early transactions were not included because, if there were a learning effect over time, (although the statistical analysis suggested that there was not) comparison with more 'expert' performance would be more valid. Also, transactions that included the addition of a new patient were excluded. The resulting average was taken from the last 91 request-only transactions. Manual completion times were measured using a stopwatch in the days immediately prior to the trial period, using the same doctors as subjects.

The mean task completion time using the prototype was 27.9 seconds, and for the manual system, it was 30.9 seconds. No statistical significance was found for this difference; the outcome of a Student's t-Test comparing these two means gave a value for  $t$  of 0.06 (with 128 df). Considering the exclusion of the printing and signing times from the prototype timings, it can

be said with some certainty that using the system did not proffer any savings in time.

## **6.6 Formative evaluation: the usability of the prototype**

The findings of the evaluation are now related back to the aims described in section 5.3.1. This first discussion will concentrate on the usability of the prototype with reference to its nature as a system for further development. Following this, the next section takes a summative perspective, containing a discussion of the impact of TAKD on the design.

Various criteria were identified in section 5.3.1 as being important measures of the usability in the context of this work. In particular, these were its *effectiveness* and *learnability*. The degree of achievement of these goals is now considered in the light of the analysis of the results given above.

### **6.6.1 Effectiveness**

Three facets of effectiveness relevant to the prototype were given earlier. These were the time taken to perform the task, the completeness of the forms, and the clarity of the forms. There will be no reference to the last of these, the clarity of the forms, as the achievement of this goal is self evident. It is worth recording anecdotally that all of the users expressed satisfaction with the presentation of the printed forms, and more objectively, that the ward sister received an unsolicited telephone call from the coagulation laboratory receptionists commenting on the excellent legibility of the forms arriving from ward P1, the trial ward. Calls of this sort were not commonplace, and thus it may be taken that the computer-generated forms were, at the least, of a considerably higher standard of legibility than normal.

#### **6.6.1.1 Time**

A simple conclusion to draw is that the prototype did not succeed in making any time savings over the paper system. It would be facile, though also partly true, to suggest that much of the lack of speed of the prototype was due to factors outside the scope of the project, such as the speed of the printer, or the particular efficiency of the software used in the implementation of the design. However, from the user's perspective, the time factor is absolutely critical, and this issue needs to be examined.

Whilst it is clear that the prototype was far slower than might have been hoped, the task timings should not be taken at face value only. Most of the users expressed doubts that the system would produce time savings given

its existing design, (but still found it effective enough to continue to use it). It is necessary here to explore the reasons why there was a failure in this respect, and to offer suggestions for improvement. Firstly, it is necessary to account for those factors which lie outside the scope of this discussion:

- Selection of a graphical design environment with an interpreted underlying language immediately imposed a time penalty that can be discounted.
- The decision to design a system that *printed* request forms as opposed to producing some other transactional representation incurred time costs, given the notorious slowness of printing documents.
- Other peripheral devices, such as bar code generators, were not considered.

Many sources of evidence point to a problem with the design of the menu for the selection of less common tests (*minor list*). The extended times spent by the users searching for these tests account for the high value for the *minor list* task quotient, and also must have been influential in deciding the statistical significance of Task Type as a predictor of task time. However, the minor list was little used, (in itself a positive outcome), and the overall time problem cannot be attributed to a difficulty with this infrequently used function.

Selection of the vast majority of tests presented few problems, although two sources of delay deserve consideration. Firstly, there was Breakdown 3, caused by the inconsistency in the representation of the tests available for selection. As outlined in the discussion following the description of the breakdown, this problem may have been attributable to the inaccuracy of the original data collection, so that the user had selected many tests before arriving at the need to make what was expected to be an extremely common choice. Two options present themselves for re-design:

- i) Moving the principal test buttons to the right, so that they head a continuous column of test choices. This would require a change in the feedback given to confirm selection of those tests.
- ii) Lowering the status of the principal tests, thereby incorporating them into the major list. This would entail deletion of the FBC & U&E option. An effect of this would be the removal of the cue that this button offers about the multiple form printing capability of the system. However, Critical Incident 3, where the user printed and re-selected as many times as there

were forms to print, shows that this cue may not have been as effective as it was intended.

Whilst the selection of tests was not in the main a lengthy process, particularly as experience was gained, the system did introduce a new time-consuming behaviour to the task. Visible lists of tests permitted the user to engage in browsing activity, (Task Type *consider investigation*), taking up 10% of all the interaction time. Although it cannot be assumed that an equivalent mental activity was not undertaken by doctors completing forms by hand, there was no evidence for this. It is most likely that any such mental browsing is very unusual, as doctors appear to initiate a request for a patient with particular investigations in mind, and will, using the paper system, simply write down those that are required. In contrast, the computer displays choices that might not otherwise come to mind. In this way, this use of the computer not only incurs a time penalty, but more importantly changes the nature of the task itself.

Patient selection, occupying nearly 14% of the interaction time, and with a rather high task quotient of 1.24 (Table 6.2), must be seen as compromising the effectiveness of the prototype. All of the users volunteered the opinion that the patient list should be arranged alphabetically. Some selection times were well below 2 seconds, but the frequent occurrence of selection times of over 10 seconds indicated the need for the interface to contain other cues for the occasions when the position of the patient in the list was unknown to the doctor.

The second most time-consuming aspect of issuing requests was the use of the *order ahead* function (17.9% of the total time). Its corresponding task quotient was only slightly raised at 0.91, indicating that the task was not particularly time consuming for the number of actions involved in carrying it out. Some problems were encountered with the use of the *Date/Time* facility, notably on the occasions described in Breakdowns 2,4 and 8, although these were in part attributable to the users' view of a transaction differing from the designer's, rather than to the design of the function itself. A simpler method for setting a date would have been beneficial, and would also have reduced the overall task time somewhat. However, the crucial respect with which the date function failed was in its dislocation from the concept of the transaction. Had the system been capable of multiple-date transactions, then the time saving potential of computerisation would have been far better realised. The transaction log recorded that multiple dates were involved in 30% of all the logical transactions, and in a very significant 51% of all the prototype

transactions. With a greatly streamlined procedure for ordering ahead, the average time per form would be very significantly reduced.

#### **6.6.1.2 Completeness**

Table 1 in Appendix D1 shows that there was a very substantial proportion of hand-written request forms which were incomplete, with an omission in 68% of all the requests. It should not be assumed that the prototype completely alleviated this problem, as it did not attempt to force the user to enter a complete set of data for each patient. Comparison of the patient details with the transaction log reveals that 24 prototype transactions were incomplete, an omission rate of 12%. In every case, the patient's date of birth was the absent data item. This would be largely alleviated if the system were connected to the PAS, as any demographic data not entered by the user could be inserted by the existence of such a link.

The automatic inclusion of the doctor's name and bleep number must be seen as a great improvement in the requesting process. There was a high rate of omission of the doctor name in the manual system, with the signature alone often acting as the identifier for the requesting clinician. Although this could suffice provided the handwriting were sufficiently legible, problems would be bound to arise. As regards the doctor's bleep number, the reduction in its omission rate from 10% to zero is an obvious and significant improvement.

A large proportion of the manual forms lacked a sample type, although most of these were on haematology forms, where the sample type is exclusively venous blood (indeed the Northern General haematology forms do not have a field for this information). However, the rate of omission of the sample type on the clinical chemistry forms, where it is critical, was high enough at 7% to warrant improvement, and again, the prototype reduced this omission rate to zero.

Finally, the prototype brought about a significant improvement in the inclusion of clinical details, which were omitted in over 13% of hand-written forms. This is not to say that there was any improvement in the quality of the information communicated to the laboratories in this respect, and this issue has not been explored.

It can be concluded from these comparisons that the system was very successful in achieving this aspect of effectiveness.

#### **6.6.2 Learnability**

The stated learnability goal was to achieve error free performance at first use. Although this may be considered to have been unrealistic, it is

necessary to see to what extent it was achieved, and how the system should be changed to improve on it.

The statistical analysis provided some evidence about the learnability of the system. Tables 6.3 and 6.4 showed that there was no significant improvement in performance times with *doctor occasion*, and that performances did not improve throughout a sequence of prototype transactions, i.e. from the beginning to the end of a logical transaction. This indicates that there was little learning requirement for the various sub-tasks, and that, once carried out, experience did not confer noticeable improvements in performance. Of course, this is something of a simplification; most of the critical incidents and breakdowns reported earlier were rarely repeated because the users' comprehension of the system was changed by their experience. It is possible that had the complete video record been used as input to the statistical analysis, then learning effects may have become more apparent. However, the evidence available shows that in some respects, the prototype did permit error free performance on first use. Selection of the patients and tests was performed well and with few problems. The notable exception to this was Breakdown 3, concerning one user's misapprehension about the principal test buttons. This was not unexpected, as the representation of the principal test selections was inconsistent with the representation of the other tests. Indeed, the fact that Breakdown 3 was a unique occurrence may testify to the appropriateness of the design decision to treat these tests as a special case.

Some problems with the use of the prototype showed little improvement with time. Selection of tests from the minor list provides the best example of this. These tests were difficult to select regardless of the user's experience with the rest of the system, as the infrequency with which the minor list menu was required made it difficult for them to become proficient in its use.

Reporting the current therapy and working diagnosis did present some learnability problems. In transaction 81, the single clinical detail reported was a drug therapy entered as the working diagnosis. The user employed a strategy which for him, simplified the task, but which as far as the system was concerned, was sub-optimal. In a complex case, such a strategy would result in more work for the user. A second problem with this component of the prototype was demonstrated in Breakdowns 5 and 6. Here, the users entered current therapies as part of the data for a new patient, but then had to reselect those therapies to ensure that they were included with the request. This represents a breakdown in the predictability of the system, in that for all other patient data entered onto the system, there was no requirement for such

reselection. Thus the user could justifiably have predicted that entry of the current therapy should also be required only once.

As well as causing usability problems in the context of effectiveness, the different conceptions of a transaction also impacted on the learnability of the prototype. This was especially noticeable in the case of doctor AF, who repeatedly had trouble with proceeding on to a following request (illustrated in Breakdowns 1, 2 and 8). Despite completing the task successfully after each breakdown, this particular user's model of the system was not sufficiently refined by his experiences to cope with the same problem in slightly different contexts. Learnability problems caused by the definition of a transaction were also displayed by doctor RH (Critical Incident 3), in that she repeatedly re-selected the patient for as many times as she needed different request forms. This problem may be interpreted as a failure on the designer's part to convey an accurate device model to the user (Kieras and Bovair, 1990) or to employ the terms of the Yoked State Space hypothesis (Payne 1991): there was a poor semantic mapping between the user's *goal space* (the transactions to be performed) and the *device space* (what is offered by the system to achieve the goal).

The previous two paragraphs illustrate a particular design problem in coping with a diversity of users. Doctor AF held a model of the system that had a broad scope, with the notion of a logical transaction taken to its extreme. Doctor RH's model was the opposite, in that she expected the system to do little more than act as a typewriter. The solution would be for the interface to afford, in the sense used by Norman (1988), the concept of a transaction held by the system.

## **6.7 Summative evaluation - the impact of TAKD on the design**

This next discussion will draw on evidence taken from several sources in order to ascertain the extent of the contribution of TAKD to the design of the prototype. Firstly, a mapping between the task performed manually and performed using the system will be presented. Secondly, the findings of the analysis of the questionnaire will be considered both alone and in the light of evidence from the wider spectrum of results.

### **6.7.1 TDH mapping**

As described in section 5.6.3, the final TDH used in the analysis formed the basis of the TDH used in the evaluation. In specific terms, the transformation was carried out as follows:

1. Removal of nodes relating to the previous system only:  
Excision of nodes referring to number of tests or number of forms.  
Removal of those nodes referring to data subsequently entered automatically by the system, namely patient details, doctor details, date and specimen.
2. Amendment of the children of remaining nodes to reflect the new structure of remaining sub-tasks:  
Simplification of sub-hierarchies describing combinations of tests, and reporting of clinical details.  
Addition of low level nodes describing search and consideration behaviour for tests, patients and clinical details.  
Addition of intermediate level nodes for ordering ahead and for special case requests.
3. Addition of high level nodes relating to entirely new sub-tasks:  
High level nodes relating to list maintenance, system login and printing.

A detailed mapping of the new task onto the old one is a fragmentary exercise, because the detailed structure of the task is considerably altered by computerisation. However, at the generic level, a direct mapping is much more obvious. This is to be expected if the fundamental task structure has indeed been carried forward to the design. Mappings between the two TDHs are evident as an occurrence of high level generic KRGs in both the original KRG sentences and in the evaluation TDH.

Three examples can be used to illustrate this mapping. Table 6.15 shows three generic KRGs that exist in both the original and prototype TDHs. In all of the examples, the mapping has been achieved after excision of the intermediate nodes *single test*, *multiple test*, *single form*, *multiple form* from the original TDH. This is justified because the mapping is essentially a logical one between tasks, and should not be seen to be rigidly dependent on one TDH. Different TDHs give different perspectives on the same task, although all may be valid. It is to be remembered that more than one TDH contributed to the analysis. Removal of the nodes described above effectively eliminates from the TDH the device dependency that their inclusion implies, and returns to the view of the task that was given by the first pass TDH, in which the highest level nodes were *state*, *report* and *request*. Example 1, the generic KRG *Request/General* is logically the *Fill in/State* high level KRG from this earlier TDH.

High Level Generic KRG	Frequency in manual system	Frequency in prototype
1 Request/General	53%	11%
2 Request/Specific/Report	15%	5%
3 Request/Specific/Investigation	13%	31%

Table 6.15 Frequencies of generic KRGs common to manual and computerised task

The mappings become useful when they are applied in a comparison of the performance of the task in its two forms. The frequency difference in example 1 indicates the effect of automating entry of the patient details, whereby in the prototype this sub-task is reduced to selection from a list. In the analysis, it was identified that a large part of the task was not specific to the request, and this general data entry could be automated. Given that the prototype was substantially effective in reducing the amount of general data entry, but did not lead to the production of incomplete or unclear request forms, it can be asserted that, in this respect, TAKD has been successful in leading to a usable design.

Example 2 shows a substantial reduction in frequency of the common KRG for reporting clinical details. In fact, there is a distorting effect because the activity list for the evaluation contained requests for a large proportion of pre-admitted patients, as described in Chapter 4. In later transactions, the entry of clinical details was confined to the period when the patient was first entered onto the system, and not at request time. Thus, regarding requests for patients with previously entered clinical details, the actual reduction in the frequency of this KRG was probably even greater. This mapping, and the reduction in sub-task frequency it has been used to show, further indicate the success of the analysis in leading to a usable design. However, this claim must be tempered by the fact that the burden of reporting the clinical details tends to occur when the patient is first added to the system, which has not been fully evaluated here.

Example 3 shows the mapping for test selection. A simplified hierarchy for test selection was carried over from the analysis into the new TDH, reflecting the simplified task structure conferred by the incorporation of the notion of a transaction into the system. From the resulting mapping, it can be seen that the proportion of the task taken up by requesting tests has increased from 13% to 31%. Unlike in the other two examples, where a reduction in frequency of the common generic KRGs is taken as a benefit, here it is an increase which is indicative of success: use of the prototype concentrates the effort of the user more onto the principal goal, which is the requesting of specific investigations.

It is possible to use the common generic KRGs to produce an overall measure of the contribution of TAKD to the design. The sum of the

frequencies of these KRGs provides a simple metric which indicates how much of the prototype is derived from the analysis, and will be referred to here as the TA contribution. This TA contribution, (which here of course excludes all list maintenance activity), comes to approximately 47% ( the remaining 53% being taken up largely with printing and ordering ahead). This is not a hard measure, but is dependent on the view of the task that is taken; this applies throughout the application of TAKD, from the selection of the degree of granularity in the construction of the activity list, through the construction of the TDH, and on to the process of producing the mappings that led to the generation of the metric itself. However, the TA contribution has value as a focal point for reasoning about and assessing the impact of design choices and refinements. If the contention that task analysis leads to more usable designs is true, then a high value for the TA contribution should be reflected in the usability of the system. One part of the prototype that has been exposed as poor is the *ordering ahead* function. If the usability of this function were improved by simplifying it as suggested earlier, then there would be a considerable reduction its share of the total activity. This would bring about a concomitant increase in the TA contribution; thus a raised TA contribution would be indicative of a more usable design.

## **6.7.2 Interpretation of the questionnaire**

In contrast to the preceding section which sought evidence for the impact of TAKD from observations of the users' behaviour, here it is the users' opinions that are interpreted for the same purpose. Reference is made to Table 6.10 and to the subsequent comments on the contradictory responses.

The questionnaire gives support to the claim, embodied in the mappings described in the previous section, that TAKD has made a positive contribution at the general level. It also reveals that the task analytic approach has shortcomings in particular respects to design at the more detailed level. These points will now be elaborated.

### **6.7.2.1 General structure of the prototype**

Firstly, the scores for assertions 1, 2 and 3 indicate good support for the overall layout and structure of the interface. There is a fine distinction between these three assertions, the second referring most closely to the physical layout of the screens, the third being more concerned with sequence, with the first being intended to be the most general. In all three cases, there was sufficient agreement from the users to be able to make the claim that task analysis made a positive impact on the design, in that it

directed the prototype towards a design which separated the interaction into components according to the general task structure described in the first pass TDH. There was a similar degree of support manifested for assertion 4, concerning the decision to base the interaction on the concept of a transaction. As reported in section 3.5.2 this decision was an outcome of the application of TAKD, and, while the actual implementation of this concept was flawed (in its omission of a batch ordering facility), the wording of assertion 4 was such that the responses related to the concept and not to the implementation.

#### **6.7.2.2 Entry of the patient details**

A satisfactory degree of automation of the entry of the patient details was achieved from the application of TAKD. This was evident in the scores for assertions 13 and 15. (Despite the poor item pairing for assertion 15 as reported in the subsequent commentary, the responses to the relevant questions themselves lend a small degree of support.) Here, a positive impact on the design was made not only by TAKD in the narrow sense, but by the broader task analysis process, in that the requirements of the laboratories for accurate and complete data were gleaned in the early stages of analysis that are essential for the definition of its purpose and scope.

#### **6.7.2.3 Test selection**

TAKD had limited, but not insignificant, success in the identification of the priorities for the selection of tests. This limitation owed much to insufficiencies in the data collection. In particular, there was the oversight of the coagulation laboratory, which is the destination of requests for the INR and KCCT tests that were so commonly requested using the prototype. (The absence of these in the original data collection, and the oversight of the laboratory, constituted a problem which will be addressed in the next chapter). Support for assertion 7, concerning the prioritisation of the tests, was weakened by this problem, although the users actually had little difficulty finding the commonest tests, as the strong support for assertion 6 indicates. Indeed, the user who was the subject of Breakdown 3, in which one of the principal test buttons was not recognised as selectable, was the most supportive of assertion 6, agreeing strongly that the most common tests were easy to locate (see Table 6.8).

Insights gained during the task analysis about the sequence of sub-tasks proved effective with respect to the priority given to the selection of tests. There was support for the decision to allow test selections to be made before identification of the patient in the responses given regarding assertion

14. However, the degree of approval was only slight (assertion score of 4), and in practice, the patient was almost invariably selected before any tests. On the occasions when this was not the case, the use of the system was sub-optimal, (Critical Incident 3) or a breakdown had occurred (Breakdown 4). Nevertheless, in pointing out the elevated importance of test selection, the sequence findings were influential in arriving at the successful screen layout.

The main role of TAKD in the design of this part of the prototype has been in identifying the high frequency of selection of the principal tests, and more importantly, their occurrence in combinations with each other and with the less common investigations, forming the basis for the transaction concept. In order to produce an accurate ranking for the non-principal tests, the supplementary data collection was sufficient, with the exception explained earlier. Importantly, the least successful part of the test selection component of the prototype was the design of the minor list, to which the task analysis made no contribution. Here we see an example of how this analysis has had an impact at the general level of the design of the prototype, but much less so at the detailed level.

#### 6.7.2.4 Ordering ahead

As the questionnaire was not devised until the first few days of the prototype trial, it was possible to use it to investigate behaviour that had not been expected. In this way, the revelation that the doctors were making heavy use of the date setting facility formed the basis of assertions 5 and 8, regarding batch ordering and ordering ahead. These assertions produced the most emphatic scores, indicating a great desire for both of the facilities concerned. This is notable because of their absence from the specification of requirements for the prototype. Their omission owed much to two factors in the analysis. Firstly, it revealed no instances of batch ordering in which the date was set (although there was a single four-form transaction involving the specification of the blood sampling time). Secondly, on the occasions when a future date was stipulated, this was done in the evening in preparation for use on the following day. It was argued in Chapter 3 that this practice occurred primarily because, as form filling was so time consuming, doctors completed them during quiet periods before they were needed; it was then suggested that simplification of the requesting process would obviate such a practice. In actuality, this suggestion proved to be incorrect. The magnitude of the omission of an adequate batch ordering facility, and the likely improvement to the system of its inclusion, have been well covered. Criticism for this is due not to the efficacy of TAKD itself, but to the inadequacy of the data collection in two respects:

i) Whilst an indication of the need for batch ordering was present in the aforementioned transaction that involved the stipulation of the sample time, this single observation was treated as an exception. Sample times are associated with particular investigations, and this particular investigation (the ACTH level) was well below thirtieth in the rankings compiled from the supplementary data collection. The inclusion of a time setting facility in the prototype did not meet with universal agreement from the users, owing to its rarity (illustrated by the total disagreement with this assertion on the part of doctor AF, presumably because in his six months' experience he had not come across such a situation). A more comprehensive data collection would have given greater accuracy.

ii) Much of the input for the activity list came from a different hospital to that used in the trial. There is the possibility of cultural differences between the two that could have accounted for the discrepancy between the findings of the analysis and the use of the system, although no other differences of this importance were evident. However, even though some of the analysis was derived from observations in the same hospital as the trial, no batch ordering was seen. As with the previous criticism, a more extensive data collection should have revealed this behaviour.

#### **6.7.2.5 Reporting of clinical details**

Assertions 10, 11 and 12 were concerned with the reporting of clinical details. Whilst it is acknowledged that the item pairings for the former two assertions were not entirely satisfactory, some inferences may be drawn from the responses to the individual items. The impact of TAKD on the design of this part of the prototype appears to have been again at a general level, the problems with the clinical details being more implementationally based. There was approval for the inclusion of the working diagnosis with each request, while the doctors were not agreed upon the degree of changeability of this information. It is clear from that approval and from the use of the prototype, in which the working diagnosis was very rarely amended, that this aspect of the design was a success. Furthermore, the design decision to include the working diagnosis was a direct consequence of the application of TAKD and the KRG analysis as described in Chapter 3.

The users confirmed the findings from the observational study (Chapter 2) that reporting the clinical details was burdensome, however assertion 11, suggesting that the design held a valid trade-off between the relevance of the clinical details to different laboratories and their ease of reporting, was largely unproven because of its poor item pairing. It is very interesting to note that the users' response to the item suggesting that *'the*

*system should allow [the user] to enter more than a working diagnosis'* was a general disagreement, yet much use was made of the *Current Therapy* area in the prototype. The division of the clinical details into *working diagnosis* and *current therapy*, which was rooted in the analysis, did not in itself present problems, indicating the validity of the knowledge description for this part of the task. Users encountered severe difficulties however, not in adding a therapy to the patient record on entry to the system, but on reporting the therapy at request time. This required a process that was fairly complex, involving the explicit request on the user's part to include a therapy, and then selection from a list, unless only one therapy was extant, in which case this was added to the form without the need for selection. [In defence of this complexity, it must be said that the prototype was originally intended to be linked to a full patient record that would include a comprehensive patient drug regime, and that selection by the doctors from this list would be required.]

Central to this discussion is the issue of the *importance* of the sub-task to the users. It is entirely appropriate that the doctors should select the relevant therapy from a list of current therapies, as the laboratories should not be loaded with excess information. However, the effort required to report the current therapy outweighs the users' motivation in using the system fully. This is amply illustrated by three examples:

- i) Critical Incident 4 cites two transactions in which therapies were entered as the sole constituents of the working diagnosis field.
- ii) In Critical Incident 2, the user's attempt to record the current therapy was unsuccessful. However, this was not of sufficient importance for her to abandon the task; the omission was tolerated. She could indeed have recorded the data in the working diagnosis field, or added it later.
- iii) The user's comments during Breakdown 5, that inclusion of a therapy in the patient record can be taken as an assumption that the therapy is to be reported to the laboratories, indicate the low status of the clinical details. In the manual system, doctors do not report every drug a patient is taking, but only those that the laboratories need to know about, but here the doctor was happy to include all the drugs regardless of their relevance to the particular investigation. The user's priority was ease of input, rather than the relevance of the data.

Whilst it can be argued that TAKD successfully identified the knowledge structure associated with reporting the clinical details, it failed to identify the lack of importance of that knowledge to the users. It did not help to foresee that, despite making this structure explicit in the interface, the

users would ignore it in problematical or busy situations, or when there was no obvious working diagnosis. The analysis *could* have been directed at this aspect of the task, but this would have required taking yet another perspective. It is clearly impractical to analyse a task from every perspective, and here we see how this has had consequences for the user interaction. That the clinical details had a low priority was well understood as a result of the early observational work, but it was assumed that an accurate representation of the users' task knowledge in the interface would counteract this poor motivation. The fact that this was not the case shows that an accurate description of the task knowledge as provided by TAKD can only be a partial factor in attaining a usable system.

The reporting of the clinical details exemplifies how TAKD contributed to the design of the prototype in constraining the design, but not in specifying the detail of the implementation of the design. It set design constraints which dictated that the working diagnosis should be a default entry on all requests, and that the current therapy should be reported separately and optionally. It did not offer an indication of how exactly this should be implemented given the constraints.

## 6.8 Conclusion

The evidence presented here makes a good case for the assertion that the application of TAKD can lead to usable computer systems. It has been shown that it is possible to produce a mapping between the analysis and design, and that those parts of the system which most closely map onto the analysis exhibit a good degree of usability. Problems have been demonstrated in two areas. Firstly, the data collection that is both a precursor and a supplement to the task analysis needs to be thorough. Inadequacies here can have a major impact on the usability of the system. Secondly, the usefulness of task analysis has been shown to be limited in that it has not provided all of the information needed to produce a design. Its role has been successful in setting a series of design constraints, and in suggesting general structures and functional areas for the system.

## Chapter 7

### Task analysis in analysis and design

In the preceding chapters, an account has been given of the processes of analysis, design, implementation and evaluation. This has included measures of the influence of TAKD on the prototype and its usability. In this chapter, a more general view of the place of task analysis in the design of systems is taken in the light of the outcomes of the trial of the prototype. Firstly, the usefulness and role of TAKD itself and then task analysis as a whole are considered. Following this, the possible role of task analysis as an input to Design Rationale is suggested.

#### 7.1 Evaluation of TAKD in the analysis and design process

While the potential benefits of task analysis in interface design are well recognised, as described in Chapter 3, its applicability and usefulness are less widely accepted. Wallace and Anderson (1993), in reviewing different approaches to interface design, rank task analysis (as part of the *cognitive engineering* approach that they categorise) quite poorly against other, more practically based methods. Similarly, Benyon (1992) criticises task analysis for the device-dependency of its outcomes, asserting the advantages of the data modelling approach to design. However, the experience of the application of TAKD in the work reported in the previous chapters offers much support for its use.

##### 7.1.1 The effectiveness of TAKD

Task analysis does not provide the only means of producing a design specification. Indeed there is an abundance of systems analysis methodologies with this aim (see Avison and Fitzgerald (1988) for an overview, or Cutts (1987) for a detailed description of one methodology), and of course within the sphere of task analysis itself there are many approaches (see Wilson *et al*, 1988). What needs to be answered, with the help of the experience gained here, is how applicable is task analysis, and TAKD in particular, to the provision of design specifications in the healthcare environment, and how useful are the results of any such application?

Scrutiny of the design specification in Chapter 3 might lead one to suggest that such a list might easily have been derived from an informed but informal assessment of test requesting. It can be argued, however, that the task analysis was crucial in reaching the specification, and that the resulting design was inherently more usable. The task analysis gave substantial justification to the inclusion of each item in the list because of the process by which those items were arrived at. Moreover, that process also resulted in a clear understanding of the place of pathology investigations in the overall job of the ward doctor, thus strengthening the case for the presence of each item.

What proved most revealing was the process of conducting the analysis, central to this being the TDH construction and its interpretation. This can be illustrated with two examples:

i) The first pass TDH took a single request form as the base unit for the task, with the completion of various data fields as sub-tasks. When the KRG sentences were being related back to the activity list, a flaw in the analysis became apparent. The frequent occurrence of clinical conditions in pairs on different forms, most usually with the combination of FBC and U&E, was not reflected in any way in the KRGs. It was thus realised that a different view should be taken, which was to see a transaction as the base unit, in which requests are made per patient rather than per form. This refutes Benyon's assertion that task analysis is device dependent, because the analysis led to a view of the task that went beyond the device used by the doctors. This had major implications for the resulting design.

ii) A property of the clinical details considered during TDH construction was the relationship between those spread across multiple forms. It was thought logically possible that there would be instances when the forms in a transaction would contain distinct clinical details. On completion of the TDH it was discovered that this was not the case. This could have been because of an inadequate sample size, but the absence of such an occurrence over thirty two transactions indicated at the very least the rarity of such a case. Thus the process of producing the TDH was instrumental in a discovery that was of importance to the design, namely that the working diagnosis should be reported by default with each request, a decision that was amply supported in the subsequent evaluation.

The application of TAKD was most valuable in obtaining requirements that related to the general system. With respect to the automation of the entry of patient demographic data; it suggested what should and should not be included in the user interface. It also underlined problems in the existing system: by acting as a census for the frequencies with which different tests were requested, it was most useful in highlighting

the very repetitious nature of many parts of the requesting process. Doctors emphasised the time consuming nature of making requests, and the analysis produced measurements of the extent of the unnecessary repetitions in the task. This guided the design in that it stressed the importance of reducing repetitive actions. TAKD also revealed patterns in the reporting of clinical details, a sub-task considered as unnecessary by the doctors, but crucial to the effective service provided by the laboratories. Thus the task analysis was able to contribute to a simpler form of data entry for the users, while maintaining the usefulness of that data for its recipients.

### **7.1.2 Application of TAKD to other areas**

The wider applicability of TAKD was shown when the focus of the analysis moved from the medical to the surgical ward, as construction of the new TDH was a very straightforward matter. While this was partly a reflection of the similarity in task structure between the two wards, with only small adjustments being needed to cope with detail, it is reasonable to suppose that such adjustments could be extended to cope with other requesting systems, such as microbiology, radiology etc. Further data collection would be needed to make the analysis appropriate, but lessons learned in all the stages of the initial analysis would render further work easier to carry out.

In principle, the methodology could be applied to the range of information based activities on the ward, and further afield. Inexperienced people can be trained fairly quickly to perform TAKD, depending on the availability of the software toolkit. Other task analysis methodologies exist which may be carried out without such software support, but their power and expressiveness are diminished accordingly. A greater obstacle to effective analysis is the acquisition of the domain knowledge in the area of application. TAKD, perhaps more than some other analysis methods, requires that those who use it have considerable understanding of the task area and environment. Reaching this understanding is a perennial problem for the analyst, although it could be addressed by involving domain experts closely. (This is discussed further in the final chapter.) Despite such obstacles however, the user-centred basis of TAKD offers a stark contrast to the reductionist systems analysis methodologies which aim to describe and model function, data and data flows, and in doing so overlook the reasons why tasks are carried out as they are.

### 7.1.3 Limitations of TAKD

Despite the positive terms in which TAKD is discussed above, several problems did emerge during its application. The limitations of the method will be considered with particular respect to its ease of use. (Although a discussion of its limitations with respect to other task analysis methods would be useful, the discussion would have to be largely conjectural: because one learns most about a method during its practical application, and since no other methods were applied, such a discussion will not be attempted.)

The rationale given in Chapter 3 for the selection of TAKD as the most suitable task analysis method included reference to the notational support offered, and the effectiveness of the task analysis outputs. While the process of constructing the TDHs and their subsequent interpretation and analysis in terms of the KRG outputs provided most of the input to the requirements specification, some of the results of the analysis were not found to be at all useful:

- i) The re-description of the activity list in the form of KRG sentences was found to be unintelligible. Although it is possible that this would not have been the case for a much shorter activity list, the form of the re-description itself, with the explicit and meaningful node names in the TDH being replaced by sequences of KRG numbers, imposed too great a burden on any attempts at its interpretation.
- ii) The representation of task sequences (Sequence Representation Grammars) was likewise of little practical value. This was again partly due to the form of representation being difficult to interpret, although it owed more to the sheer volume of output. It is acknowledged that to some extent this was because of the immaturity of the LUTAKD software, of which an early version was used. A facility to limit the output to particular levels of generification, or to search the output data in some way, would have eased this problem considerably. However, the difficulty of comprehending large numbers of near identical KRG terms would remain.

As a means of providing a body of data for the interrogation regarding the task, TAKD was very successful. Wallace and Anderson (1993) accuse the *cognitive engineering* approach to HCI of producing excessive detail. While this is partly true of TAKD, it is also true that the analyst is given ample information upon which to draw. The question of what is sufficient detail may be much more easy to answer retrospective to the analysis rather than before it.

Carrying out the analysis proved to be an intellectually demanding task. For example, it was not always obvious which were the significant outputs of the analysis, and which constituted superfluous detail. It was also difficult to decide how many times to re-construct a TDH in order to provide sufficient perspectives. TAKD certainly provides no protection against ineffective analysis, but this is partly a consequence of the very flexibility of the TDH concept, which must be seen as a definite strength of the method. The need for iteration in the use of TAKD is emphasised by Diaper (1989b): such an approach, which frequently brings the analyst back to the users, perhaps would have made the analysis easier to conduct. It may well be that TAKD is indeed difficult to use in comparison to other task analysis techniques, as Diaper (1991a) suggests. However, analysis itself is an exacting pursuit. DeMarco's seminal work on structured analysis contains in its opening chapter the statement that analysis is "*frustrating....indefinite, and difficult*" (DeMarco, 1978). Perhaps it is in the nature of the exercise that construction and interpretation of a TDH are not straightforward, and that this is a necessary drawback of a powerful analytic method. The author's experience of TAKD gives weight to Diaper's recommendation (Diaper, 1989b) that TAKD should be carried out by groups of people rather than individuals, as the many subjective decisions that need to be made are greatly assisted in a collaborative environment.

## **7.2 Applicability of task analysis in general**

There have been positive outcomes to the application of TAKD which would probably have occurred regardless of the method used (within reason), and can thus be attributed to task analysis in general. Likewise, certain limitations to the task analytic approach have been exposed. This section looks at these issues, and discusses how they fit in with current practice in the healthcare domain.

### **7.2.1 Positive aspects of the use of task analysis**

The degree of success of the method in eliciting the requirements for the prototype ward based system has been discussed at length in the preceding chapter - suffice it to say here that it was found suitable for the detailed analysis of a functional area of ward activity. That this was achieved entirely within a user-centred framework shows its potential for wider application.

In addition to that success, the approach achieved several other desirable goals:

- The user-centred ethos that task analysis brought to the domain engendered very favourable attitudes and levels of co-operation amongst the personnel involved. There was very strong support for the motivation behind the analysis at the level of the real users of the potential system. This allowed the data collection to be more thorough and meaningful than it might otherwise have been.
- It raised awareness of the possibilities of ward based systems amongst people who might otherwise only expect to have a computer system imposed upon them.
- It gave those involved in the analysis a sense of empowerment, in that the essential tasks they performed were placed at the centre of the computer system (as they would see it).

Although there is a risk of raising unreasonable expectations by using such an approach, this may be avoided if the users involved are briefed properly. Also, this risk has to be balanced against the benefits that accrue from the production of an interface design specification early in the system life cycle. Such a specification is essential to the procurement and design of the system as a whole, because at its basis are the needs of the end users themselves, so increasing the likelihood of its usefulness and acceptance.

### **7.2.2 Limitations of task analysis in design**

It was clear during the analysis that TAKD was of limited usefulness because, as a task analysis method, its scope is necessarily restricted. This was the case in two particular respects.

Firstly, although it was effective in arriving at a set of requirements, those requirements did not themselves inform some important aspects of the design itself. The requirements were a clear statement of *what* the system should do, but decisions concerning the interaction style in general, and the dialogue and much design detail in particular had to be made in the light of other knowledge. This is perhaps not a valid criticism of task analysis. It may be wrong to expect an analytic technique to inform design to that extent. It is the use to which the outputs of the analysis are put that is critical and that provides the link between analysis and design. Knowledge gleaned about the task must be combined with other information in order to create the best design. Different approaches to this bridging requirement are evident. Diaper (1991a) reports on research that seeks to generate design specifications written in Z as a direct output of the analysis. Kelly and Colgan (1992) report on the incorporation of task models (derived from task analyses) with user models and design knowledge, in the form of an expert

system, in the development of the ADEPT design environment. There is a problem however, in that the user model must be derived at least in part from the task analysis. The quality of the task analysis would therefore be crucial, and it seems incongruous that the ADEPT environment includes no direct support for that task analysis. A different approach to using task analysis directly in design is to incorporate its outputs into a design rationale. This is discussed further in the next section.

The second major limitation of TAKD was that the analysis was principally useful in deriving requirements for a user interface and not for an information system. It achieved its success because of the limited nature of the prototype, and the clear definition of the output of the system, namely the request forms. It is possible that it would not have had the same success if applied to a much larger or more poorly defined system. Indeed, the data collection for the prototype required additional input from the laboratories. However, this additional input was only utilised in the interpretation of the task analysis outputs. Critically, it did not contribute to the activity list, and thus neither to the analysis proper. Again, this criticism may be unwarranted - the major claims for task analysis are that it has potential for *interface* design rather than *systems* design. Yet if a user-centred approach to the integration of hospital information systems were to be taken, task analysis for the design of the HISS user interfaces would be insufficient. A HISS is in essence a collaborative system; the work of one section may affect several others. It would be likely that elements of CSCW and collaborative work systems requirements capture would be necessary to complement the narrow task analytic approach that was employed here.

### 7.3 Task Analysis as an input to Design Rationale

A design rationale is a record of the reasoning that has gone into the construction of an artifact. Although DR exists largely in the realm of academic research, many attempts are being made to strengthen the case for its wider application, to the extent of claiming that it may provide a unifying framework for the discipline of HCI (Carroll, 1993). The motivations for constructing an explicit DR are, according to Carroll and Moran (1991):

*"...to support reasoning processes in design, to facilitate communication among the various players in the design process.....and to further the cumulation of development of design knowledge across design projects and products"*

It is the first of these motivations that is of interest to this discussion, i.e. that a DR might contribute to the process of design as it takes place. In particular, it is proposed in this section that a major input from the problem domain into the design space might come from task analysis. Thus, a means of bridging between task analysis and user interface design will be postulated.

### 7.3.1 From TAKD to the design of the prototype

The experience of progressing from analysis to design in the production of the prototype was very revealing about how those two facets of software development may be coupled. Given the problem of translating a particular interface requirement from the specification list given at the end of Chapter 3, any number of design possibilities presented themselves. The application of a framework for the design was useful in restricting those possibilities, as described in the first half of Chapter 4. However, even given an interaction style and development environment to constrain the work, the range of possible artifacts that might satisfy the requirement was enormous. In other words, there existed a large *design space* within which, hypothetically, the 'best' design could be found. The eventual construction of the prototype came from reasoning within this space. As this process unfolded, an informal structure became apparent:

- The requirements acted as a focal point for reasoning about the design. Lines of thought originated from each of the demands embodied in the specification.
- Given each demand, there was a set of possible solutions.
- For each possible solution, there were arguments for and against its inclusion. These arguments were based on knowledge from a variety of sources (including the various influences on the designer discussed in Chapter 4). Crucially, the analyst's knowledge of the problem domain came to bear on the eventual design choices that were made.

The contribution of the task analysis to this structure was twofold:

- i) The list of requirements, drawn from the analysis of the formal outputs of TAKD, provided the basis for reasoning about design.
- ii) The analyst's domain knowledge, derived from the entire process of task analysis, provided some of the basis for selecting from the options available to meet the requirements.

The possible linkage of these roles played by the task analysis to an existing DR approach is now described.

### 7.3.2 Design Space Analysis

The classification of DR techniques that is given by Lee and Lai (1991) describes three types:

- Those that provide a history of the process by which an artifact came into being.
- Those that consist of a set of psychological claims embodied by an artifact.
- Those that describe how an artifact is located within the space of possible design alternatives.

This last type most closely concurs with the author's experience of designing the prototype ward ordering system. It is typified by the Design Space Analysis approach devised by Maclean *et al* (1991). The primary aim of Design Space Analysis is to produce a record of the reasoning that has led to the design of an artifact within the space of possible designs. This record may then be used for reviewing and maintaining the design. However, a view held tentatively by its proponents is that it can facilitate innovation and reasoning, expose assumptions, and help to point the way to better alternatives. This motivation for producing a DR is very attractive. It should be noted that similar claims are made for the other forms of DR - the intention here is not to compare different DRs, but rather to illustrate the possibilities of linking task analysis with DR, using Design Space Analysis as a suitable example.

An appealing aspect of Design Space Analysis is its simple notation. The Questions, Options, and Criteria notation, or QOC, forms the basis for building the DR. Briefly, the design space is explored firstly by generating *Questions* that address key design issues, then by considering the possible *Options* to answer the questions, and finally by assessing the Options against particular *Criteria*. Links between the options and criteria may be positive or negative, and are denoted as such. Options may generate further questions, and Criteria may depend upon others at different levels of generality. By linking these various parts of the notation, a picture of the *argumentation* behind the artifact is built. Figure 7.1 illustrates the components of the QOC notation for the design space for a scroll bar.

### 7.3.3 Linking Task Analysis to Design Space Analysis

Taking the informal structure that emerged in the design of the prototype described in section 7.3.1, it is suggested that there is a possible input into Design Space Analysis from the task analysis:

- i) The list of requirements generates the initial set of Questions. It would be unlikely that these would be phrased in the same way as the imperative statements in the requirements list. However, questions could be derived from the requirements so that one could begin to reason about the design problem, eventually leading to a design proposal.
- ii) The Criteria upon which Options are selected are based in part on the broader understanding of the domain. TAKD provides no explicit means of expressing this knowledge, although it is integral to analysis in general, and plays an essential part in the

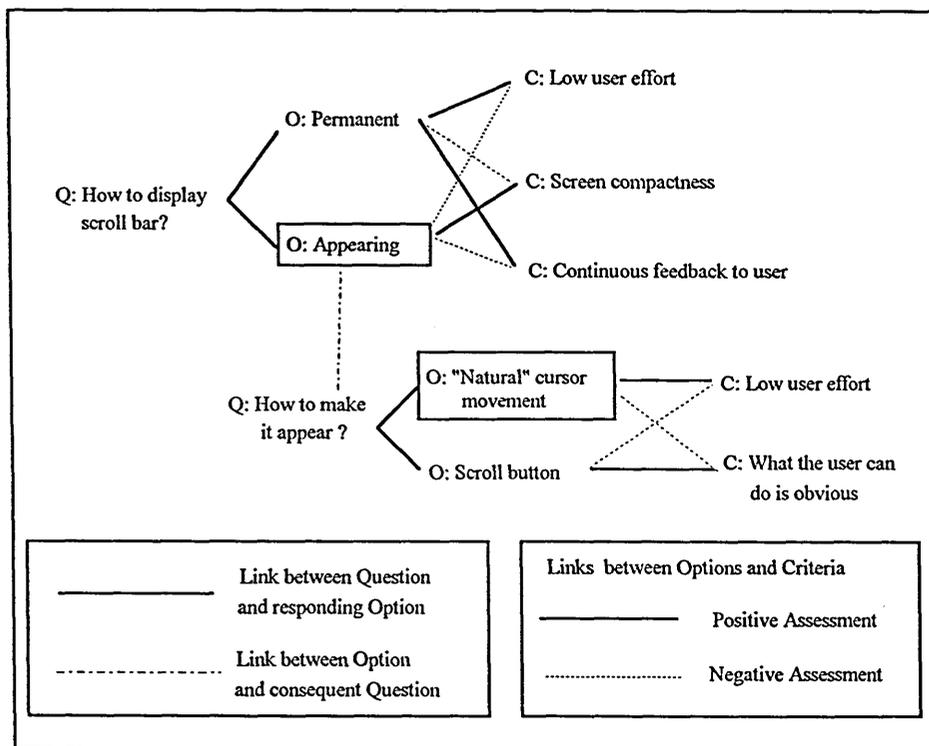


Figure 7.1 A QOC representation of the design space for a scroll bar. Design decisions are shown by the options in the boxes. (From Maclean *et al*, 1991).

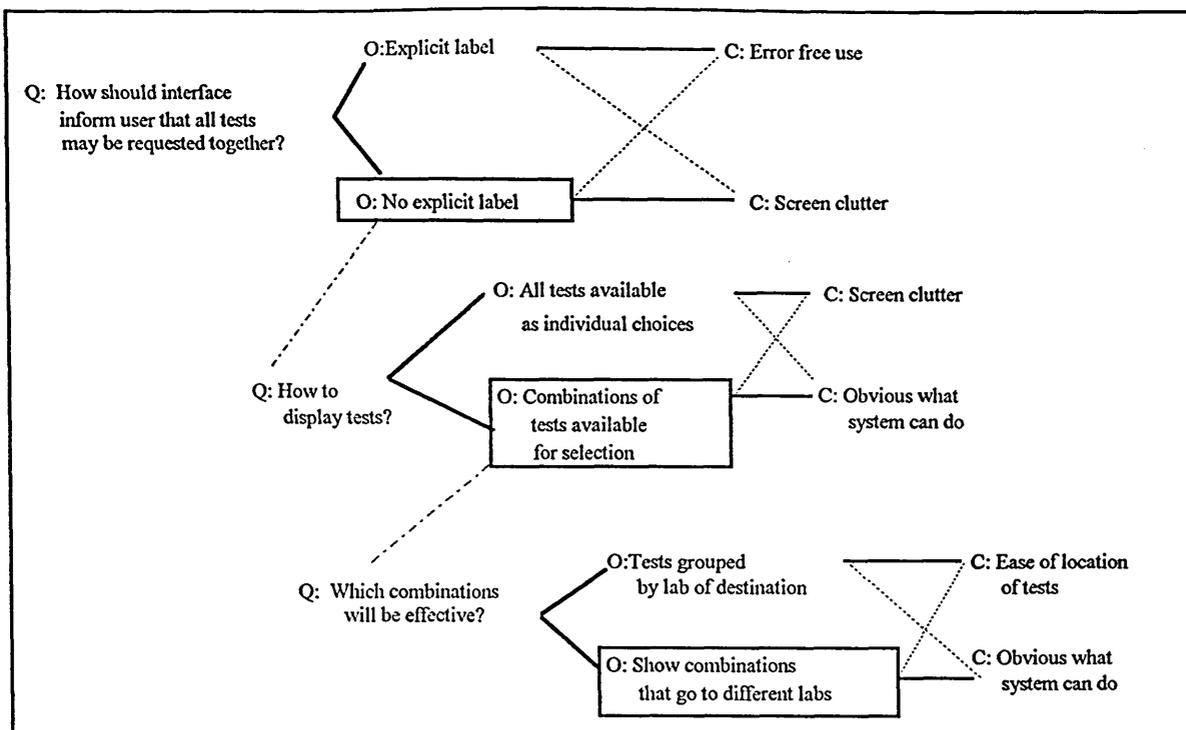


Figure 7.2 A simple DR for one of the TAKD-derived interface requirements.

interpretation of the formal outputs of task analysis. Similarly, it is difficult to define precisely how this understanding comes to bear on design, and how this can be incorporated into the DR.

Figure 7.2 shows a worked example of how one of the requirements specified following the analysis might lead to a DR. Reference is made to Specification 2 from the requirements list:

*Specification 2: The system should permit the performance of transactions as identified in the final TDH, in that selection of the patient enables the user to request as many tests as are required for that patient.*

Rephrasing the requirements statement as a question carries the danger of a loss of meaning. However, this would be minimised by maintaining the link between the statement and question during design. Figure 7.2 by no means shows all of the possible options, nor does it raise all of the questions that would need to be generated during the process of satisfying the design requirement. Nevertheless, it does show a possible structure for the design rationale, and thus the exploration of a fragment of the possible design space for the prototype. Crucially, the exploration is instigated directly by the outcome of the application of task analysis. It is not intended that the formal outputs of TAKD provide the input to the DR - the respective notations are far too dissimilar for such a liaison. Moreover, it is considered here that TAKD is more fruitful when its formal outputs are

incorporated into an interpretative process, rather than if used directly, for example in a Z specification.

It must be stressed that this has been a tentative exercise. The author's own knowledge of DR is limited through a lack of direct experience of its use, and the rationale shown above is far from complete. However, there are similarities between Figure 7.2 and the rationale given for the design given in Chapter 4. Such similarities reflect that design occurs according to certain logical processes that are partially amenable to description and articulation. What is important, and has been the thrust of this discussion, is the exploration of the possibility of integrating two strands of HCI, admittedly at different levels of maturity, into a form that combines their respective strengths.

## **7.4 Conclusion**

Task analysis has a positive role in the capture of user interface requirements. In particular, TAKD proved to be a powerful analytic method. Its limitations were due largely to the poor usability of certain parts of the technique, especially the comprehensibility of some of the grammar representations. However, too much should not be expected of task analysis - its scope is limited, but within this scope it has real applicability to user interface design. It may be possible to extend its use into the area of Design Rationale, in an attempt to more closely link the processes of analysis and design.

The application of task analysis in the integration of hospital information systems is of great local benefit, but its usefulness in the wider sense remains unproved. The position of user-centred design in hospital information systems will be the focus of the following, concluding chapter.

# Chapter 8

## Conclusions

This final chapter seeks to draw together the various strands that have characterised the work that has been described. In particular, it aims to assess the viability of the approach that was taken with respect to the integration of hospital information systems. Given the benefit of hindsight, it will compare this approach with other user-centred methods that have been applied in the healthcare environment, and will suggest how the lessons learned may be applied.

### 8.1 User centred methods in the integration of hospital information systems

The introduction of computers into hospital wards is fraught with many problems, some that are unique to that area, and others that are general to the use of information technology. In the past, IT has been aimed at administrators and managers, who are removed from the core activity of the hospital. There is a growing realisation that the real users of hospital information systems are those who are closest to clinical care, along with their supporting workers. This recognition requires that appropriate methods be employed to discover the information system requirements of the real users, and to design usable systems to meet these requirements.

It has been shown that task analysis has a positive contribution to make in response to the need to focus on doctors and nurses. Not only does the analysis proper allow revealing and insightful outputs, but the entire process of observation, data collection and iteration (the last admittedly not a strong feature of the work that has been reported) places the activity of the users at the centre of the development of the system. The high profile of the analysis and explicit focus on the clinical staff is beneficial to the process of legitimate requirements capture.

### 8.2 Alternative user centred methods in health care

The application of task analysis is not the only user centred approach that has been taken in the development of medical information systems. A clinical workstation for use in general practice has been developed under the

Pen & Pad project (Horan *et al*, 1990) within a user centred framework. This project has been a large collaborative exercise with doctors closely involved as a part of design and evaluation teams in a rapid prototyping environment. Where Pen & Pad differs from the work reported in the previous chapters is:

- Scale - Pen & Pad was a major enterprise aimed at producing a particular system for general use, rather than offering an *approach* that might be taken up in hospitals.
- Definition - there was a clear boundary, i.e. a workstation for use in a GP consulting room. The needs of ward personnel are more diffuse, and are more interlinked with other departments.
- Analysis - Horan *et al* make passing reference to "*task analysis techniques*" that were used to assist in data gathering. There is no indication of the degree of rigour involved.
- User selection - it is not clear how the collaborating doctors were selected for Pen & Pad, or how typical they were of the wider user population.

These differences raise some important points that came to light during the application of TAKD:

- Firstly, the users involved should be drawn from the pool of the most *typical* users and should not be self selected, or selected on the basis of computer experience. An advantage of TAKD is that the data collection is carried out on normal work activity, reducing the distortion that may come from either over-enthusiastic or reluctant co-operation.
- Secondly, task analysis may reveal underlying task structures that may not be apparent to those performing them, or may not lend themselves to articulation. This does not decry more openly participative methods, but implies that those methods would be richer if they could incorporate this analytical power.

In acknowledging the need for a more formal approach, Kirby and Heathfield (1993) have developed a hybrid technique that has been used as part of an extension of Pen & Pad into the elderly care sector. Their notation, called Task Oriented Flow Diagrams, combines HTA with Data Flow Diagrams. It has been used to aid communication with nurses, and more importantly, to integrate task related information with systems design. By definition, this technique will have the weaknesses of HTA described in Chapter 3; in fact, these will probably be more severe, as their version of HTA is necessarily simplified in order to portray it in graphical form. Nevertheless, it displays a perceived need to provide more structure to an otherwise rather 'soft' method.

Additional recognition of the need for user centred design in health care has come from Scandinavia, where there is a philosophy that advocates a holistic approach to software requirements capture, as discussed by Sandblad (1991). Within this context, the involvement of the users in the development of medical software is characterised by the application of *Action Design* (Timpka *et al*, 1991). This achieves its focus on the users by the close collaboration of medical staff in negotiating the system requirements and a design rationale, with the dynamics of the participation group being held to the fore. It is intended to lead to a system that enhances the work of the whole organisation and the individuals in it. Action design belongs to the paradigm of analysis that sees the context of human work activity, and the quality of that work activity, as paramount. Timpka *et al* could be criticised for omitting an 'objective' task analytic component from their methods. However, this misses the point of their approach. Bannon and Bødker (1991), in critiquing conventional HCI methods, state that a task analysis can never be sufficiently informed about the domain to be of real use in future design. In the context of medical informatics, Timpka *et al* may be right to eschew reductionist, or 'scientific' methods. However, a point that has been made repeatedly here is that the value of task analysis must not be seen only in its formal outputs. It is the *process* of task analysis that is equally valuable, and the domain knowledge that is gained during the (effective) application of TAKD is crucial. Nonetheless, it must be said that TAKD can be conducted without the in-depth understanding of the domain that was sought in this work. As stated in a previous chapter, it offers no protection against poor analysis. The strength of the Action Design approach is that it has methods for acquiring empathy with the domain actually built into it.

### **8.3 User centred requirements capture for integration**

A point made in the previous chapter was that task analysis successfully provided requirements for the user interface rather than for the information system. If user centred approaches are to be considered for application on a larger scale than a small prototype, then the issue of interconnecting requirements must be addressed. Requirements capture for large systems is already standard practice in hospitals and elsewhere, although, as has been discussed, this practice does not have a user centred focus.

It has been frequently expressed that the best chance for HCI techniques to have an impact on the real world is for them to be integrated

into systems analysis methodologies (see Sutcliffe, 1989). This opinion is held because of the widespread use and acceptance of these methodologies. Such attempts at integration have been made with Jackson System Development (Sutcliffe, 1988; Lim *et al*, 1992; Walsh, 1989). While these attempts have been considered to hold some promise, it is unlikely that they would be applicable in a HISS development; JSD is orientated towards software rather than organisational needs, and does not address database or file design, both of which are central to hospital information systems. Meanwhile, methodologies which do address organisational needs, such as ORDIT (Harker *et al*, 1990) lack the granularity that task analysis provides and which is necessary for the specification of user interaction.

That task analysis was successful in leading to the design of a usable (and useful) prototype is not doubted. It is also certain that the methods used incorporated the information requirements, as they related to the prototype, of the laboratories. What was lacking from these methods was a firm structure for the capture of these 'peripheral' requirements. However, even with the informal approach that was taken, the result was the *effective* integration of the ward and laboratory information systems, albeit on a small scale. An appropriate notation to express these additional requirements would be necessary in an expanded application, and the lead taken by Kirby and Heathfield is promising in this respect.

#### **8.4 Concluding remarks**

Given the recent history of health care computing provision, and the rather poor uptake of HCI methods in IT in general, it may be that the best that HCI techniques can offer is in the form of piecemeal applications at the periphery of the mainstream of medical informatics. It is significant that at the most recent World Congress on Medical Informatics (Medinfo '92), of approximately three hundred presentations, only twelve were in the category of 'Human Factors'. However, recognition of the importance of the end users of health care computer systems is growing. The prototype produced for this work was considered to be a success by its external sponsors, and is being further developed for hospital-wide implementation. However, the extension work has proceeded without any of the detailed and rigorous task observation and analysis that characterised the research work. In the real world, the application of HCI techniques is still held to be an expensive option.

# References

- Addison, M. and Diaper, D. (1990)  
*LUTAKD User Manual (version 1)*. University of Liverpool, Unpublished material.
- Anderson, R.I. (1990)  
Task Analysis: The Oft Missing Step in the Development of Computer-Human Interfaces; Its Desirable Nature, Value and Role. In: *Human-Computer Interaction - INTERACT '90*. Diaper, D., Gilmore, D., Cockton, G. & Shackel, B. (Eds). North Holland:Elsevier, pp.1051-1054.
- Annett, J., Duncan, K.D., Stammers, R.B. & Gray, M.J. (1971)  
*Task Analysis*. Training Information Number 6, HMSO, London.
- Audit Commission (1992)  
*Caring Systems*. London: HMSO.
- Avison, D.E. and Fitzgerald, G. (1988)  
*Information Systems Development: Methodologies, Techniques and Tools*. Oxford: Blackwell Scientific Publications.
- Bailey, J.E. (1990)  
Development of an instrument for the management of computer user attitudes in hospitals. *Methods of Information in Medicine*, 29(1), pp.51-56.
- Bainbridge, L. (1990)  
Verbal protocol analysis. In: *Evaluation of human work*. Wilson, J.R. and Corlett, E.N. (Eds). London:Taylor and Francis, pp.161-179.
- Bannon, L.J. and Bødker, S. (1991)  
Beyond the Interface: Encountering Artifacts in Use. In: *Designing Interaction: Psychology at the Human-Computer Interface*. Carroll, J.M. (Ed). Cambridge: Cambridge University Press, pp.227-253.
- Barber, B., Garwood, D. and Treacher, A. (1993)  
The business of security. In: *Proc MIE 93* Reichert, A., Sadan, B.A., Bengtsson, S., Bryant, J. and Piccolo, U. (Eds) London: Freund, pp.396-401.
- Barnett, D.E. (1993)  
Computers and nursing. *Computer Bulletin*, 5(3), pp17-18.
- Bellotti, V.M.E. (1990)  
A Framework for assessing the Applicability of HCI Techniques. In: *Human-Computer Interaction - INTERACT' 90*. Diaper, D., Gilmore, G., Cockton, G. and Shackel, B. (Eds), North-Holland: Elsevier, pp.213:218.

- Benson, T. (1991)  
*Medical Informatics*. Harlow: Longman.
- Benson, T. (1993)  
 The rise of clinical computing. *British Journal of Healthcare Computing*, 10(2), pp 35-39.
- Benyon, D. (1992)  
 The role of task analysis in system design. *Interacting with Computers*, 4(1), pp102-123.
- Bhat, B.V., Puri, R.K. and Srinivasan, S. (1989)  
 Time utilisation study in pediatric outpatient of a referral hospital. *Indian Paediatrics*, 26, pp.1042-1044.
- Booth, P. (1989)  
*An Introduction to Human-Computer Interaction*. Hove: Lawrence Erlbaum Associates.
- Box, G.E.P. and Cox, D.R. (1964)  
 An Analysis of Transformations. *Journal of the Royal Statistical Society, B*, 26, pp.211-243.
- Brodts, A. and Stronge, J.H. (1986)  
 Nurses' attitudes towards computerisation in a midwestern community hospital. *Computers in Nursing* 4(2), pp.82-86.
- Brown, P. (Ed) (1992)  
 Union says LAS troubled by CAD's entry. *British Journal of Healthcare Computing*. 9(2), p6.
- Card, S.K., Moran, T.P., & Newell, A. (1980)  
 The Keystroke Level Model for User Performance Time with Interactive Systems. *Communications of the ACM* 23(7), pp.396-410.
- Card, S.K., Moran, T.P., & Newell, A. (1983)  
*The Psychology of Human-Computer Interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Carroll, J.M. (1993)  
 Creating a design science of human-computer interaction. *Interacting with Computers*, 5(1), pp 3-12.
- Carroll, J.M. and Moran, T.P. (1991)  
 Introduction to This Special Issue on Design Rationale. *Human-Computer Interaction*, 6, pp 197-200.
- Carroll, J.M., Kellogg, W.A., and Rosson, M.B. (1991)  
 The Task-Artifact Cycle. Designing Interaction: In: *Psychology at the Human-Computer Interface*. Carroll, J.M. (Ed). Cambridge: Cambridge University Press, pp.74-102.
- Cooper, G. (1991)  
 Context and its representation. *Interacting with Computers*, 3(3), pp.243-352.

- Corbett, M., Macleod, M. and Kelly, M. (1993)  
Quantitative Usability Evaluation - The ESPiRiT MUSiC Project. *Human-Computer Interaction: Applications and Case Studies. Proc HCI international '93*. Smith, M.J. and Salvendy, G. (Eds), pp.313-318. Amsterdam: Elsevier.
- Cordingley, E. (1989)  
Knowledge elicitation techniques for knowledge-based systems. In: *Knowledge elicitation: principles, techniques and applications*. Diaper, D. (Ed), Chichester: Ellis Horwood, pp.89-172.
- Cutts, G.T. (1987)  
*Structured Systems Analysis and Design Methodology*. London: Paradigm.
- DeMarco, T. (1978)  
*Structured Analysis and System Specification*. Englewood Cliffs, NJ: Prentice-Hall.
- Department of Health (1989)  
*Working for Patients*. London: HMSO.
- Department of Health (1990)  
*Framework for Information Systems: the Next Steps*. London: HMSO.
- Department of Health and Social Security (1986)  
Health Services Management - Resource Management (Management Budgeting) in Health Authorities. *Health Notice, NH(86)34*.
- Diaper, D. (1989a)  
Task Observation for Human Computer Interaction. In: *Task Analysis for Human Computer Interaction*. Diaper, D. (Ed). Chichester: Ellis Horwood, 1989.
- Diaper, D. (1989b)  
Task Analysis for Knowledge Descriptions (TAKD): the method and an example. In: *Task Analysis for Human-Computer Interaction*. Diaper, D. (Ed). Chichester: Ellis Horwood, pp.108-158.
- Diaper, D. (1990)  
Analysing Focused Interview Data with Task Analysis for Knowledge Descriptions (TAKD). In: *Human-Computer Interaction - INTERACT '90*. Diaper, D., Gilmore, D., Cockton, G. and Shackel, B. (Eds). North Holland: Elsevier, pp.277-282.
- Diaper, D. (1991a)  
*HCI '91 Tutorial Notes. Task Analysis for HCI*. Unpublished material.
- Diaper, D. (1991b)  
*TDH Construction: Advice and Heuristics* University of Liverpool, Unpublished material.
- Diaper, D. and Johnson, P. (1989)  
Task analysis for knowledge descriptions: theory and application in training. In: *Cognitive Ergonomics*, Long, J.B. and Whitefield, A. (Eds). Cambridge: Cambridge University Press.

- Dillon, A., Sweeney, M. and Maguire, M. (1993)  
 A Survey of Usability Engineering Within the European IT Industry. In: *People and Computers VIII*, Alty, J.L., Diaper, D., and Guest, S. (Eds) Cambridge: Cambridge University Press, pp.81-94.
- Dix, A., Finlay, J., Abowd, G. and Beale, R. (1993)  
*Human Computer Interaction*. Hemel Hempstead: Prentice Hall International.
- Dorenfest, S.I. (1993)  
 United States and England: a comparison of progress in automation. In: *Current Perspectives Healthcare Computing 1993*. Richards, B. (Ed). Weybridge: BJHC Books, pp.289-296.
- Downton, A. (1991)  
 Evaluation techniques for human-computer systems design. *Engineering the Human-Computer Interface* Downton, A (Ed), New York: McGraw Hill.
- Drury, C.G. (1990)  
 Methods for direct observation of performance. In: *Evaluation of human work*. Wilson, J.R. and Corlett, E.N. (Eds), London: Taylor and Francis, pp.35-57.
- Eason, K. (1984)  
 Towards the experimental study of usability. *Behaviour & Information Technology*, 3(2).
- Eason, K.D. (1989)  
*Information Technology and Organisational Change*. London: Taylor and Francis.
- Engström, B. (1988)  
 Solving patients' information problems by the nursing process and collaboration between medical and nursing staff. *Scandinavian Journal of Caring Sciences*, 2(2), pp.65-73.
- Fischer, G., Lemke, A.C., McCall, R. and Morch, A.I. (1991)  
 Making Argumentation Serve Design. *Human-Computer Interaction*, 6, pp 393-419.
- Fowler, C., Kirby, M., Macauley, L., and Hutt, A. (1988)  
 User Skills and Task Match (USTM): a human factors based methodology for determining product requirements. In: *Proc 4th Alvey Conf, Swansea*. 208-211.
- Frascina, T. (1990)  
*An Investigation Into The Design Of The Human-Computer Interface In Ward Based Hospital Systems*. Unpublished MSc thesis, Sheffield City Polytechnic.
- Gillanders, W. and Heiman, M. (1971)  
 Time study of intern programs. *Journal of Medical Education*, 46, pp.142-149.
- Gough, T. (1991a)  
 Giants lose patients over hospital contract. *Computing*, 5th Sept 1991:p. 1.
- Gough, T. (1991b)  
 Prescriptions to remedy a medical mess. *Computing* 12th Sept 1991:pp.24-25.

- Gould, J.D. (1988)  
How to Design Usable Systems. *Handbook of Human-Computer Interaction*, Helander, M. (Ed), North-Holland: Elsevier, pp.757-789.
- Gould, J.D. and Lewis, C. (1985)  
Designing for Usability: Key Principles and What Designers Think. *Communications of the ACM* 28,(3), pp.300-311.
- Gould, J.D., Boies, S. J., Levy, S.E., Richards, J.T. and Schoonard, J.W.  
The 1984 Olympic Message System - A Test of Behavioural Principles of System Design. In: *Human-Computer Interaction: Selected Readings* Preece, P. and Keller, L. (Eds), Hemel Hempstead: Prentice Hall, pp.260-295.
- Griffiths, R. (1983)  
*NHS Management Inquiry*. London: Department of Health and Social Security.
- Grobe, S.J. (1984)  
Conquering computer cowardice. *Journal of Nursing Education* 23(6), pp.232-239.
- Gronlund, T.A.C. (1991)  
HISS systems: an epidemic or panacea? In: *Current Perspectives in Healthcare Computing 1991*. Richards, B.(Ed). Weybridge: BJHC Books, pp.198-203.
- Grudin, J. (1992)  
Utility and usability: research issues and development contexts. *Interacting with Computers*, 4(2),pp.209-217.
- Harker, S.D.P., Olphert, C.W. and Eason, K.D. (1990)  
The development of tools to assist in organisational requirements definition for information technology systems. In: *Human-Computer Interaction - INTERACT '90*.Diaper, D., Gilmore, D., Cockton, G. & Shackel, B. (Eds). North-Holland: Elsevier, pp.295-300.
- Henderson, A. (1991)  
A Development Perspective on Interface, Design, and Theory. In *Designing Interaction: Psychology at the Human-Computer Interface*. Carroll, J.M. (Ed). Cambridge: Cambridge University Press, pp.254-268.
- Hendrickson, G. & Kovner, C.T. (1990)  
Effects of Computers on Nursing Resource Use. *Computers in Nursing*, 8 (1), pp.16-22.
- Hewett, T.T. (1986)  
The role of iterative evaluation in designing systems for usability. In: *People and Computers: Designing for Usability* Harrison, M.D. and Monk, A.F. (Eds). Cambridge: Cambridge University Press, pp.196-214.
- Horan B., Rector A.L., Sneath E.L., Goble, T.J., Kay, S., Nowlan, W.A. and Wilson, A. (1990)  
Supporting a humanly impossible task: the clinical human-computer environment. In: *Human-Computer Interaction - Proceedings of Interact '90*. Diaper, D., Gilmore, D., Cockton, G. and Shackel, B. (Eds). North-Holland: Elsevier Science, pp.247-252.

- Hughes, J.A., Somerville, I., Bentley, R. and Randall, D. (1993)  
 Designing with ethnography: making work visible. *Interacting with Computers*, 5(2), pp.239-253.
- Jacobson, S.F., Holder, M.E., and Dearer, J.F. (1989)  
 Computer anxiety among nursing students, educators, staff and administrators. *Computers in Nursing*, 7(6), pp.266-272.
- Johnson, H. and Johnson, P. (1989)  
 Integrating task analysis into system design: Surveying designer's needs. *Ergonomics*,(32)11, pp.1451-1467.
- Johnson, P. and Nicolosi, E. (1990)  
 Task-based user interface development tools. In: *Human-Computer Interaction - INTERACT '90*. Diaper, D, Gilmore, D, Cockton, G and Shackel, B (Eds). North Holland: Elsevier, pp.383-387.
- Johnson, P. (1985)  
 Towards a task model of messaging: an example of the application of TAKD to user interface design. In: *People and Computers. Designing the Interface*. Johnson, P. and Cook, S. (Eds).Cambridge: Cambridge University Press, pp.46-62.
- Johnson, P. (1989)  
 Supporting system design by analyzing current task knowledge. In: *Task Analysis for Human-Computer Interaction*. Diaper, D.(Ed) Chichester: Ellis Horwood.
- Johnson, P. (1992)  
*Human Computer Interaction: Psychology, Task Analysis and Software Engineering*. Maidenhead: McGraw-Hill.
- Johnson, P. and Johnson, H. (1991)  
 Knowledge analysis of tasks: task analysis and specification for human:computer systems. In: *Engineering the Human-Computer Interface*. Downton, A. (Ed). McGraw-Hill: Maidenhead.
- Johnson, P., Diaper, D. and Long, J.B. (1984)  
 Tasks, skills and knowledge: task analysis for knowledge based descriptions. In: *Human-Computer Interaction -INTERACT'84*. Shackel, B. (Ed).Amsterdam: North Holland, pp.499-503.
- Jones, T. (1988)  
*Report on Information Technology Inventory Project on Systems at the Royal Hallamshire Hospital*. District Information Department, Sheffield Health Authority.
- Jordan, P.W., Draper, S.W., Macfarlane, K.K. and McNulty, S-A (1991)  
 Guessability, Learnability, and Experienced User Performance. In: *People and Computers VI*. Diaper, D. and Hammond, N. (Eds) Cambridge: Cambridge University Press, pp.237-245.

- Kammersgaard, J. (1990)  
Four Different Perspectives on Human-Computer Interaction. In: *Human-Computer Interaction: Selected Readings*, Preece, P. and Keller, L. (Eds). Hemel Hempstead, Prentice Hall, pp.42-64.
- Katz, M.H. and Schroeder, S.A. (1988)  
The sounds of the hospital - paging patterns in three teaching hospitals. *New England Journal of Medicine*, 319, pp.1585-1589.
- Kelly, C. and Colgan, L. (1992)  
User Modelling and User Interface Design. In: *People and Computers VII*. Monk, A., Diaper, D., and Harrison, M. (Eds). Cambridge: Cambridge University Press, pp.227-239.
- Kieras, D. and Polson, P.G. (1985)  
An approach to the formal analysis of user complexity. *International Journal of Man-Machine Studies*, (22), pp.365-394.
- Kieras, D.E., Bovair, S. (1990)  
The Role of a Mental Model in Learning to Operate a Device. In: *Human-Computer Interaction: Selected Readings*. Preece, P. and Keller, L. (Eds). Hemel Hempstead: Prentice Hall, pp.205-21.
- Kirby, J. and Heathfield, H.A. (1993)  
An Analysis Technique for User Centred Design. In: *Human-Computer Interaction: Software and Hardware Interfaces, Proc HCI International '93*. Salvendy, G. and Smith, M.J. (Eds). Amsterdam: Elsevier, pp.991-996.
- Kjerulff, K.H., Salloway, J.C., and Counte, M.A. (1989)  
The impact of computer systems in a medical environment. *Comput Med Imaging Graph*, 13(1), pp.137-143.
- Körner, E. (1982)  
*Steering Group on Health Services Information: First Report* London: HMSO.
- Laurent, C.M. (1987)  
Categorisation of nursing activities as observed in medical-surgical wards/units in Metro-Manila. *Anphi Papers*, 22(1), pp.20-34.
- Lee, J. and Lai, K-W. (1991)  
What's in Design Rationale? *Human-Computer Interaction*, 6, pp 251-280.
- Leslie, P.J., Williams, J.A., McKenna, C., Smith, G. and Heading, R.C. (1990)  
Hours, volume and type of work of preregistration house officers. *British Medical Journal*, 300, pp.1038-1041.
- Lim, K.Y., Long, J.B. and Silcock, N. (1992)  
Integrating Human Factors with the Jackson system Development Method: An Illustrated Overview. *Ergonomics, Special Issue*.
- Linder, C.A. (1990)  
Work measurement and nursing time standards. *Nursing Management*, 20(10), pp.44-49.

- Long, J. (1986)  
 People and computers: Designing for Usability. In: *People and computers: Designing for Usability*, Harrison, M.D. and Monk, A.F., (Eds). Cambridge: Cambridge University Press, pp.2-23.
- Long, J. (1989)  
 Cognitive ergonomics and human-computer interaction: an introduction. In: *Cognitive ergonomics and human-computer interaction*. Long, J. and Whitefield, A. (Eds), Cambridge: Cambridge University Press, pp.3-34.
- Lurie, N., Rank, B., Parent, C., Woolley, T. and Snoke, W. (1989)  
 How do house officers spend their nights ? - A time study of internal medicine house staff on call. *New England Journal of Medicine*, 320, pp.1673-1677.
- Maclean, A., Young, R.M., Bellotti, V.M.E. and Moran, T.P. (1991)  
 Questions, Options, and Criteria: Elements of Design Space Analysis. *Human-Computer Interaction*, 6, pp 210-250.
- Markopoulos, P., Pycocock, J., Wilson, S., Johnson, P. (1992)  
 Adept: A Task-based Design Environment. In: *Proc 25th Hawaii Int Conf on System Sciences*, Shriver, B.D. (Ed), pp.587-596.
- Mayer, G.G., Buckley, R.F. and White, T.L. (1990)  
 Direct care given to patients in a subacute rehabilitation centre. *Rehabilitation Nursing*, 15(2), pp.86-88.
- McDonald, C.J. and Barnett, G.O. (1990)  
 Medical Record Systems. In: *Medical Informatics*, Shortliffe, E.H. *et al* (Eds), Reading, MA: Addison-Wesley.
- McMichael, S. (1987)  
 Measuring workload at Misericordia. *Dimensions in Health Service*, 64(7), pp.38-40.
- McQuaid, L. (1993)  
 Central Middlesex hospital and I.T. In: *Proc MIE 93*, Reichert, A., Sadan, B.A., Bengtsson, S., Bryant, J. and Piccolo, U. (Eds) London: Freund, pp.326-327.
- Miller, R.B. (1962)  
 Task description and analysis. In: *Psychological principles in system development*. Gage, R.M.(Ed) New York: Holt, Reinhart and Winston.
- Miller, R.B. (1971)  
 Human ease of criteria and their trade-offs. *IBM Report TR 00.2185*. Poughkeepsie, New York: IBM.
- Misener, T.R., Frelin, A.J. and Twist, P.A. (1987)  
 Sampling nursing time pinpoints staffing needs. *Nursing and Health Care*, 8(4), pp.233-237.

- Monk, A. & Wright, P.C. (1989)  
 Evaluation for Design. In: *People and Computers V*, Sutcliffe, A. & Macaulay, L. (Eds).  
 Cambridge: Cambridge University Press, pp.345-358.
- Monk, A. & Wright, P.C. (1991)  
 Observations and inventions: new approaches to the study of human-computer interaction.  
*Interacting with Computers* 3(2), pp.204-216.
- Montgomery, D.C. (1991)  
*Design and Analysis of Experiments. 3rd Edition*, Chichester: Wiley.
- Moran, T.P. (1981)  
 The Command Language Grammar, a representation of the user interface for interactive  
 computer systems. *International Journal of Man-Machine Studies* 15(1), pp.3-50.
- Moran, T.P. (1983)  
 Getting into a system: external-internal task mapping analysis. In: *CHI'83. Conference on  
 Human Factors in Computing Systems*. New York: ACM, pp.45-49.
- Morris, M.E. and Cooper, P.A. (1991)  
 The Multi-Media Hospital In: *Current Perspectives in Healthcare Computing 1991*,  
 Richards, B.(Ed), Weybridge: BJHC Books, pp.172-178.
- Mumford, E. (1983)  
*Designing Participatively*. Manchester: Manchester Business School.
- NHS Information Management Centre (1990)  
*Common Basic Specification. The generic model reference manual, CBS001-1.0*.  
 Birmingham: NHS-IMC.
- NHS Management Executive (1990)  
*Nursing Information Requirements: Identification and Computerisation*. NHS  
 Management Executive: Resource Management Unit.
- NHS Management Executive Information Management Group (1993)  
*Integrated Clinical Workstation: User Requirements (Acute Hospitals)*. Leeds: NHSME  
 IMG.
- Nielsen, J. & Molich, R. (1990)  
 Heuristic evaluation of user interfaces. In: *Proc CHI'90: Empowering People*, Chew, J.C. &  
 Whiteside, J. (Eds). New York: ACM, pp.249-256.
- Norman, D.A. (1991)  
 Cognitive Artifacts. Designing Interaction: In: *Psychology at the Human-Computer  
 Interface*. Carroll, J.M. (Ed). Cambridge: Cambridge University Press, pp.17-38.
- Norman, D.A. (1988)  
*The Psychology of Everyday Things*. New York: Basic Books.

- O'Brien-Pallas, L. (1988)  
An analysis of the multiple approaches to measuring nursing workload. *Canadian Journal of Nursing Administration*, 1(2), pp.8-11.
- O'Brien-Pallas, L., Leatt, P., Deber, R. and Till, J. (1989)  
A comparison of workload estimates using three methods of patient classification. *Canadian Journal of Nursing Administration*, 2(3), pp.16-23.
- Payne, S.J. & Green, T.R.G. (1989)  
Task-Action Grammar: the model and its developments. In: *Task Analysis for Human-Computer Interaction*. Diaper, D.(Ed) Chichester: Ellis Horwood.
- Payne, S.J. (1991)  
Interface Problems and Resources. In: *Designing Interaction: Psychology at the Human-Computer Interface*. Carroll, J.M. (Ed). Cambridge: Cambridge University Press, pp.128-153
- Payson, H.E., Gaenslen, E.C. and Stargardter, F.L. (1961)  
Time study of an internship on a university medical service. *New England Journal of Medicine*, 264, pp.439-443.
- Philips, M.P., Bashinski, H.S., Ammerman, H. and Fligg, C. (1988)  
A task analytic approach to dialogue design. In: *Handbook of Human-Computer Interaction Helander, M (Ed)*, North-Holland:Elsevier, pp.835-857.
- Pluyter-Wenting, E. (1992)  
Hospital Information Systems and Nursing. *Information Technology n Nursing* 4(1), p8-9.
- Pollock, C. (1988)  
Training for Optimising Transfer between Word Processors. In: *People and Computers IV*. Jones, D.M. and Winder, R. (Eds). Cambridge University Press: Cambridge. pp. 309-328.
- Polson, P.G., Lewis, C., Rieman, J., & Wharton, C. (1992)  
Cognitive walkthroughs: a method for theory-based evaluation of user interfaces. *International Journal of Man-Machine Studies* 36, pp.741-773.
- Porteus, M.A. & Kirakowski, J. (1992)  
*Software Usability Measurement Inventory Handbook (3rd Ed)*. University College, Cork, Ireland.
- Preece, J., Davis,G. and Keller, L. (Eds) (1990)  
*A Guide to Usability*. Open University: Milton Keynes, in association with the Department of Trade and Industry.
- Read, J.D. and Fitter, M. (1991)  
Read codes: current experience and future plans. In: *Current Perspectives Healthcare Computing 1993*. Richards, B. (Ed). Weybridge: BJHC Books, pp.394-402.
- Robson, D.J. and Joyce, B.I. (1993)  
The Greenwich hospital information system. In: *Current Perspectives Healthcare Computing 1993*. Richards, B. (Ed). Weybridge: BJHC Books, pp.329-334.

- Safran, C. (1993)  
Don't drink the water. A report on Healthcare Computing '93 conference. *British Journal of Healthcare Computing*, 10(3), p 8.
- Sandblad, B. (1991)  
Software Requirements for the Design and Development of Efficient User Interfaces. In: *Software Engineering in Medical Informatics*. Timmers, T. and Blum, B.I. (Eds). North-Holland: Elsevier Science, pp.139-150.
- Schwirian, P., Malone, J.A., Stone, V.J., Nunley, B. and Francisco T. (1989)  
Computers in nursing practice - a comparison of the attitudes of nurses and nursing students. *Computers in Nursing*, 7(4), pp.168-176.
- Seeyle, A. (1982)  
On the nurse's trail. *Health and Social Service Journal*, Jan 7th, 1982, pp.12-14.
- Shackel, B. (1984)  
The Concept of Usability. In: *Visual Display Terminals: Usability Issues and Health Concerns*. Bennett, J.L., Case, D., Sandelin, J. and Smith, M. (Eds). Englewood Cliffs, NJ: Prentice Hall, pp.161-184.
- Shackel, B. (1986)  
Ergonomics in Design for Usability. In: *People and Computers IV: Designing for Usability* Jones, D.M. and Winder R. (Eds). Cambridge: Cambridge University Press, pp.44-64.
- Shackel, B. (1990)  
Human Factors and Usability. :In: *Human-Computer Interaction: Selected Readings*. Preece, P. and Keller, L. (Eds). Hemel Hempstead: Prentice Hall, pp.27-41.
- Shackel, B. (1991)  
Usability- Context, Framework, Definition, Design and Evaluation. In: *Human Factors for Informatics Usability* Shackel, B. and Richardson S. (Eds). Cambridge: Cambridge University Press, pp.21-37.
- Shadbolt, N. and Burton, M. (1990)  
Knowledge elicitation. In: *Evaluation of human work*. Wilson, J.R. and Corlett, E.N. (Eds). London:Taylor and Francis, pp.321-325.
- Sharratt, B.(1987)  
The incorporation of early interface evaluation into command language grammar specifications. In: *People and Computers III*, Diaper, D. and Winder, R (Eds). Cambridge University Press: Cambridge. pp 11-28.
- Shepherd, A. (1989)  
Analysis and training in information technology tasks. In: *Task Analysis for Human Computer Interaction*. Diaper, D. (Ed). Chichester: Ellis Horwood, 1989.
- Shneiderman, B. (1987)  
*Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Reading, MA: Addison-Wesley.

- Somerville, I., Rodden, T., Sawyer, P. and Bentley, R. (1992)  
Sociologists can be Surprisingly Useful in Interactive Systems Design. In: *People and Computers VII*. Monk, A., Diaper, D. and Harrison, M.D. (Eds), Cambridge: Cambridge University Press, pp.341-353.
- Spinnaker Software Corporation (1991)  
*Spinnaker Plus User Manual*.
- Stammers, R. (1989)  
Simulation in training and in user interface design. In: *Simulation in the development of user interfaces*. Ergonomics Society, pp.1-4.
- Suchman, L. (1987)  
*Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge: Cambridge University Press.
- Sultana, N. (1990)  
Nurses' attitudes towards computerisation in clinical practice. *Journal of Advanced Nursing*, 15, pp.696-701.
- Sutcliffe, A. (1988)  
*Human-Computer Interface Design*. London: Macmillan.
- Sutcliffe, A. (1988)  
Some Experiences in Integrating Specification of Human Computer Interaction within a Structured System Development Method. In: *People and Computers IV*. Jones, D.M. and Winder, R. (Eds) Cambridge University Press: Cambridge. pp.145-160.
- Sutcliffe, A. (1989)  
Task analysis, systems analysis and design: symbiosis or synthesis? *Interacting with Computers*, 1(1), pp 6-12.
- Sweeney, M., Maguire, M. and Shackel, B. (1993)  
Evaluating user-computer interaction: a framework. *International Journal of Man-Machine Studies* 38, pp.689-711.
- Tange, H.J. and Smeets, R.P.H.M. (1993)  
Information exchange between physicians and nurses. In: *Proc MIE 93*, Reichert, A., Sadan, B.A., Bengtsson, S., Bryant, J. and Piccolo, U. (Eds) London: Freund, pp.213-217.
- Teach, R.L. and Shortliffe, E.D. (1981)  
An analysis of physician attitudes regarding computer-based clinical consultation systems. *Computers in Biomedical Research* 14, pp.542-558.
- Tetzlaff, L. and Mack, R. (1991)  
Discussion: Perspectives on Methodology in HCI Research and Practice. In: *Designing Interaction: Psychology at the Human-Computer Interface*. Carroll, J.M. (Ed).Cambridge: Cambridge University Press, pp.286-314.
- Thimbleby, H. (1990)  
*User Interface Design*. New York: ACM Press.

- Thorp, J. (1993)  
Hospital information systems: the current state of play. *Computer Bulletin*, 5(3), pp.7-9.
- Timpka, T., Hedblom, P. and Holmgren, H. (1991)  
ACTION DESIGN: Using an Object-oriented Environment for Group Process Development of Medical Software. In: *Software Engineering in Medical Informatics*. Timmers, T. and Blum, B.I. (Eds) North-Holland: Elsevier Science, pp. 151-165.
- Turnbull, N.B., Miles, N.A. and Gallen, I.W. (1990)  
Junior doctors' on call activities: differences in workload and patterns among grades. *British Medical Journal* 301, pp.1191-1192.
- Tyldesley, D. A. (1988)  
Employing Usability Engineering in the Development of Office Products. *Computer Journal* 31(5), pp.431-436.
- Tyson, J.E., Clarkson, J.E., Sinclair, J.C. and Leitch, R. (1981)  
Analysis of newborn intensive care by time-lapse photography. *Critical Care Medicine*, 9(11), pp.780-784.
- Upton, P. (1989)  
House officers' workload - little change in 20 years. *Health Bulletin (Edinburgh)*, 47(4), pp.179-181.
- Vainio-Larsson, A. and Orring, R. (1990)  
Evaluating the usability of user interfaces: research in practice. *Human-Computer Interaction- Interact '90* Diaper, D., Gilmore, D., Cockton, G. and Shackel, B. (Eds). North Holland: Elsevier, pp.329-335.
- Vincent, R. (1993)  
Computers and the clinician. *Computer Bulletin*, 5(3), pp12-13.
- Walker, J. (1990)  
Through the looking glass. In: *The Art of Human-Computer Interface Design*. Laurel, B. (Ed). Reading, MA : Addison Wesley, pp. 439-447.
- Wallace, M.D. and Anderson, T.J. (1993)  
Approaches to Interface Design. *Interacting with Computers*. 5(3), pp.259-278.
- Walsh, P.A. (1989)  
Analysis for Task Object Modelling (ATOM): towards a method of integrating task analysis with Jackson System Development for user interface software design. In: *Task Analysis for Human-Computer Interaction*. Diaper, D. (Ed). Chichester: Ellis Horwood, pp.186-209.
- Warnock-Matherton, A. and Plummer, C. (1988)  
Introducing nursing information systems in the clinical setting. In: *Nursing Informatics. Where Caring and Technology Meet*, Ball, M.J., Hannah, K.J., Gerdin Jelger, U. and Peterson, H. (Eds). New York: Springer-Verlag, pp.115-127.

- Warren, C.P. (1993)  
The TOM approach to system development: methods and tools for task oriented modelling of real-time safety critical systems. In: *Human-Computer Interaction: Software and Hardware Interfaces, Proc HCI International '93*. Salvendy, G. and Smith, M.J. (Eds). Amsterdam: Elsevier, pp.285-290.
- Warren, L. (1992)  
Power, corruption and lies. *British Journal of Healthcare Computing*.9(7), pp.9-12.
- Whitefield, A., Wight, J., Life, A. and Colbert, M. (1991a)  
Assessing the Programming Language PML as a Task Analysis Method and Product. In: *People and Computers VI*. Diaper, D. and Hammond, N. (Eds) Cambridge: Cambridge University Press, pp.403-417.
- Whitefield, A., Wilson, F. & Dowell, J. (1991b)  
A Framework for Human Factors Evaluation. *Behaviour and Information Technology*, 10(1), pp.65-80.
- Whiteside, J., Bennett, J., and Holtzblatt, K. (1988)  
Usability Engineering: Our Experience and Evolution. In: *Handbook of Human-Computer Interaction* Helander, M (Ed), North-Holland:Elsevier, pp.791-817.
- Wilson, M.D., Barnard, P.J., Green, T.R.G. and Maclean, A. (1988)  
Knowledge-based task analysis for human-computer systems. In: *Working with computers: theory versus outcome*. Van Der Veer, G.C., Green, T.R.G., Hoc, J. and Murray, D.M.(Eds). London: Academic Press, pp.47-87.
- Wilson, S., Johnson, P., Markopoulos, P. and Pycock, J. (1992)  
Adept: task based user interface design. *HCI'92 Conference demonstration*. York, September, 1992.
- Winer, B.J. (1971)  
*Statistical principles in Experimental Design 2nd Edition*, New York: McGraw-Hill.
- Winograd, T. & Flores, F. (1986)  
*Understanding Computers and Cognition: A New Foundation for Design*. Norwood, New Jersey: Ablex.
- Worthington, D. and Guy, M. (1988)  
Allocating nursing staff to hospital wards - a case study. *European Journal of Operational Research*, 33, pp.174-182.
- Young, D.W. (1990)  
Clinical computing systems: their slow introduction. *Postgraduate Medical Journal*, 66, pp.333-335.
- Young, D.W., Chapman, T. and Poile, C. (1990)  
Physician reveal thyself. *British Journal of Healthcare Computing*, 7(9), pp.18-21.

# Appendix A

## Selected TAKD stages

### A1 Activity lists

These are included both for the analysis and evaluation stages. They are presented in the form of specific action and object lists, in which the activity line numbers and specific objects are denoted.

#### A1.1 Completion of request forms

##### A1.1.1 Medical ward

#%509	32 write (requesting doctor)
#+1	33 write (bleep number)
1 stick on (sticky label)	34 select investigation (FBC)
2 write (ward)	35 write (date)
3 write (consultant)	#-4
4 select investigation (U&E)	#+5
5 give clinical condition (fast AF)	36 stick on (sticky label)
6 give clinical condition (CCF)	37 write (consultant)
7 request specimen (VB)	38 write (ward)
8 write (date)	39 select investigation (U&E)
9 write (requesting doctor)	40 give clinical condition (MI)
10 write (bleep number)	41 report drug therapy (on diuretin)
#-1	42 write (bleep number)
#+2	43 write (requesting doctor)
11 stick on (sticky label)	44 write (date)
12 write (ward)	45 request specimen (VB)
13 write (consultant)	#-5
14 give clinical condition (fast AF)	#+6
15 give clinical condition (CCF)	46 stick on (sticky label)
16 write (requesting doctor)	47 write (consultant)
17 write (bleep number)	48 write (ward)
18 select investigation (FBC)	49 give clinical condition (MI)
19 write (date)	50 give clinical condition (anaemic)
#-2	51 write (requesting doctor)
#+3	52 write (bleep number)
20 stick on (sticky label)	53 select investigation (FBC)
21 write (ward)	54 write (date)
22 write (consultant)	#-6
23 select investigation (U&E)	#+7
24 speculate on clinical condition (?CVA)	55 stick on (sticky label)
25 request specimen (VB)	56 write (consultant)
26 write (requesting doctor)	57 write (ward)
27 write (bleep number)	58 select investigation (U&E)
#-3	59 request specimen (VB)
#+4	60 write (date)
28 stick on (sticky label)	61 write (requesting doctor)
29 write (consultant)	62 write (bleep number)
30 write (ward)	63 give clinical condition (confusion)
31 speculate on clinical condition (?CVA)	64 give clinical condition ('downarrow' Na+)
	65 query cause of clinical condition (?cause)

#-7  
#+8  
66 stick on (sticky label)  
67 write (ward)  
68 write (consultant)  
69 give clinical condition (confusion)  
70 query cause of clinical condition (?cause)  
71 select investigation (FBC)  
72 write (requesting doctor)  
73 write (bleep number)  
74 write (date)  
#-8  
#+9  
75 stick on (sticky label)  
76 write (consultant)  
77 write (ward)  
78 select investigation (U&E)  
79 report drug therapy (on diuretin)  
80 give clinical condition (CCF)  
81 request specimen (VB)  
82 write (date)  
83 write (requesting doctor)  
84 write (bleep number)  
#-9  
#+10  
85 stick on (sticky label)  
86 write (ward)  
87 write (consultant)  
88 give clinical condition (CCF)  
89 write (requesting doctor)  
90 write (bleep number)  
91 select investigation (FBC)  
92 write (date)  
#-10  
#+11  
93 stick on (sticky label)  
94 write (consultant)  
95 write (ward)  
96 give clinical condition (DM)  
97 give clinical condition (infected foot)  
98 select investigation (U&E)  
99 report drug therapy (on diuretin)  
100 request specimen (VB)  
101 write (date)  
102 write (requesting doctor)  
103 write (bleep number)  
#-11  
#+12  
104 stick on (sticky label)  
105 give clinical condition (DM)  
106 give clinical condition (infected foot)  
107 write (consultant)  
108 write (ward)  
109 write (requesting doctor)  
110 write (bleep number)  
111 select investigation (FBC)  
112 write (date)  
#-12  
#+13  
113 stick on (sticky label)

114 write (consultant)  
115 write (ward)  
116 give clinical condition (CCF)  
117 report drug therapy (diuretin)  
118 select investigation (U&E)  
119 request specimen (VB)  
120 write (date)  
121 write (requesting doctor)  
122 write (bleep number)  
#-13  
#+14  
123 stick on (sticky label)  
124 write (ward)  
125 write (consultant)  
126 give clinical condition (CCF)  
127 write (requesting doctor)  
128 write (bleep number)  
129 select investigation (FBC)  
130 write (date)  
#-14  
#+15  
131 stick on (sticky label)  
132 write (ward)  
133 give clinical condition (post Tx)  
134 write (consultant)  
135 select investigation (U&E)  
136 request specimen (VB)  
137 write (date)  
138 write (requesting doctor)  
139 write (bleep number)  
#-15  
#+16  
140 stick on (sticky label)  
141 give clinical condition (post Tx)  
142 select investigation (FBC)  
143 write (date)  
144 write (requesting doctor)  
145 write (bleep number)  
146 write (consultant)  
147 write (ward)  
#-16  
#+17  
148 stick on (sticky label)  
149 write (ward)  
150 write (consultant)  
151 select investigation (U&E)  
152 select investigation (LFT)  
153 request specimen (VB)  
154 write (date)  
155 report drug therapy (dig)  
156 give clinical condition (chest infection)  
157 write (requesting doctor)  
158 write (bleep number)  
#-17  
#+18  
159 stick on (sticky label)  
160 write (ward)  
161 write (consultant)  
162 give clinical condition (chest infection)  
163 write (requesting doctor)

164 write (bleep number)  
165 select investigation (FBC)  
166 write (date)  
#-18  
#+19  
167 stick on (sticky label)  
168 write (ward)  
169 write (consultant)  
170 select investigation (U&E)  
171 give clinical condition (chest infection)  
172 request specimen (VB)  
173 write (date)  
174 write (requesting doctor)  
175 write (bleep number)  
#-19  
#+20  
176 stick on (sticky label)  
177 write (ward)  
178 write (consultant)  
179 give clinical condition (chest infection)  
180 select investigation (FBC)  
181 write (requesting doctor)  
182 write (bleep number)  
#-20  
#+21  
183 stick on (sticky label)  
184 write (ward)  
185 write (consultant)  
186 select investigation (U&E)  
187 give clinical condition (CCF)  
188 request specimen (VB)  
189 write (date)  
190 write (requesting doctor)  
191 write (bleep number)  
#-21  
#+22  
192 stick on (sticky label)  
193 give clinical condition (CCF)  
194 write (consultant)  
195 write (ward)  
196 write (requesting doctor)  
197 write (bleep number)  
198 select investigation (FBC)  
199 write (date)  
#-22  
#+23  
200 stick on (sticky label)  
201 write (ward)  
202 write (consultant)  
203 select investigation (U&E)  
204 request specimen (VB)  
205 write (date)  
206 write (requesting doctor)  
207 write (bleep number)  
208 give clinical condition (GI bleed)  
#-23  
#+24  
209 stick on (sticky label)  
210 write (ward)  
211 write (consultant)

212 write (requesting doctor)  
213 write (bleep number)  
214 select investigation (FBC)  
215 write (date)  
216 give clinical condition (GI bleed)  
217 give clinical condition (abdominal pain)  
#-24  
#+25  
218 stick on (sticky label)  
219 give clinical condition (chest infection)  
220 write (consultant)  
221 write (ward)  
222 select investigation (U&E)  
223 request specimen (VB)  
224 write (date)  
225 write (requesting doctor)  
226 write (bleep number)  
#-25  
#+26  
227 stick on (sticky label)  
228 write (consultant)  
229 write (ward)  
230 give clinical condition (chest infection)  
231 write (requesting doctor)  
232 write (bleep number)  
233 select investigation (FBC)  
234 write (date)  
#-26  
#+27  
235 stick on (sticky label)  
236 write (ward)  
237 write (consultant)  
238 select investigation (U&E)  
239 give clinical condition (DM)  
240 write (bleep number)  
241 write (requesting doctor)  
242 request specimen (VB)  
243 write (date)  
#-27  
#+28  
244 stick on (sticky label)  
245 write (consultant)  
246 write (ward)  
247 write (requesting doctor)  
248 write (bleep number)  
249 give clinical condition (DM)  
250 select investigation (FBC)  
251 write (date)  
#-28  
#+29  
252 stick on (sticky label)  
253 give clinical condition (pneumonic)  
254 write (consultant)  
255 write (ward)  
256 select investigation (U&E)  
257 request specimen (VB)  
258 write (date)  
259 write (requesting doctor)  
260 write (bleep number)  
#-29

#+30	309 write (ward)
261 stick on (sticky label)	310 write (consultant)
262 write (consultant)	311 select investigation (U&E)
263 write (ward)	312 give clinical condition (chest infection)
264 give clinical condition (pneumonia)	313 request specimen (VB)
265 select investigation (FBC)	314 write (date)
266 write (requesting doctor)	315 write (requesting doctor)
267 write (bleep number)	316 write (bleep number)
268 write (date)	#-35
#-30	#+36
#+31	317 stick on (sticky label)
269 give clinical condition (MI)	318 write (consultant)
270 stick on (sticky label)	319 write (ward)
271 write (ward)	320 select investigation (U&E)
272 write (consultant)	321 give clinical details (COAD)
273 select investigation (CEPIII)	322 write (requesting doctor)
274 select investigation (U&E)	323 write (bleep number)
275 request specimen (VB)	324 request specimen (VB)
276 write (date)	325 write (date)
277 write (requesting doctor)	#-36
278 write (bleep number)	#+37
#-31	326 write (hospital number)
#+32	327 write (forename)
279 stick on (sticky label)	328 write (surname)
280 give clinical condition (MI)	329 write (ward)
281 give clinical condition (LVF)	330 write (consultant)
282 write (consultant)	331 select investigation (U&E)
283 write (ward)	332 request specimen (VB)
284 write (requesting doctor)	333 write (date)
285 write (bleep number)	334 write (requesting doctor)
286 select investigation (FBC)	335 write (bleep number)
287 write (date)	336 give clinical condition (CCF)
#-32	337 report drug therapy (on diuretin)
#+33	#-37
288 select investigation (U&E)	#+38
289 select investigation (CEPII)	338 write (surname)
290 stick on (sticky label)	339 write (forename)
291 write (consultant)	340 write (dob)
292 write (ward)	341 write (sex)
293 request specimen (VB)	342 write (ward)
294 write (date)	343 write (consultant)
295 write (requesting doctor)	344 select investigation (blood gases)
296 write (bleep number)	345 give clinical condition (dyspnoea)
297 speculate on cause of clinical condition (?MI)	346 give clinical condition (cyanose)
#-33	347 report other therapy (on 22% O2)
#+34	348 request specimen (AB)
298 stick on (sticky label)	349 write (date)
299 select investigation (FBC)	350 write (requesting doctor)
300 select investigation (ESR)	351 write (bleep number)
301 write (requesting doctor)	#-38
302 write (date)	#+39
303 write (consultant)	352 write (surname)
304 write (ward)	353 write (forename)
305 give clinical condition (dig toxicity)	354 write (hospital number)
306 give clinical condition (pneumonia)	355 write (ward)
307 speculate on clinical condition (?My)	356 write (consultant)
#-34	357 select investigation (CEPIII)
#+35	358 select investigation (U&E)
308 stick on (sticky label)	359 give clinical condition (LVF)

360 query cause of clinical condition (?2\* to MI)  
361 report drug therapy (on IV frusemide)  
362 request specimen (VB)  
363 write (date)  
364 write (requesting doctor)  
365 write (bleep number)  
#-39  
#+40  
366 write (forename)  
367 write (surname)  
368 write (hospital number)  
369 write (ward)  
370 write (consultant)  
371 give clinical condition (uparrow WCC)  
372 query cause of clinical condition (?canc)  
373 query cause of clinical condition (?malignancy)  
374 write (requesting doctor)  
375 write (bleep number)  
376 select investigation (FBC)  
377 write (date)  
#-40  
#+41  
378 stick on (sticky label)  
379 write (consultant)  
380 write (ward)  
381 speculate on clinical condition (?DVT)  
382 report drug therapy (heparin)  
383 request investigation (KCIT)  
384 write (date)  
385 write (requesting doctor)  
386 write (bleep number)  
#-41  
#+42  
387 write (forename)  
388 write (surname)  
389 write (hospital number)  
390 write (ward)  
391 write (consultant)  
392 request investigation (ACTH level)  
393 speculate on clinical condition (cyclical Cushing's syndrome)  
394 request specimen (VB)  
395 write (date)  
396 write (requesting doctor)  
397 write (bleep number)  
398 stipulate sample time (12.00pm midnight)  
#-42  
#+43  
399 write (forename)  
400 write (surname)  
401 write (hospital number)  
402 write (ward)  
403 write (consultant)  
404 request investigation (ACTH level)  
405 stipulate sample time (9.00am level)  
406 request specimen (VB)  
407 write (tomorrow's date)

408 speculate on clinical condition (cyclical Cushing's syndrome)  
409 give instructions about specimen (orange bottle empty -> ice -> lab immediately)  
410 write (requesting doctor)  
411 write (bleep number)  
#-43  
#+44  
412 write (forename)  
413 write (surname)  
414 write (hospital number)  
415 write (ward)  
416 write (consultant)  
417 select investigation (cortisol level)  
418 stipulate sample time (12.00pm midnight)  
419 request specimen (VB)  
420 write (date)  
421 speculate on clinical condition (cyclical Cushing's syndrome)  
422 write (requesting doctor)  
423 write (bleep number)  
#-44  
#+45  
424 write (forename)  
425 write (surname)  
426 write (hospital number)  
427 write (consultant)  
428 write (ward)  
429 select investigation (cortisol level)  
430 write (date)  
431 request specimen (VB)  
432 speculate on clinical condition (cyclical Cushing's syndrome)  
433 write (requesting doctor)  
434 write (bleep number)  
435 stipulate sample (9.00 am level)  
#-45  
#+46  
436 write (surname)  
437 write (forename)  
438 write (hospital number)  
439 write (consultant)  
440 write (ward)  
441 report on drug therapy (warfarin)  
442 write (requesting doctor)  
443 write (bleep number)  
444 select investigation (FBC)  
445 write (date)  
#-46  
#+47  
446 stick on (sticky label)  
447 write (ward)  
448 write (consultant)  
449 write (requesting doctor)  
450 write (bleep number)  
451 select investigation (FBC)  
452 give clinical condition (septicaemia)  
453 give clinical condition (pneumonia)  
454 write (date)  
#-47

#+48  
 455 write (forename)  
 456 write (surname)  
 457 write (hospital number)  
 458 write (ward)  
 459 write (consultant)  
 460 give clinical condition (pubic ramus -  
 pelvic haematoma)  
 461 write (requesting doctor)  
 462 write (bleep number)  
 463 select investigation (FBC)  
 464 write (date)  
 #-48  
 #+49  
 465 stick on (sticky label)  
 466 write (ward)  
 467 write (consultant)  
 468 select investigation (U&E)  
 469 request specimen (VB)  
 470 write (tomorrow's date)  
 471 write (requesting doctor)  
 472 write (bleep number)  
 473 give clinical condition (chronic renal  
 failure)  
 474 report drug therapy (on high dose  
 diuretics)  
 #-49  
 #+50  
 475 stick on (sticky label)  
 476 write (ward)  
 477 write (consultant)  
 478 select investigation (U&E)  
 479 request specimen (VB)  
 480 write (tomorrow's date)  
 481 give clinical condition (severe CCF)  
 482 report drug therapy (on high dose diuretic)  
 483 write (requesting doctor)  
 484 write (bleep number)  
 #-50  
 #+51  
 485 stick on (sticky label)  
 486 write (ward)  
 487 write (consultant)  
 488 select investigation (U&E)  
 489 request specimen (VB)  
 490 write (date)  
 491 give clinical condition (dehydration)  
 492 report other therapy (on IV fluids)  
 493 write (requesting doctor)  
 494 write (bleep number)  
 #-51  
 #+52  
 495 stick on (sticky label)  
 496 write (date)  
 497 request specimen (urine)  
 498 write (requesting doctor)  
 499 write (bleep number)  
 500 write (consultant)  
 501 write (ward)  
 502 report clinical condition (pigmented skin)  
 503 request investigation (24hr urinary free  
 cortoid)  
 #-52

## A1.1.2 Surgical ward

#%199  
#+1  
1 stick on (sticky label)  
2 report clinical details (pre-op turp)  
3 request specimen (VB)  
4 write (date)  
5 select investigation (FBC)  
6 write (requesting doctor)  
7 write (bleep number)  
#-1  
#+2  
8 stick on (sticky label)  
9 select specimen (VB)  
10 write (date)  
11 select investigation (U&E)  
12 report clinical details (pre-op turp)  
13 write (requesting doctor)  
14 select investigation (RBS)  
15 write (bleep number)  
#-2  
#+3  
16 select investigation (FBC)  
17 request specimen (VB)  
18 write (date)  
19 stick on (sticky label)  
20 report clinical details (pre-op frenuloplasty)  
21 write (requesting doctor)  
22 write (bleep number)  
#-3  
#+4  
23 request specimen (VB)  
24 write (date)  
25 select investigation (U&E)  
26 stick on (sticky label)  
27 report clinical details (pre-op frenuloplasty)  
28 write (requesting doctor)  
29 write (bleep number)  
#-4  
#+5  
30 stick on (sticky label)  
31 request specimen (VB)  
32 write (date)  
33 select investigation (FBC)  
34 report clinical details (pre-op turp)  
35 write (requesting doctor)  
36 write (bleep number)  
#-5  
#+6  
37 request specimen (VB)  
38 write (date)  
39 select investigation (RBS)  
40 select investigation (U&E)  
41 write (requesting doctor)  
42 write (bleep number)  
43 report clinical details (pre-op turp)  
#-6  
#+7  
44 stick on (sticky label)  
45 request specimen (VB)  
46 write (date)  
47 select investigation (FBC)  
48 report clinical details (pre-op turp)  
49 write (requesting doctor)  
50 write (bleep number)  
#-7  
#+8  
51 request specimen (VB)  
52 write (date)  
53 select investigation (U&E)  
54 stick on (sticky label)  
55 report clinical details (pre-op turp)  
56 write (requesting doctor)  
57 write (bleep number)  
#-8  
#+9  
58 request specimen (VB)  
59 write (date)  
60 select investigation (U&E)  
61 stick on (sticky label)  
62 write (requesting doctor)  
63 write (bleep number)  
64 report clinical details (pre-op)  
#-9  
#+10  
65 select investigation (FBC)  
66 request specimen (VB)  
67 write (date)  
68 stick on (sticky label)  
69 write (requesting doctor)  
70 write (bleep number)  
71 report clinical details (pre-op)  
#-10  
#+11  
72 request specimen (VB)  
73 write (date)  
74 select investigation (FBC)  
75 report clinical details (pre-op turt)  
76 write (requesting doctor)  
77 write (bleep number)  
78 stick on (sticky label)  
#-11  
#+12  
79 request specimen (VB)  
80 write (date)  
81 select investigation (U&E)  
82 select investigation (RBS)  
83 report clinical details (pre-op turt)  
84 write (requesting doctor)  
85 write (bleep number)  
86 stick on (sticky label)  
#-12  
#+13  
87 request specimen (VB)  
88 write (date)  
89 select investigation (FBC)  
90 stick on (sticky label)

91 report clinical details (pre-op turp)  
 92 write (requesting doctor)  
 93 write (bleep number)  
 #-13  
 #+14  
 94 request specimen (VB)  
 95 write (date)  
 96 select investigation (U&E)  
 97 select investigation (RBS)  
 98 stick on (sticky label)  
 99 report clinical details (pre-op turp)  
 100 write (requesting doctor)  
 101 write (bleep number)  
 #-14  
 #+15  
 102 stick on (sticky label)  
 103 request specimen (VB)  
 104 write (date)  
 105 select investigation (FBC)  
 106 report clinical details (for BSO)  
 107 write (requesting doctor)  
 108 write (bleep number)  
 #-15  
 #+16  
 109 stick on (sticky label)  
 110 request specimen (VB)  
 111 write (date)  
 112 select investigation (U&E)  
 113 select investigation (RBS)  
 114 report clinical details (pre-op BSO)  
 115 write (requesting doctor)  
 116 write (bleep number)  
 #-16  
 #+17  
 117 fill in on ward round  
 118 stick on (sticky label)  
 119 select investigation (FBC)  
 120 fill in after ward round  
 121 request specimen (VB)  
 122 write (date)  
 123 write (requesting doctor)  
 124 write (bleep number)  
 #-17  
 #+18  
 125 fill in on ward round  
 126 stick on (sticky label)  
 127 request specimen (VB)  
 128 write (date)  
 129 select investigation (U&E)  
 130 write (requesting doctor)  
 131 write (bleep number)  
 132 report clinical details (clinically dehydrated)  
 #-18  
 #+19  
 133 fill in on ward round  
 134 stick on (sticky label)  
 135 select investigation (U&E)  
 136 fill in after ward round  
 137 request specimen (VB)  
 138 write (date)  
 139 write (requesting doctor)  
 140 write (bleep number)  
 #-19  
 #+20  
 141 fill in on ward round  
 142 stick on (outpatients sticky label)  
 143 request specimen (VB)  
 144 write (date)  
 145 select investigation (U&E)  
 146 write (ward)  
 147 write (consultant)  
 148 write (requesting doctor)  
 149 write (bleep number)  
 #-20  
 #+21  
 150 fill in on ward round  
 151 stick on (sticky label)  
 152 write (date)  
 153 select investigation (FBC)  
 154 report clinical details (details)  
 155 write (requesting doctor)  
 156 write (bleep number)  
 #-21  
 #+22  
 157 fill in on ward round  
 158 stick on (outpatients sticky label)  
 159 request specimen (VB)  
 160 write (date)  
 161 select investigation (FBC)  
 162 report clinical details (post-op turt)  
 163 write (requesting doctor)  
 164 write (bleep number)  
 165 write (consultant)  
 166 write (ward)  
 #-22  
 #+23  
 167 fill in on ward round  
 168 write (name)  
 169 write (hospital number)  
 170 write (date) of birth  
 171 write (sex)  
 172 write (hospital)  
 173 write (consultant)  
 174 write (ward)  
 175 request specimen (VB)  
 176 write (date)  
 177 select investigation (U&E)  
 178 report clinical details (post-op)  
 179 write (requesting doctor)  
 180 write (bleep number)  
 #-23  
 #+24  
 181 fill in on ward round  
 182 stick on (sticky label)  
 183 request specimen (VB)  
 184 write (date)  
 185 request investigation (stone screen)  
 186 report clinical details (ureter colic)  
 187 write (requesting doctor)  
 188 write (bleep number)

#-24

#+25

189 fill in on ward round

190 stick on (sticky label)

191 select investigation (phosphate)

192 select investigation (cysteine)

193 select investigation (oxalate)

194 select investigation(uric acid)

195 select investigation(Ca<sup>2+</sup>)

196 write (requesting doctor)

197 write (bleep number)

198 request specimen (24 hrs urine collection)

#-25

## A1.2 Evaluation of the prototype

##545

1  
#+1  
2 select (add patient btn 3.2)  
3 enter (pat name 22.9)  
4 enter (hos no 10.3)  
5 enter (sex 2.6)  
6 enter (dob 23.2)  
7 enter (ward 10.1)  
8 enter (consultant 2.4)  
9 consider (current therapy 14.4)  
10 consider (save details btn 5.2)  
11 enter (working diagnosis 30)  
12 select (save details btn 1.8)  
13 select (show pat list btn 2.4)  
#-1  
#+2  
14 select (patient 6.7)  
15 select (U&E 2.9)  
16 select (print btn 0.8)  
17 enter (working diag 21.7)  
18 confirm (print form 5.1)  
#-2  
#+3  
19 select (patient 12.0)  
20 select (U&E 10.6)  
21 select (LFT 2.0)  
22 select (print btn 1.7)  
23 enter (working diag 14.23)  
24 confirm (print form 1.4)  
#-3  
#+4  
25 select (patient 2.1)  
26 select (KCCT 3.0)  
27 consider (test 2.8)  
28 select (print btn 2.1)  
29 enter (working diag 9.6)  
30 confirm (print form 1.3)  
#-4  
#+5  
31 select (add patient btn 2.1)  
32 select (save dets btn 15.4)  
33 undo selection (save details btn 23.1)  
34 select (exit btn 1.4)  
#-5  
#+6  
35 select (patient 3.5)  
36 select (INR 8.5)  
37 select (KCCT 1.8)  
38 search for (test 15.8)  
39 select (print btn 2.8)  
40 confirm (print form 0.9)  
#-6  
#+7  
41 select (patient 2.1)  
42 select (FBC 0.8)  
43 undo selection (FBC 2.6)

44 select (FBC & U&E)  
45 select (print btn 3.6)  
46 enter (working diagnosis 21.3)  
47 confirm (print form 2.9)  
48 select (exit btn 0.5)  
#-7  
#+8  
49 select (patient 4.1)  
50 search for (test 12.4)  
51 select (print icon 3.6)  
52 confirm (handwritten 4.1)  
53 confirm (print form 2.7)  
#-8  
#+9  
54 select (add patient btn 1.9)  
55 undo selection (add patient btn 52.4)  
56 select (patient 1.7)  
57 select (print icon 1.5)  
58 confirm (handwritten 1.8)  
59 confirm (print form 1.6)  
60 select (exit btn 3.0)  
#-9  
#+10  
61 select (patient 5.1)  
62 select (INR 6.0)  
63 select (KCCT 0.1)  
64 select (date btn 0.7)  
65 select (tomorrow 1.9)  
66 confirm (OK date 1.8)  
67 consider (clin dets 4.4)  
68 select (print btn 1.5)  
69 confirm (print form 2.1)  
#-10  
#+11  
70 select (patient 4.6)  
71 undo selection (show pat list 3.1)  
72 select (remove pat btn 0.9)  
73 select (patient 5.6)  
74 confirm (remove pat 1.1)  
#-11  
#+12  
75 select (patient 4.5)  
76 undo selection (show pat list 1.9)  
77 select (remove pat btn 0.5)  
78 select (patient 3.5)  
79 confirm (remove pat 1.4)  
#-12  
#+13  
80 select (remove pat btn 1.0)  
81 select (patient 3.1)  
82 confirm (remove pat 0.8)  
#-13  
#+14  
83 search for (patient 8.1)  
84 select (add pat btn 1.1)  
85 enter (pat name 17.8)  
86 enter (hos no 26.5)  
87 enter (sex 6.5)  
88 enter (dob 10.4)

89 enter (consultant 26.8)  
90 enter (working diagnosis 13.5)  
91 select (save details btn 1.7)  
92 consider (CEP2 5.2)  
93 consider (date btn 9.1)  
94 select (CEP2 2.9)  
95 select (print btn 4.2)  
96 confirm (print form 3.5)  
#-14  
#+15  
97 select (patient 1.9)  
98 select (date btn 1.6)  
99 select (tomorrow 1.0)  
100 select (OK 4.2)  
101 select (CEP3 2.0)  
102 select (print btn 2.2)  
103 confirm (print form 1.5)  
#-15  
#+16  
104 select (patient 11.1)  
105 select (U&E 2.8)  
106 consider (tests 5.2)  
107 select (print btn 1.6)  
108 confirm (print form 1.7)  
#-16  
#+17  
109 select (patient 1.3)  
110 undo selection (show pat list 2.0)  
111 select (remove pat btn 1.1)  
112 select (patient 1.5)  
113 confirm (remove pat 1.9)  
#-17  
#+18  
114 select (patient 2.4)  
115 select (INR 2.4)  
116 select (date btn 1.0)  
117 select (tomorrow 0.2)  
118 confirm (OK date 0.6)  
119 select (print btn 1.8)  
120 enter (therapy as working diag 16.7)  
121 confirm (print form 1.8)  
#-18  
#+19  
122 select (patient 5.3)  
123 consider (test 4.1)  
124 select (FBC & U&E 2.2)  
125 consider (test 4.0)  
126 select (LFT 1.5)  
127 consider (test 1.0)  
128 select (RBS 0.5)  
129 consider (test 5.8)  
130 select (print btn 1.8)  
131 enter (working diag 20.2)  
132 confirm (print form 2.3)  
#-19  
#+20  
133 select (patient 5.6)  
134 select (FBC 2.6)  
135 undo selection (FBC & U&E 2.6)  
136 select (LFT 2.7)

137 select (TFT 1.4)  
138 select (print btn 5.3)  
139 enter (working diag 10.6)  
140 confirm (print form 2.1)  
#-20  
#+21  
141 select (patient 2.5)  
142 select (CEP1 2.0)  
143 select (print btn 3.1)  
144 confirm (print form 2.1)  
#-21  
#+22  
145 select (patient 1.2)  
146 select (CEP2 1.8)  
147 select (date btn 1.4)  
148 select (tomorrow 2.4)  
149 confirm (OK date 2.4)  
150 select (print btn 1.3)  
151 confirm (print form 2.1)  
#-22  
#+23  
152 select (patient 1.8)  
153 select (CEP3 1.4)  
154 select (date btn 1.4)  
155 select (further ahead 1.9)  
156 enter (time ahead 5.0)  
157 confirm (OK date 2.5)  
158 select (print btn 0.6)  
159 confirm (print form 1.5)  
#-23  
#+24  
160 select (patient 3.1)  
161 select (U&E 3.6)  
162 select (urgent btn 1.9)  
163 select (phone btn 0.9)  
164 error removed this is blank  
165 confirm (OK phone 2.7)  
166 select (print btn 1.3)  
167 select (print btn 2.3)  
168 confirm (print form 1.4)  
#-24  
#+25  
169 select (patient 4.8)  
170 select (therapy btn 2.7)  
171 enter (therapy 14.7)  
172 select (clotting screen 12.2)  
173 select (print btn 2.1)  
174 confirm (print form 1.8)  
#-25  
#+26  
175 select (remove pat btn 2.1)  
176 select (patient 1.8)  
177 confirm (remove pat 4.6)  
#-26  
#+27  
178 select (patient 1.9)  
179 consider (test 2.0)  
180 select (FBC & U&E 1.7)  
181 consider (test 1.2)  
182 undo selection (FBC & U&E 0.9)

183 select (U&E 0.6)  
 184 consider (clin dets 2.5)  
 185 select (KCCT 3.4)  
 186 select (print btn 1.9)  
 187 undo selection (cancel print 4.7)  
 188 select (date btn 1.0)  
 189 select (tomorrow 1.1)  
 190 confirm (OK date 4.0)  
 191 consider (test 1.1)  
 192 select (print btn 1.4)  
 193 confirm (print form 2.2)  
 #-27  
 #+28  
 194 select (remove pat btn 1.3)  
 195 consider (patient 3.8)  
 196 select (patient 1.0)  
 197 confirm (remove pat 1.4)  
 198 scan list for discharged pats  
 199 select (no patient 19.0)  
 #-28  
 #+29  
 200 select (patient 2.9)  
 201 select (date btn 3.0)  
 202 select (tomorrow 1.4)  
 203 confirm (OK date 2.7)  
 204 consider (clin dets 6.6)  
 205 select (INR 2.0)  
 206 select (KCCT 0.9)  
 207 select (print btn 2.9)  
 208 confirm (print form 2.3)  
 #-29  
 #+30  
 209 select (patient 2.0)  
 210 select (FBC 1.4)  
 211 undo selection (FBC & U&E 1.4)  
 212 consider (test 1.1)  
 213 select (print btn 1.4)  
 214 confirm (print form 3.4)  
 215 select (exit btn 2.2)  
 #-30  
 #+31  
 216 select (add patient btn 2.1)  
 217 enter (pat name 9.1)  
 218 enter (hos no 10.4)  
 219 correct (hos no 4.5)  
 220 enter (sex 5.0)  
 221 enter (dob 7.8)  
 222 enter (ward 10.1)  
 223 enter (consultant 1.7)  
 224 consider (current therapy 14.4)  
 225 consider (save details btn 5.2)  
 226 enter (working diagnosis 10.4)  
 227 select (therapy btn 2.7)  
 228 select (current therapy label 6.2)  
 229 undo selection (error msg 2.7)  
 230 select (current therapy label 1.8)  
 231 select (current therapy label 0.7)  
 232 select (save details btn 3.8)  
 233 consider (therapy 2.6)  
 234 select (FBC & U&E 2.6)  
 235 select (RBS 4.0)  
 236 select (LFT 1.3)  
 237 select (therapy btn 3.2)  
 238 undo selection (cancel include 6.3)  
 239 select (print btn 4.7)  
 240 confirm (print form 3.0)  
 241 select (exit btn 2.9)  
 #-31  
 #+32  
 242 select (add patient btn 1.4)  
 243 enter (pat name 13.2)  
 244 enter (hos no 8.3)  
 245 enter (sex 2.5)  
 246 enter (dob 7.8)  
 247 enter (ward 10.1)  
 248 enter (consultant 2.7)  
 249 enter (working diagnosis 5.7)  
 250 enter (current therapy 5.5)  
 251 select (save details btn 1.4)  
 252 consider (test 1.5)  
 253 select (INR 3.1)  
 254 select (KCCT 3.0)  
 255 select (print btn 5.3)  
 256 confirm (print form 3.2)  
 257 select (exit btn 1.1)  
 #-32  
 #+33  
 258 select (date btn 1.6)  
 259 select hour btn 7.6)  
 260 select hour btn 1.6)  
 261 select hour btn 2.4)  
 262 undo selection (OK date 5.1)  
 263 select (patient 1.5)  
 264 select (date btn 1.8)  
 265 select (tomorrow btn 0.8)  
 266 confirm (OK date 1.4)  
 267 select (FBC & U&E 13.7)  
 268 select (LFT 1.6)  
 269 select (clotting screen 22.3)  
 270 consider (tests 0.5)  
 271 select (print btn 1.4)  
 272 confirm (print form 2.3)  
 #-33  
 #+34  
 273 select (date btn 0.9)  
 274 select (further ahead 0.5)  
 275 enter (2 days ahead 14.7)  
 276 confirm (OK date 9.7)  
 277 select (patient 2.7)  
 278 consider (test 8.0)  
 279 select (FBC & U&E 0.6)  
 280 consider (test 2.1)  
 281 select (print icon 1.4)  
 282 confirm (print form 1.7)  
 #-34  
 #+35  
 283 select (patient 2.6)  
 284 select (date btn 1.9)  
 285 select (further ahead 0.6)  
 286 enter (3 days ahead 3.7)

287 confirm (OK date 1.8)  
288 consider (test 3.2)  
289 select (FBC & U&E 1.8)  
290 select (LFT 1.8)  
291 select (icon clotting screen 32.9)  
292 consider (date 3.8)  
293 select (print btn 1.1)  
294 confirm (print fom 1.8)  
#-35  
#+36  
295 forgets that multiple forms are printed  
296 select (patient 6.1)  
297 consider (test 2.9)  
298 error removed this is blank  
299 select (FBC 2.5)  
300 select (Film 2.7)  
301 select (print icon 3.9)  
302 confirm (print form 2.3)  
#-36  
#+37  
303 consider (test 5.5)  
304 select (patient 1.8)  
305 select (ESR 1.8)  
306 select (print btn 5.1)  
307 confirm (print form 1.6)  
#-37  
#+38  
308 select (icon Haem screen 21.9)  
309 select (patient 3.7)  
310 consider (test 5.5)  
311 select (print icon 2.1)  
312 confirm (print form 1.7)  
#-38  
#+39  
313 select (immunoglobulins 10.1)  
314 consider (test 6.3)  
315 select (patient 5.7)  
316 select (print icon 2.0)  
317 confirm (print form 5.5)  
318 end of forget  
#-39  
#+40  
319 select (add patient btn 1.3)  
320 enter (pat name 28.6)  
321 enter (sex 1.1)  
322 enter (ward 8.6)  
323 enter (consultant 5.2)  
324 enter (working diagnosis 20.0)  
325 enter (current therapy 9.8)  
326 select (save details btn 2.7)  
327 select (date btn 2.6)  
328 select (tomorrow 2.9)  
329 confirm (OK date 2.7)  
330 consider (test 1.1)  
331 select (KCCT 1.1)  
332 select (INR 1.3)  
333 select (print btn 2.9)  
334 confirm (print form 2.0)  
#-40  
#+41

335 complete beginner  
336 select (add patient icon 1.9)  
337 enter (pat name 80.3)  
338 enter (sex 15.0)  
339 enter (ward 13.1)  
340 enter (consultant 13.4)  
341 enter (working diagnosis 52.2)  
342 enter (current therapy 42.6)  
343 select (FBC 8.0)  
344 undo selection (error msg 5.6)  
345 select (save details icon 3.2)  
346 select (change details btn 5.5)  
347 select (date btn 7.1)  
348 undo selection (error msg 15.0)  
349 select (date btn 10.0)  
350 undo selection (error msg 4.3)  
351 select (save details icon 3.0)  
352 select (date btn 16.2)  
353 select (tomorrow 3.4)  
354 confirm (OK date 3.3)  
355 select (FBC 3.3)  
356 select (clotting screen 30.7)  
357 select (print btn 4.2)  
358 confirm (print form 2.8)  
#-41  
#+42  
359 select (add patient icon 1.0)  
360 enter (name 8.5)  
361 enter (hos no 14.3)  
362 enter (sex 3.1)  
363 enter (dob 11.9)  
364 enter (consultant 9.5)  
365 enter (working diag 17.9)  
366 select (save details btn 10.4)  
367 consider (tests 2.4)  
368 select (amylase 2.3)  
369 unresponsive mouse  
370 select (TFT 8.3)  
371 select (print icon 2.9)  
372 confirm (print form 2.0)  
#-42  
#+43  
373 complete beginner  
374 select (patient 11.1)  
375 select (KCCT 9.0)  
376 select (print btn 39.3)  
377 confirm (print form 4.4)  
#-43  
#+44  
378 select (patient 8.3)  
379 select (KCCT 3.2)  
380 select (print btn 0.6)  
381 confirm (print form 3.4)  
382 select (exit btn 9.6)  
#-44  
#+45  
383 select (no patient 19.9)  
384 select (add patient btn 2.1)  
385 enter (name 21.1)  
386 enter (hos no 10.3)

387 enter (sex 17.5)  
388 enter (dob 8.7)  
389 enter (consultant 6.8)  
390 enter (working diag 17.6)  
391 select (save details btn 2.7)  
392 unresponsive mouse  
393 select (FBC & U&E 5.8)  
394 select (TFT 2.0)  
395 consider (date btn 4.7)  
396 select (RBS 2.7)  
397 select (print btn 3.5)  
398 confirm (print form 2.4)  
#-45  
#+46  
399 select (patient 10.5)  
400 first time for this function  
401 select (date btn 11.8)  
402 select (tomorrow 2.1)  
403 confirm (OK date 2.8)  
404 select (KCCT 4.6)  
405 wrong patient  
406 select (show pat list btn 23.3)  
407 select (exit btn 4.6)  
#-46  
#+47  
408 select (patient 7.4)  
409 consider (tests 2.5)  
410 select (FBC 0.5)  
411 select (ESR 1.8)  
412 select (LFT 10.5)  
413 select (TFT 0.7)  
414 consider (tests 4.0)  
415 select (print btn 2.8)  
416 confirm (print form 3.0)  
#-47  
#+48  
417 select (patient 5.5)  
418 consider (tests 2.0)  
419 select (date btn 1.3)  
420 select (tomorrow 1.1)  
421 confirm (OK date 2.6)  
422 select (INR 4.0)  
423 select (KCCT 0.9)  
424 select (date btn 5.0)  
425 select (further ahead 1.0)  
426 undo selection (cancel no of days 20.0)  
427 undo selection (cancel set date 2.7)  
428 select (print btn 0.7)  
429 undo selection (cancel confirm 15.0)  
430 select (date btn 3.6)  
431 select (tomorrow 4.7)  
432 confirm (OK date 1.6)  
433 select (print btn 0.3)  
434 confirm (print form 2.9)  
#-48  
#+49  
435 select (patient 1.9)  
436 select (date btn 1.7)  
437 select (further ahead 0.9)  
438 enter (2 days ahead 6.2)

439 confirm (OK date 0.8)  
440 select (KCCT 3.4)  
441 select (INR 1.0)  
442 select (print btn 2.4)  
443 confirm (print form 2.4)  
#-49  
#+50  
444 select (patient 1.3)  
445 select (date btn 1.5)  
446 select (further ahead 1.5)  
447 enter (3 days ahead 3.5)  
448 confirm (OK date 3.4)  
449 select (INR 0.9)  
450 select (KCCT 0.7)  
451 select (print btn 1.7)  
452 confirm (print form 1.6)  
453 select (exit btn 1.4)  
#-50  
#+51  
454 select (patient 10.9)  
455 select (TFT 3.5)  
456 select (print btn 3.8)  
457 confirm (print form 1.6)  
458 select (exit icon 1.2)  
#-51  
#+52  
459 select (patient 1.6)  
460 select (Digoxin 5.2)  
461 select (U&E 103.0)  
462 select (print icon 4.0)  
463 confirm (print form 2.0)  
464 select (exit icon 0.5)  
#-52  
#+53  
465 select (patient 1.1)  
466 select (working diag fld 1.7)  
467 consider (clin dets 2.2)  
468 consider (tests 2.3)  
469 select (U&E 1.6)  
470 consider (tests 6.1)  
471 select (calcium 2.7)  
472 select (LFT 5.2)  
473 consider (tests 39.5)  
474 select (TFT 2.0)  
475 consider (clin dets 5.2)  
476 select (print btn 3.8)  
477 confirm (print form 1.7)  
#-53  
#+54  
478 select (no patient 23.0)  
479 select (add patient btn 3.9)  
480 enter (name 31.0)  
481 enter (hos no 10.1)  
482 enter (sex 2.1)  
483 enter (dob 14.0)  
484 enter (working diag 68.4)  
485 select (U&E greyed 8.5)  
486 select (save details btn 2.7)  
487 undo selection (OK save details 3.9)  
488 select (save details btn 1.4)

489 select (U&E 9.1)  
490 select (digoxin 8.7)  
491 select (LFT 10.4)  
492 consider (tests 7.0)  
493 select (TFT 1.9)  
494 consider (tests 3.1)  
495 select (print btn 1.5)  
496 confirm (print form 4.0)  
#-54  
#+55  
497 select (patient 1.6)  
498 consider (tests 4.5)  
499 select (INR 2.0)  
500 select (print btn 3.3.)  
501 confirm (print form 1.9)  
#-55  
#+56  
502 select (add patient btn 3.7)  
503 enter (name 10.2)  
504 enter (hos no 24.6)  
505 enter (sex 4.8)  
506 enter (dob 21.7)  
507 enter (ward 8.2 )  
508 enter (consultant 4.3)  
509 correct (ward 30.1)  
510 consider (clin dets 21.1)  
511 consider (tests 4.7)  
512 select (save details btn 5.6)  
513 consider (patient details 4.1)  
514 select (U&E 4.1)  
515 select (print btn 9.0)  
516 confirm (print btn 1.6)  
#-56

#+57  
517 select (date btn 0.6)  
518 select (tomorrow 3.1)  
519 confirm (OK date 0.9)  
520 consider (tests 3.8)  
521 select (U&E 1.5)  
522 thought was still in patient  
523 select (no print btn 11.7)  
524 select (exit btn 7.5)  
525 login (login 8.5)  
526 select (patient 18.9)  
527 select (U&E 7.4)  
528 select (print btn 1.9)  
529 confirm (print form 2.2)  
#-57  
#+58  
530 select (patient 1.7)  
531 select (date btn 1.7)  
532 first time for further ahead  
533 select (further ahead 39.2)  
534 enter (1 day ahead 9.8)  
535 confirm (OK date 4.8)  
536 select (date btn 1.6)  
537 select (further ahead 0.4)  
538 enter (2 days ahead 3.0)  
539 confirm (OK date 1.6)  
540 select (print btn 2.7)  
541 confirm (no tests error msg 5.8)  
542 select (U&E 2.8)  
543 select (print btn 1.9)  
544 confirm (print form 1.8)  
#-58

## A2 Task Descriptive Hierarchies

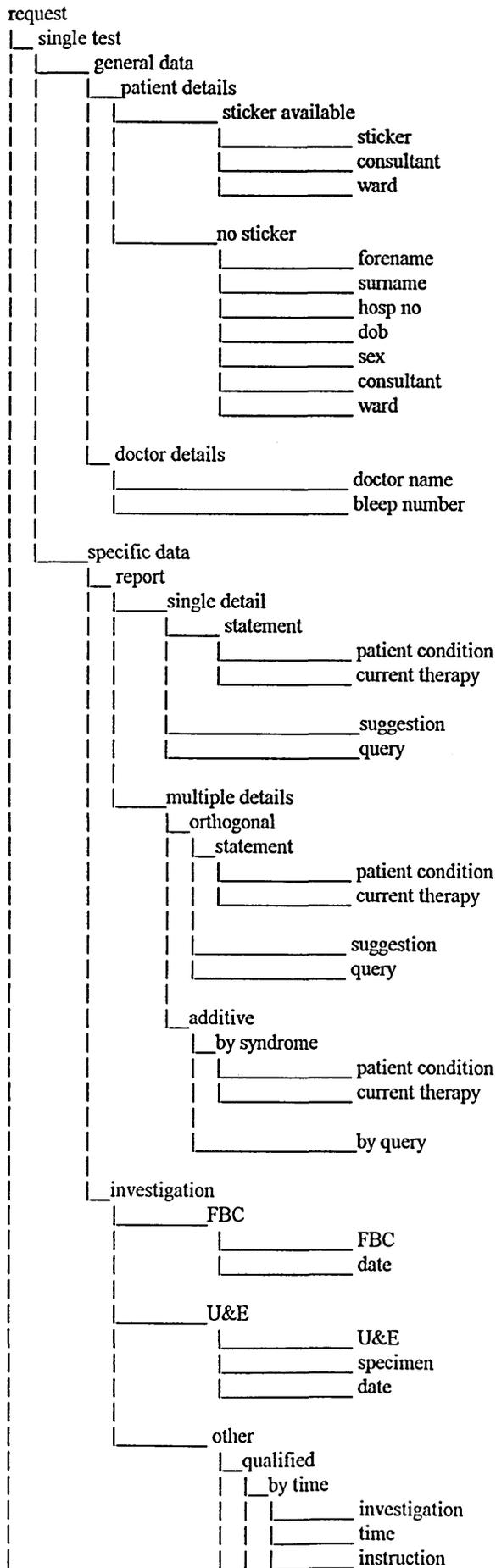
These are included for the analysis and evaluation stages, and are presented in 'skeleton' form. A complete TDH with attached specific objects is presented for the evaluation and for the final analysis of the surgical ward. For the sake of brevity, complete TDHs are not included for the first pass analysis, or for the final analysis of the medical ward.

### A2.1 First pass TDH skeleton, analysis stage

```
fill in
{__report
{  {__current therapy
{    {
{      {_____ non-drug
{      {
{        {__drug
{        {
{          {_____ qualified
{          {
{            {_____ unqualified
{            {
{              {_____ abbreviation
{              {
{                {_____ full text
{                {
{          {
{        {
{      {
{    {
{  {__patient condition
{    /__ set size
{      / _____ one
{      / _____ two
{      / _____ three
{      /
{    /__ form
{      / _____ text only
{      / _____ with abbreviation
{      / _____ full text
{      /
{      / _____ acronym
{      / _____ no text
{      / _____ with text
{      /
{    /__ certainty
{      _____ query
{      _____ suggestion
{      _____ statement
{
{  {__state
{    /_____ doctor details
{      / _____ bleep number
{      / _____ requesting doctor
{      /
{    /_____ patient details
{      _____ sticker available
{        _____ outpatient sticker
{          /_____ sticker
{          /_____ consultant
{          /_____ ward
{        _____ inpatient sticker
{          {_____ sticker
{          {_____ consultant
{          {_____ ward
{        _____ no sticker
{          {_____ hospital
{          {_____ forename
{          {_____ surname
{          {_____ hospital number
```



## A2.2 Final TDH skeleton, analysis stage



by sequence  
unqualified  
specimen  
date

multiple tests

single form

general data

patient details

sticker available  
sticker  
consultant  
ward

no sticker  
forename  
surname  
hosp no  
dob  
sex  
consultant  
ward

doctor details

doctor name  
bleep number

specific data

report

single detail

statement  
patient condition  
current therapy  
suggestion  
query

multiple details

orthogonal

statement  
patient condition  
current therapy  
suggestion  
query

additive

by syndrome  
patient condition  
current therapy  
by query

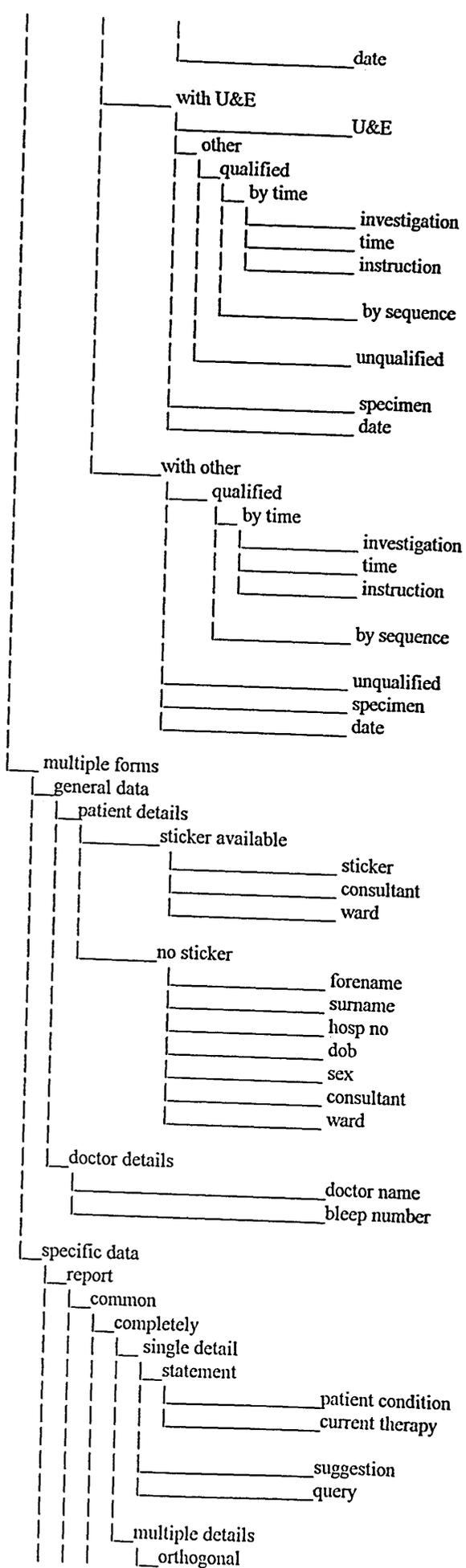
investigation

with FBC

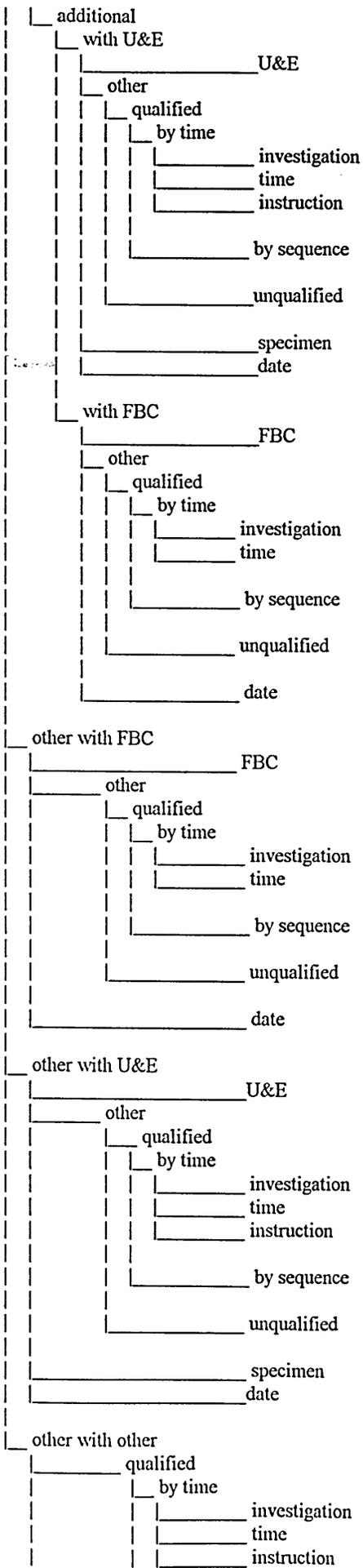
FBC

other

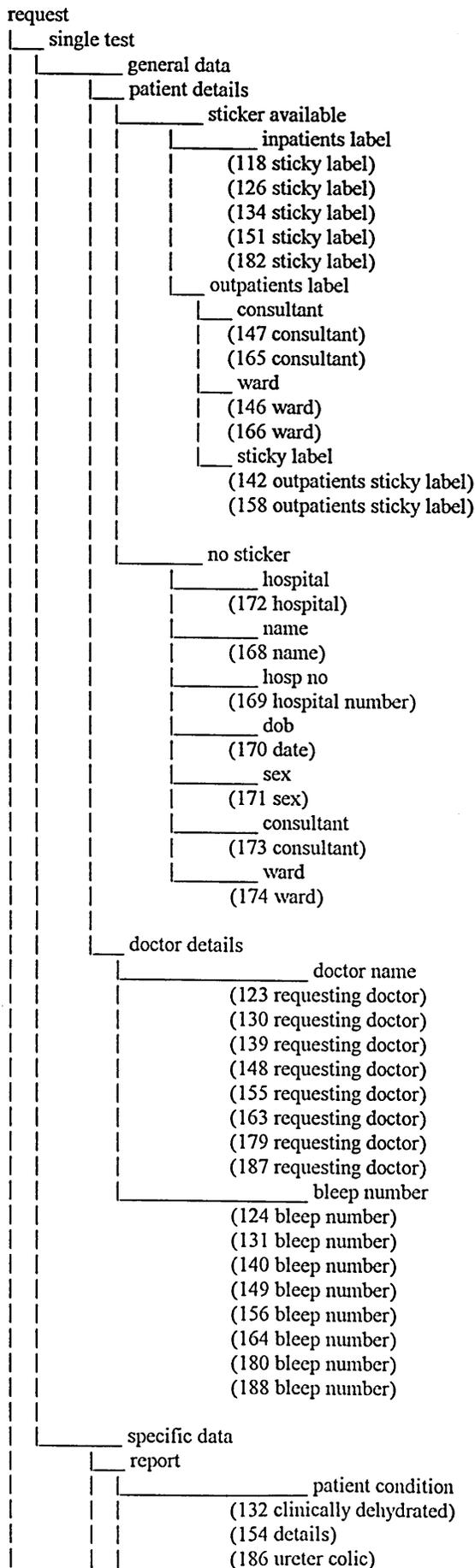
qualified  
by time  
investigation  
time  
by sequence  
unqualified

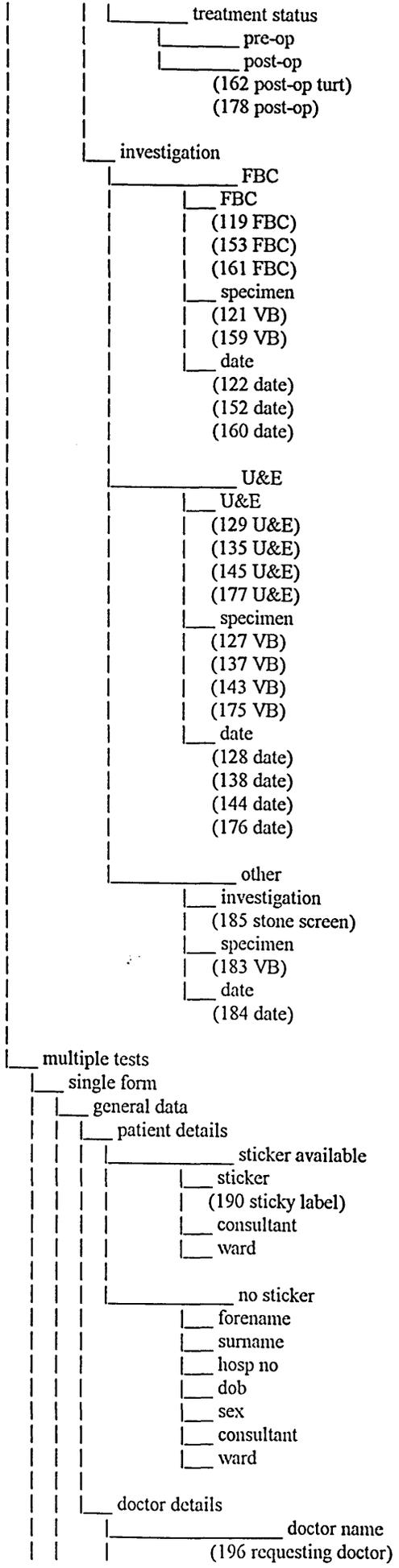


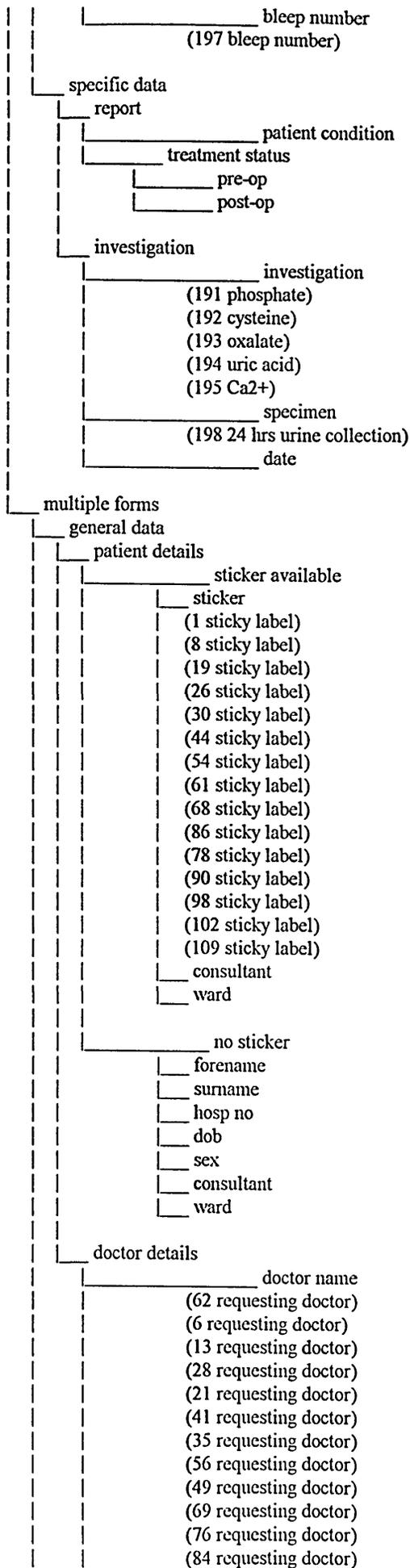


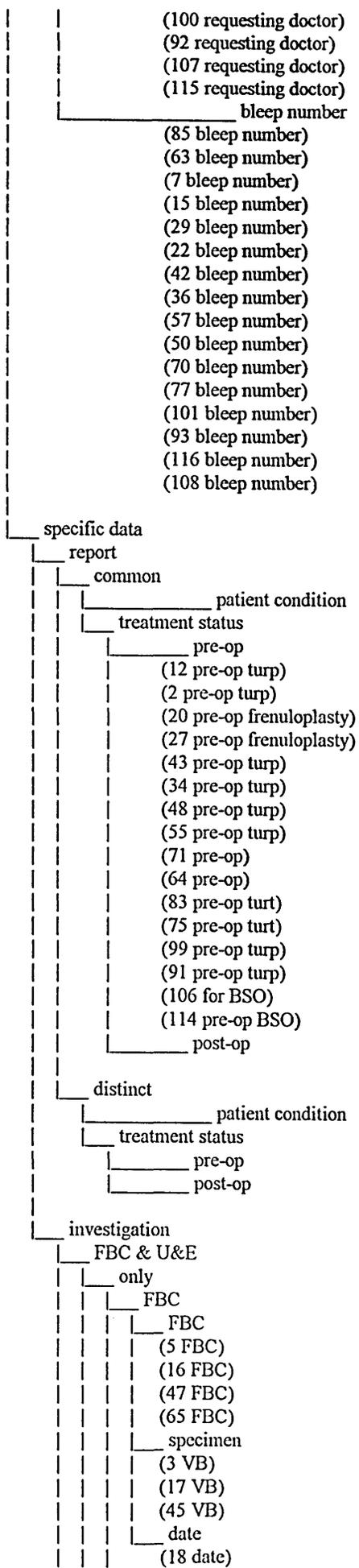


## A2.3 Full final TDH, analysis of surgical ward





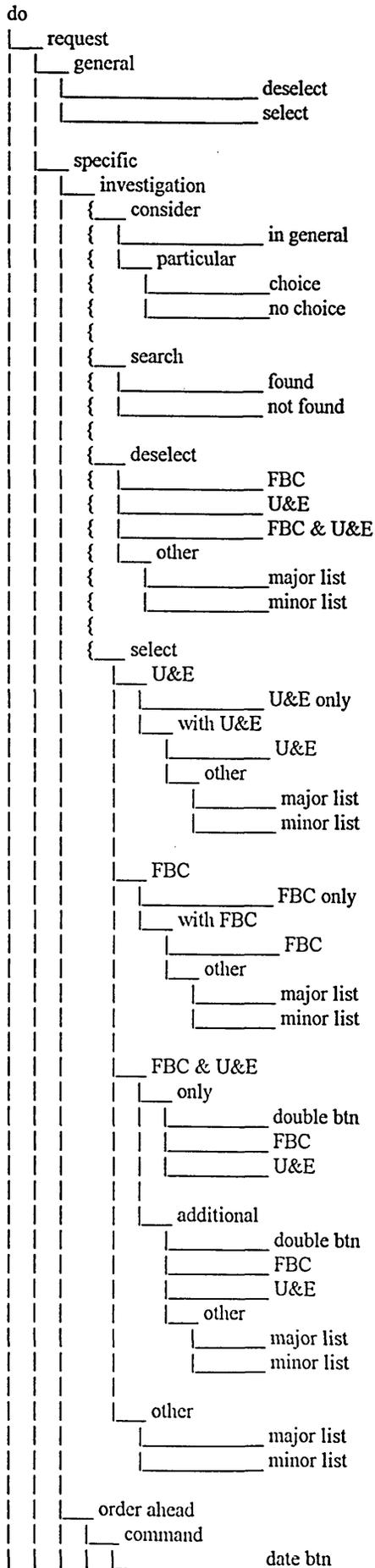


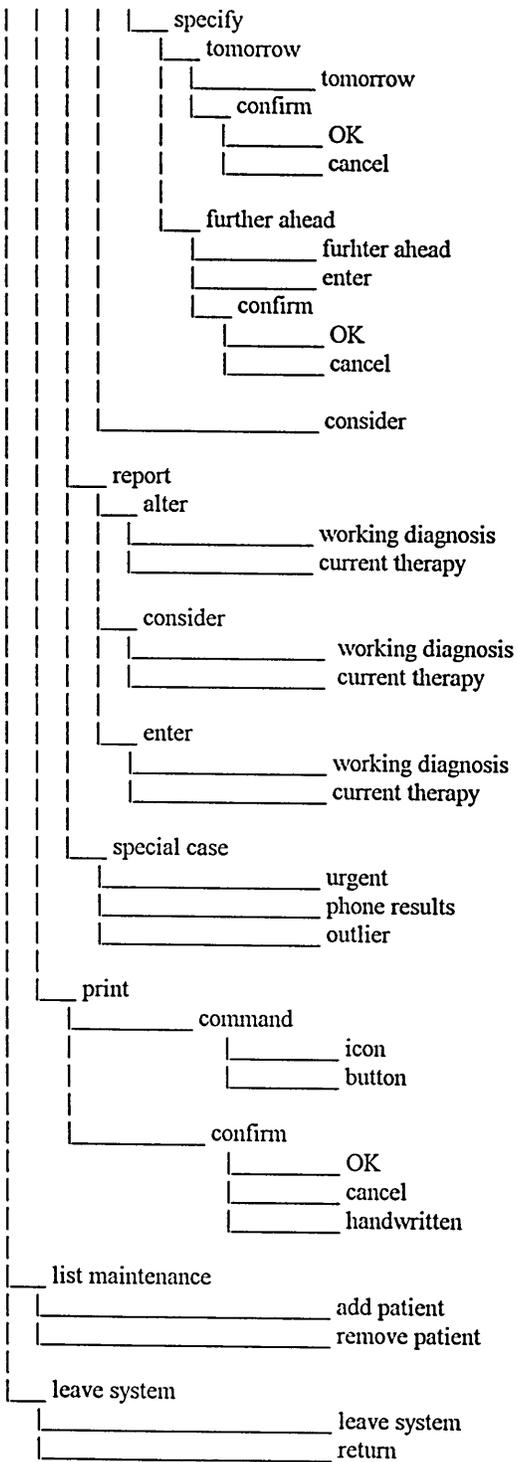


- (4 date)
- (46 date)
- U&E
  - U&E
    - (25 U&E)
    - (53 U&E)
    - (60 U&E)
  - specimen
    - (23 VB)
    - (51 VB)
    - (58 VB)
    - (66 VB)
  - date
    - (24 date)
    - (52 date)
    - (59 date)
    - (67 date)
- additional
  - with U&E
    - U&E
      - (11 U&E)
      - (40 U&E)
      - (81 U&E)
      - (96 U&E)
      - (112 U&E)
    - other
      - (14 RBS)
      - (39 RBS)
      - (82 RBS)
      - (97 RBS)
      - (113 RBS)
    - specimen
      - (9 VB)
      - (37 VB)
      - (79 VB)
      - (110 VB)
    - date
      - (10 date)
      - (38 date)
      - (80 date)
      - (95 date)
      - (111 date)
  - with FBC
    - FBC
      - (33 FBC)
      - (74 FBC)
      - (89 FBC)
      - (105 FBC)
    - specimen
      - (31 VB)
      - (72 VB)
      - (87 VB)
      - (94 VB)
      - (103 VB)
    - date
      - (32 date)
      - (73 date)
      - (88 date)
      - (104 date)
- other with FBC
  - FBC
  - specimen
  - date

|  
| other with U&E  
| \_\_\_\_\_ U&E  
| \_\_\_\_\_ specimen  
| \_\_\_\_\_ date  
|  
| other with other  
| \_\_\_\_\_ investigation  
| \_\_\_\_\_ specimen  
| \_\_\_\_\_ date

## A2.4 TDH skeleton, evaluation of prototype,





## A2.5 Full TDH, evaluation of prototype

```

do
  request
  general
    deselect
    (406 show pat list btn 23.3)
    select
      (209 patient 2.0)
      (530 patient 1.7)
      (526 patient 18.9)
      (497 patient 1.6)
      (465 patient 1.1)
      (459 patient 1.6)
      (454 patient 10.9)
      (444 patient 1.3)
      (435 patient 1.9)
      (417 patient 5.5)
      (408 patient 7.4)
      (399 patient 10.5)
      (378 patient 8.3)
      (374 patient 11.1)
      (315 patient 5.7)
      (309 patient 3.7)
      (296 patient 6.1)
      (283 patient 2.6)
      (145 patient 1.2)
      (141 patient 2.5)
      (133 patient 5.6)
      (122 patient 5.3)
      (114 patient 2.4)
      (104 patient 11.1)
      (97 patient 1.9)
      (61 patient 5.1)
      (56 patient 1.7)
      (49 patient 4.1)
      (41 patient 2.1)
      (35 patient 3.5)
      (25 patient 2.1)
      (19 patient 12.0)
      (14 patient 6.7)
      (152 patient 1.8)
      (160 patient 3.1)
      (169 patient 4.8)
      (178 patient 1.9)
      (200 patient 2.9)
      (263 patient 1.5)
      (277 patient 2.7)
      (304 patient 1.8)
      (513 patient details 4.1)
  specific
    investigation
      consider
        in general
          (270 tests 0.5)
          (494 tests 3.1)
          (418 tests 2.0)
          (414 tests 4.0)
          (314 test 6.3)
          (310 test 5.5)
          (297 test 2.9)
          (129 test 5.8)
          (106 tests 5.2)
          (27 test 2.8)
          (212 test 1.1)
          (280 test 2.1)
          (303 test 5.5)
          (191 test 1.1)
          (511 tests 4.7)
        particular
          choice
            (409 tests 2.5)
            (288 test 3.2)
            (520 tests 3.8)
            (498 tests 4.5)
            (492 tests 7.0)
            (473 tests 39.5)
            (470 tests 6.1)

```

```

{ | (468 tests 2.3)
{ | (367 tests 2.4)
{ | (330 test 1.1)
{ | (305 ESR 1.8)
{ | (127 test 1.0)
{ | (125 test 4.0)
{ | (123 test 4.1)
{ | (92 CEP2 5.2)
{ | (179 test 2.0)
{ | (181 test 1.2)
{ | (252 test 1.5)
{ | (278 test 8.0)
{ | _____ no choice
{
{ search
{ | _____ found
{ | _____ not found
{ | (50 test 12.4)
{ | (38 test 15.8)
{
{ deselect
{ | _____ FBC
{ | (134 FBC 2.6)
{ | (43 FBC 2.6)
{ | (210 FBC 1.4)
{ | _____ U&E
{ | _____ FBC & U&E
{ | (182 FBC & U&E 0.9)
{ | other
{ | _____ major list
{ | _____ minor list
{
{ select
{ | U&E
{ | _____ U&E only
{ | (527 U&E 7.4)
{ | (521 U&E 1.5)
{ | (514 U&E 4.1)
{ | (105 U&E 2.8)
{ | (15 U&E 2.9)
{ | (161 U&E 3.6)
{ | (542 U&E 2.8)
{ | with U&E
{ | _____ U&E
{ | (489 U&E 9.1)
{ | (469 U&E 1.6)
{ | (461 U&E 103.0)
{ | (20 U&E 10.6)
{ | (183 U&E 0.6)
{ | other
{ | major list
{ | (493 TFT 1.9)
{ | (491 LFT 10.4)
{ | (490 digoxin 8.7)
{ | (474 TFT 2.0)
{ | (472 LFT 5.2)
{ | (471 calcium 2.7)
{ | (460 Digoxin 5.2)
{ | (21 LFT 2.0)
{ | (185 KCCT 3.4)
{ | _____ minor list
{
{ FBC
{ | _____ FBC only
{ | (42 FBC 0.8)
{ | (210 FBC 1.4)
{ | with FBC
{ | _____ FBC
{ | (410 FBC 0.5)
{ | (355 FBC 3.3)
{ | (299 FBC 2.5)
{ | other
{ | major list
{ | (413 TFT 0.7)
{ | (412 LFT 10.5)
{ | (411 ESR 1.8)
{ | (300 Film 2.7)
{ | _____ minor list
{ | (356 clotting screen 30.7)

```

FBC & U&E

only

double btn

- (44 FBC & U&E)
- (211 FBC & U&E 1.4)
- (279 FBC & U&E 0.6)

FBC

U&E

additional

double btn

- (393 FBC & U&E 5.8)
- (289 FBC & U&E 1.8)
- (135 FBC & U&E 2.6)
- (124 FBC & U&E 2.2)
- (180 FBC & U&E 1.7)
- (234 FBC & U&E 2.6)
- (267 FBC & U&E 13.7)

FBC

U&E

other

major list

- (396 RBS 2.7)
- (394 TFT 2.0)
- (331 KCCT 1.1)
- (290 LFT 1.8)
- (137 TFT 1.4)
- (136 LFT 2.7)
- (128 RBS 0.5)
- (126 LFT 1.5)
- (235 RBS 4.0)
- (236 LFT 1.3)
- (268 LFT 1.6)

minor list

- (291 icon clotting screen 32.9)
- (269 clotting screen 22.3)

other

major list

- (499 INR 2.0)
- (455 TFT 3.5)
- (450 KCCT 0.7)
- (449 INR 0.9)
- (441 INR 1.0)
- (440 KCCT 3.4)
- (423 KCCT 0.9)
- (422 INR 4.0)
- (404 KCCT 4.6)
- (379 KCCT 3.2)
- (375 KCCT 9.0)
- (370 TFT 8.3)
- (368 amylase 2.3)
- (332 INR 1.3)
- (142 CEP1 2.0)
- (115 INR 2.4)
- (101 CEP3 2.0)
- (94 CEP2 2.9)
- (63 KCCT 0.1)
- (62 INR 6.0)
- (37 KCCT 1.8)
- (36 INR 8.5)
- (26 KCCT 3.0)
- (146 CEP2 1.8)
- (153 CEP3 1.4)
- (205 INR 2.0)
- (206 KCCT 0.9)
- (253 INR 3.1)
- (254 KCCT 3.0)

minor list

- (313 immunoglobulins 10.1)
- (308 icon Haem screen 21.9)
- (172 clotting screen 12.2)

order ahead

command

date btn

- (536 date btn 1.6)
- (531 date btn 1.7)

(517 date btn 0.6)  
(445 date btn 1.5)  
(419 date btn 1.3)  
(284 date btn 1.9)  
(273 date btn 0.9)  
(264 date btn 1.8)  
(258 date btn 1.6)  
(201 date btn 3.0)  
(188 date btn 1.0)  
(64 date btn 0.7)  
(98 date btn 1.6)  
(116 date btn 1.0)  
(147 date btn 1.4)  
(154 date btn 1.4)  
(327 date btn 2.6)  
(352 date btn 16.2)  
(401 date btn 11.8)  
(424 date btn 5.0)  
(430 date btn 3.6)  
(436 date btn 1.7)

specify

tomorrow

tomorrow

(518 tomorrow 3.1)  
(265 tomorrow btn 0.8)  
(202 tomorrow 1.4)  
(189 tomorrow 1.1)  
(65 tomorrow 1.9)  
(99 tomorrow 1.0)  
(117 tomorrow 0.2)  
(148 tomorrow 2.4)  
(328 tomorrow 2.9)  
(353 tomorrow 3.4)  
(402 tomorrow 2.1)  
(420 tomorrow 1.1)  
(431 tomorrow 4.7)

confirm

OK

(519 OK date 0.9)  
(266 OK date 1.4)  
(203 OK date 2.7)  
(190 OK date 4.0)  
(66 OK date 1.8)  
(100 OK 4.2)  
(118 OK date 0.6)  
(149 OK date 2.4)  
(329 OK date 2.7)  
(354 OK date 3.3)  
(403 OK date 2.8)  
(421 OK date 2.6)  
(432 OK date 1.6)

cancel

(262 OK date 5.1)

further ahead

further ahead

(537 further ahead 0.4)  
(533 further ahead 39.2)  
(446 further ahead 1.5)  
(285 further ahead 0.6)  
(274 further ahead 0.5)  
(155 further ahead 1.9)  
(425 further ahead 1.0)  
(437 further ahead 0.9)

enter

(534 1 day ahead 9.8)  
(447 3 days ahead 3.5)  
(438 2 days ahead 6.2)  
(286 3 days ahead 3.7)  
(275 2 days ahead 14.7)  
(156 time ahead 5.0)  
(538 2 days ahead 3.0)

confirm

OK

(535 OK date 4.8)  
(448 OK date 3.4)  
(439 OK date 0.8)  
(287 OK date 1.8)  
(276 OK date 9.7)

- (157 OK date 2.5)
  - (539 OK date 1.6)
  - cancel
    - (426 cancel no of days 20.0)
    - (427 cancel set date 2.7)
  - consider
    - (292 date 3.8)
    - (93 date btn 9.1)
    - (395 date btn 4.7)
- report
  - alter
    - working diagnosis
    - current therapy
  - consider
    - working diagnosis
      - (204 clin dets 6.6)
      - (67 clin dets 4.4)
      - (184 clin dets 2.5)
      - (466 working diag fld 1.7)
      - (467 clin dets 2.2)
      - (475 clin dets 5.2)
    - current therapy
      - (233 therapy 2.6)
  - enter
    - working diagnosis
      - (17 working diag 21.7)
      - (23 working diag 14.23)
      - (29 working diag 9.6)
      - (46 working diagnosis 21.3)
      - (120 therapy as working diag 16.7)
      - (131 working diag 20.2)
      - (139 working diag 10.6)
    - current therapy
      - (238 cancel include 6.3)
      - (237 therapy btn 3.2)
      - (170 therapy btn 2.7)
      - (171 therapy 14.7)
- special case
  - urgent
    - (162 urgent btn 1.9)
  - phone results
    - (163 phone btn 0.9)
    - (165 OK phone 2.7)
  - outlier
- print
  - command
    - icon
      - (371 print icon 2.9)
      - (51 print icon 3.6)
      - (57 print icon 1.5)
      - (281 print icon 1.4)
      - (301 print icon 3.9)
      - (311 print icon 2.1)
      - (316 print icon 2.0)
      - (462 print icon 4.0)
    - button
      - (293 print btn 1.1)
      - (380 print btn 0.6)
      - (397 print btn 3.5)
      - (376 print btn 39.3)
      - (357 print btn 4.2)
      - (333 print btn 2.9)
      - (16 print btn 0.8)
      - (22 print btn 1.7)
      - (28 print btn 2.1)
      - (39 print btn 2.8)
      - (45 print btn 3.6)
      - (68 print btn 1.5)
      - (95 print btn 4.2)
      - (102 print btn 2.2)
      - (107 print btn 1.6)
      - (119 print btn 1.8)
      - (130 print btn 1.8)

(138 print btn 5.3)  
(143 print btn 3.1)  
(150 print btn 1.3)  
(158 print btn 0.6)  
(166 print btn 1.3)  
(167 print btn 2.3)  
(173 print btn 2.1)  
(186 print btn 1.9)  
(192 print btn 1.4)  
(207 print btn 2.9)  
(213 print btn 1.4)  
(239 print btn 4.7)  
(255 print btn 5.3)  
(271 print btn 1.4)  
(306 print btn 5.1)  
(415 print btn 2.8)  
(428 print btn 0.7)  
(433 print btn 0.3)  
(442 print btn 2.4)  
(451 print btn 1.7)  
(456 print btn 3.8)  
(476 print btn 3.8)  
(495 print btn 1.5)  
(500 print btn 3.3.)  
(515 print btn 9.0)  
(528 print btn 1.9)  
(523 no print btn 11.7)  
(540 print btn 2.7)  
(543 print btn 1.9)

confirm

OK

(294 print fom 1.8)  
(398 print form 2.4)  
(381 print form 3.4)  
(377 print form 4.4)  
(372 print form 2.0)  
(358 print form 2.8)  
(334 print form 2.0)  
(317 print form 5.5)  
(18 print form 5.1)  
(24 print form 1.4)  
(30 print form 1.3)  
(40 print form 0.9)  
(47 print form 2.9)  
(53 print form 2.7)  
(59 print form 1.6)  
(69 print form 2.1)  
(96 print form 3.5)  
(103 print form 1.5)  
(108 print form 1.7)  
(121 print form 1.8)  
(132 print form 2.3)  
(140 print form 2.1)  
(144 print form 2.1)  
(151 print form 2.1)  
(159 print form 1.5)  
(168 print form 1.4)  
(174 print form 1.8)  
(193 print form 2.2)  
(214 print form 3.4)  
(240 print form 3.0)  
(256 print form 3.2)  
(272 print form 2.3)  
(208 print form 2.3)  
(282 print form 1.7)  
(302 print form 2.3)  
(307 print form 1.6)  
(312 print form 1.7)  
(416 print form 3.0)  
(434 print form 2.9)  
(443 print form 2.4)  
(452 print form 1.6)  
(457 print form 1.6)  
(463 print form 2.0)  
(477 print form 1.7)  
(496 print form 4.0)  
(501 print form 1.9)  
(516 print btn 1.6)

- | (529 print form 2.2)
- | (544 print form 1.8)
- | cancel
- | (187 cancel print 4.7)
- | (429 cancel confirm 15.0)
- | (541 no tests error msg 5.8)
- | handwritten
- | (58 handwritten 1.8)
- | (52 handwritten 4.1)

list maintenance

- add patient
- (391 save details btn 2.7)
- (390 working diag 17.6)
- (389 consultant 6.8)
- (388 dob 8.7)
- (387 sex 17.5)
- (386 hos no 10.3)
- (385 name 21.1)
- (384 add patient btn 2.1)
- (383 no patient 19.9)
- (366 save details btn 10.4)
- (365 working diag 17.9)
- (364 consultant 9.5)
- (363 dob 11.9)
- (362 sex 3.1)
- (361 hos no 14.3)
- (360 name 8.5)
- (359 add patient icon 1.0)
- (351 save details icon 3.0)
- (350 error msg 4.3)
- (349 date btn 10.0)
- (348 error msg 15.0)
- (347 date btn 7.1)
- (346 change details btn 5.5)
- (345 save details icon 3.2)
- (344 error msg 5.6)
- (343 FBC 8.0)
- (342 current therapy 42.6)
- (341 working diagnosis 52.2)
- (340 consultant 13.4)
- (339 ward 13.1)
- (338 sex 15.0)
- (337 pat name 80.3)
- (336 add patient icon 1.9)
- (326 save details btn 2.7)
- (325 current therapy 9.8)
- (324 working diagnosis 20.0)
- (323 consultant 5.2)
- (322 ward 8.6)
- (321 sex 1.1)
- (320 pat name 28.6)
- (319 add patient btn 1.3)
- (251 save details btn 1.4)
- (250 current therapy 5.5)
- (249 working diagnosis 5.7)
- (248 consultant 2.7)
- (247 ward 10.1)
- (246 dob 7.8)
- (245 sex 2.5)
- (244 hos no 8.3)
- (243 pat name 13.2)
- (242 add patient btn 1.4)
- (232 save details btn 3.8)
- (231 current therapy label 0.7)
- (230 current therapy label 1.8)
- (229 error msg 2.7)
- (228 current therapy label 6.2)
- (227 therapy btn 2.7)
- (226 working diagnosis 10.4)
- (225 save details btn 5.2)
- (224 current therapy 14.4)
- (223 consultant 1.7)
- (222 ward 10.1)
- (221 dob 7.8)
- (220 sex 5.0)
- (219 hos no 4.5)
- (218 hos no 10.4)
- (217 pat name 9.1)

(216 add patient btn 2.1)  
(2 add patient btn 3.2)  
(3 pat name 22.9)  
(4 hos no 10.3)  
(5 sex 2.6)  
(6 dob 23.2)  
(7 ward 10.1)  
(8 consultant 2.4)  
(9 current therapy 14.4)  
(10 save details btn 5.2)  
(11 working diagnosis 30)  
(12 save details btn 1.8)  
(13 show pat list btn 2.4)  
(31 add patient btn 2.1)  
(32 save dets btn 15.4)  
(33 save details btn 23.1)  
(54 add patient btn 1.9)  
(55 add patient btn 52.4)  
(83 patient 8.1)  
(84 add pat btn 1.1)  
(85 pat name 17.8)  
(86 hos no 26.5)  
(87 sex 6.5)  
(88 dob 10.4)  
(89 consultant 26.8)  
(90 working diagnosis 13.5)  
(91 save details btn 1.7)  
(478 no patient 23.0)  
(479 add patient btn 3.9)  
(480 name 31.0)  
(481 hos no 10.1)  
(482 sex 2.1)  
(483 dob 14.0)  
(484 working diag 68.4)  
(485 U&E greyed 8.5)  
(486 save details btn 2.7)  
(487 OK save details 3.9)  
(488 save details btn 1.4)  
(502 add patient btn 3.7)  
(503 name 10.2)  
(504 hos no 24.6)  
(505 sex 4.8)  
(506 dob 21.7)  
(507 ward 8.2 )  
(508 consultant 4.3)  
(509 ward 30.1)  
(510 clin dets 21.1)  
(512 save details btn 5.6)  
\_ remove patient  
(70 patient 4.6)  
(71 show pat list 3.1)  
(72 remove pat btn 0.9)  
(73 patient 5.6)  
(74 remove pat 1.1)  
(75 patient 4.5)  
(76 show pat list 1.9)  
(79 remove pat 1.4)  
(77 remove pat btn 0.5)  
(78 patient 3.5)  
(80 remove pat btn 1.0)  
(81 patient 3.1)  
(82 remove pat 0.8)  
(109 patient 1.3)  
(110 show pat list 2.0)  
(111 remove pat btn 1.1)  
(112 patient 1.5)  
(113 remove pat 1.9)  
(175 remove pat btn 2.1)  
(176 patient 1.8)  
(177 remove pat 4.6)  
(194 remove pat btn 1.3)  
(195 patient 3.8)  
(196 patient 1.0)  
(197 remove pat 1.4)  
(199 no patient 19.0)

leave system

leave system  
(453 exit btn 1.4)

(407 exit btn 4.6)  
(382 exit btn 9.6)  
(257 exit btn 1.1)  
(241 exit btn 2.9)  
(215 exit btn 2.2)  
(464 exit icon 0.5)  
(458 exit icon 1.2)  
(34 exit btn 1.4)  
(48 exit btn 0.5)  
(60 exit btn 3.0)  
(524 exit btn 7.5)  
return  
(525 login 8.5)

### A3 KRG sentences, evaluation of prototype

For the sake of brevity, only this set of KRG sentences is included. In addition, the re-described activity list is confined to a few lines only, in order to give an indication of the appearance of this particular output of the LUTAKD toolkit.

#### KRG 1

Line(s) 525  
do(leave system((((((return))))))))

#### KRG 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524  
do(leave system((((((leave system))))))))

#### KRG 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199  
do(list maintenance((((((remove patient))))))))

#### KRG 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512  
do(list maintenance((((((add patient))))))))

#### KRG 5

Line(s) 58, 52  
do(request(print((((confirm(handwritten))))))))

#### KRG 6

Line(s) 187, 429, 541  
do(request(print((((confirm(cancel))))))))

#### KRG 7

Line(s) 294, 398, 381, 377, 372, 358, 334, 317, 18, 24, 30, 40, 47, 53, 59, 69, 96, 103, 108, 121, 132, 140, 144, 151, 159, 168, 174, 193, 214, 240, 256, 272, 208, 282, 302, 307, 312, 416, 434, 443, 452, 457, 463, 477, 496, 501, 516, 529, 544  
do(request(print((((confirm(OK))))))))

#### KRG 8

Line(s) 293, 380, 397, 376, 357, 333, 16, 22, 28, 39, 45, 68, 95, 102, 107, 119, 130, 138, 143, 150, 158, 166, 167, 173, 186, 192, 207, 213, 239, 255, 271, 306, 415, 428, 433, 442, 451, 456, 476, 495, 500, 515, 528, 523, 540, 543  
do(request(print((((command(button))))))))

#### KRG 9

Line(s) 371, 51, 57, 281, 301, 311, 316, 462  
do(request(print((((command(icon))))))))

#### KRG 10

Line(s) 163, 165  
do(request(specific(special case((((phone results))))))))

#### KRG 11

Line(s) 162  
do(request(specific(special case((((urgent))))))))

#### KRG 12

Line(s) 238, 237, 170, 171  
do(request(specific(report(enter((((current therapy))))))))

#### KRG 13

Line(s) 17, 23, 29, 46, 120, 131, 139  
do(request(specific(report(enter((((working diagnosis))))))))

#### KRG 14

Line(s) 233  
do(request(specific(report(consider((((current therapy))))))))

#### KRG 15

Line(s) 204, 67, 184, 466, 467, 475  
do(request(specific(report(consider((((working diagnosis))))))))

#### KRG 16

Line(s) 292, 93, 395

do(request(specific(order ahead((((consider))))))))

KRG 17

Line(s) 426, 427

do(request(specific(order ahead(command(specify(further ahead(confirm(cancel))))))))

KRG 18

Line(s) 535, 448, 439, 287, 276, 157, 539

do(request(specific(order ahead(command(specify(further ahead(confirm(OK))))))))

KRG 19

Line(s) 534, 447, 438, 286, 275, 156, 538

do(request(specific(order ahead(command(specify(further ahead((enter))))))))

KRG 20

Line(s) 537, 533, 446, 285, 274, 155, 425, 437

do(request(specific(order ahead(command(specify(further ahead((further ahead))))))))

KRG 21

Line(s) 262

do(request(specific(order ahead(command(specify(tomorrow(confirm(cancel))))))))

KRG 22

Line(s) 519, 266, 203, 190, 66, 100, 118, 149, 329, 354, 403, 421, 432

do(request(specific(order ahead(command(specify(tomorrow(confirm(OK))))))))

KRG 23

Line(s) 518, 265, 202, 189, 65, 99, 117, 148, 328, 353, 402, 420, 431

do(request(specific(order ahead(command(specify(tomorrow((tomorrow))))))))

KRG 24

Line(s) 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436

do(request(specific(order ahead(command((((date btn))))))))

KRG 25

Line(s) 313, 308, 172

do(request(specific(investigation{select(other(((minor list))))}))

KRG 26

Line(s) 499, 455, 450, 449, 441, 440, 423, 422, 404, 379, 375, 370, 368, 332, 142, 115, 101, 94, 63, 62, 37, 36, 26, 146, 153, 205, 206, 253, 254

do(request(specific(investigation{select(other(((major list))))}))

KRG 27

Line(s) 291, 269

do(request(specific(investigation{select(FBC & U&E(additional(other(minor list))))}))

KRG 28

Line(s) 396, 394, 331, 290, 137, 136, 128, 126, 235, 236, 268

do(request(specific(investigation{select(FBC & U&E(additional(other(major list))))}))

KRG 29

Line(s) 393, 289, 135, 124, 180, 234, 267

do(request(specific(investigation{select(FBC & U&E(additional((double btn))))}))

KRG 30

Line(s) 44, 211, 279

do(request(specific(investigation{select(FBC & U&E(only((double btn))))}))

KRG 31

Line(s) 356

do(request(specific(investigation{select(FBC(with FBC(other(minor list))))}))

KRG 32

Line(s) 413, 412, 411, 300

do(request(specific(investigation{select(FBC(with FBC(other(major list))))}))

KRG 33

Line(s) 410, 355, 299

do(request(specific(investigation{select(FBC(with FBC((FBC))))}))

KRG 34

Line(s) 42

do(request(specific(investigation{select(FBC(((FBC only))))}))

KRG 35

Line(s) 493, 491, 490, 474, 472, 471, 460, 21, 185

do(request(specific(investigation{select(U&E(with U&E(other(major list))))}))

KRG 36  
Line(s) 489, 469, 461, 20, 183  
do(request(specific(investigation{select(U&E(with U&E((U&E))))})))))

KRG 37  
Line(s) 527, 521, 514, 105, 15, 161, 542  
do(request(specific(investigation{select(U&E(((U&E only))))})))))

KRG 38  
Line(s) 182  
do(request(specific(investigation{deselect(((FBC & U&E))))})))))

KRG 39  
Line(s) 134, 43  
do(request(specific(investigation{deselect(((FBC))))})))))

KRG 40  
Line(s) 210  
do(request(specific(investigation{deselect(((FBC))))} {select(FBC(((FBC only))))})))))

KRG 41  
Line(s) 50, 38  
do(request(specific(investigation{search(((not found))))})))))

KRG 42  
Line(s) 409, 288, 520, 498, 492, 473, 470, 468, 367, 330, 305, 127, 125, 123, 92, 179, 181, 252, 278  
do(request(specific(investigation{consider(particular(((choice))))})))))

KRG 43  
Line(s) 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511  
do(request(specific(investigation{consider(((in general))))})))))

KRG 44  
Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56,  
49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513  
do(request(general((((select)))))))))

KRG 45  
Line(s) 406  
do(request(general((((deselect)))))))))

KRG' 1  
Line(s) 525  
do(leave system((((return)))))))))

KRG' 2  
Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524  
do(leave system((((leave system)))))))))

KRG' 3  
Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199  
do(list maintenance((((remove patient)))))))))

KRG' 4  
Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343,  
342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231,  
230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85,  
86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512  
do(list maintenance((((add patient)))))))))

KRG' 5  
Line(s) 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151,  
144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58  
do(request(print((((confirm)))))))))

KRG' 6  
Line(s) 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239,  
213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293  
do(request(print((((conunand)))))))))

KRG' 7  
Line(s) 163, 165  
do(request(specific(special case(((phone results)))))))))

KRG' 8  
Line(s) 162  
do(request(specific(special case(((urgent)))))))))

KRG' 9

Line(s) 238, 237, 170, 171  
do(request(specific(report(enter(((current therapy)))))))

KRG' 10  
Line(s) 17, 23, 29, 46, 120, 131, 139  
do(request(specific(report(enter(((working diagnosis)))))))

KRG' 11  
Line(s) 233  
do(request(specific(report(consider(((current therapy)))))))

KRG' 12  
Line(s) 204, 67, 184, 466, 467, 475  
do(request(specific(report(consider(((working diagnosis)))))))

KRG' 13  
Line(s) 292, 93, 395  
do(request(specific(order ahead(((consider)))))))

KRG' 14  
Line(s) 539, 157, 276, 287, 439, 448, 535, 427, 426  
do(request(specific(order ahead(command(specify(further ahead(confirm)))))))

KRG' 15  
Line(s) 534, 447, 438, 286, 275, 156, 538  
do(request(specific(order ahead(command(specify(further ahead(enter)))))))

KRG' 16  
Line(s) 537, 533, 446, 285, 274, 155, 425, 437  
do(request(specific(order ahead(command(specify(further ahead(further ahead)))))))

KRG' 17  
Line(s) 432, 421, 403, 354, 329, 149, 118, 100, 66, 190, 203, 266, 519, 262  
do(request(specific(order ahead(command(specify(tomorrow(confirm)))))))

KRG' 18  
Line(s) 518, 265, 202, 189, 65, 99, 117, 148, 328, 353, 402, 420, 431  
do(request(specific(order ahead(command(specify(tomorrow(tomorrow)))))))

KRG' 19  
Line(s) 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436  
do(request(specific(order ahead(command(((date btn)))))))

KRG' 20  
Line(s) 313, 308, 172  
do(request(specific(investigation{select(other((minor list)))))))

KRG' 21  
Line(s) 499, 455, 450, 449, 441, 440, 423, 422, 404, 379, 375, 370, 368, 332, 142, 115, 101, 94, 63, 62, 37, 36, 26, 146, 153, 205, 206, 253, 254  
do(request(specific(investigation{select(other((major list)))))))

KRG' 22  
Line(s) 268, 236, 235, 126, 128, 136, 137, 290, 331, 394, 396, 269, 291  
do(request(specific(investigation{select(FBC & U&E(additional(other)))))))

KRG' 23  
Line(s) 393, 289, 135, 124, 180, 234, 267  
do(request(specific(investigation{select(FBC & U&E(additional(double btn)))))))

KRG' 24  
Line(s) 44, 211, 279  
do(request(specific(investigation{select(FBC & U&E(only(double btn)))))))

KRG' 25  
Line(s) 300, 411, 412, 413, 356  
do(request(specific(investigation{select(FBC(with FBC(other)))))))

KRG' 26  
Line(s) 410, 355, 299  
do(request(specific(investigation{select(FBC(with FBC(FBC)))))))

KRG' 27  
Line(s) 42  
do(request(specific(investigation{select(FBC((FBC only)))))))

KRG' 28  
Line(s) 185, 21, 460, 471, 472, 474, 490, 491, 493  
do(request(specific(investigation{select(U&E(with U&E(other)))))))

KRG' 29

Line(s) 489, 469, 461, 20, 183

do(request(specific(investigation{select(U&E(with U&E(U&E))))}))

KRG' 30

Line(s) 527, 521, 514, 105, 15, 161, 542

do(request(specific(investigation{select(U&E((U&E only))))}))

KRG' 31

Line(s) 182

do(request(specific(investigation{deselect(((FBC & U&E))))}))

KRG' 32

Line(s) 134, 43

do(request(specific(investigation{deselect(((FBC))))}))

KRG' 33

Line(s) 210

do(request(specific(investigation{deselect(((FBC)))}{select(FBC((FBC only))))}))

KRG' 34

Line(s) 50, 38

do(request(specific(investigation{search(((not found))))}))

KRG' 35

Line(s) 409, 288, 520, 498, 492, 473, 470, 468, 367, 330, 305, 127, 125, 123, 92, 179, 181, 252, 278

do(request(specific(investigation{consider(particular((choice))))}))

KRG' 36

Line(s) 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511

do(request(specific(investigation{consider(((in general))))}))

KRG' 37

Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56,

49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513

do(request(general((((select))))))

KRG' 38

Line(s) 406

do(request(general((((deselect))))))

KRG" 1

Line(s) 525

do(leave system((((return))))))

KRG" 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524

do(leave system((((leave system))))))

KRG" 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199

do(list maintenance((((remove patient))))))

KRG" 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512

do(list maintenance((((add patient))))))

KRG" 5

Line(s) 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151,

144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58

do(request(print((((confirm))))))

KRG" 6

Line(s) 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239,

213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293

do(request(print((((command))))))

KRG" 7

Line(s) 163, 165

do(request(specific(special case((((phone results))))))

KRG" 8

Line(s) 162

do(request(specific(special case((((urgent))))))

KRG\* 9  
Line(s) 238, 237, 170, 171  
do(request(specific(report(enter((current therapy))))))

KRG\* 10  
Line(s) 17, 23, 29, 46, 120, 131, 139  
do(request(specific(report(enter((working diagnosis))))))

KRG\* 11  
Line(s) 233  
do(request(specific(report(consider((current therapy))))))

KRG\* 12  
Line(s) 204, 67, 184, 466, 467, 475  
do(request(specific(report(consider((working diagnosis))))))

KRG\* 13  
Line(s) 292, 93, 395  
do(request(specific(order ahead(((consider))))))

KRG\* 14  
Line(s) 437, 425, 155, 274, 285, 446, 533, 537, 538, 156, 275, 286, 438, 447, 534, 426, 427, 535, 448, 439, 287, 276, 157, 539  
do(request(specific(order ahead(command(specify(further ahead))))))

KRG\* 15  
Line(s) 431, 420, 402, 353, 328, 148, 117, 99, 65, 189, 202, 265, 518, 262, 519, 266, 203, 190, 66, 100, 118, 149, 329, 354, 403, 421, 432  
do(request(specific(order ahead(command(specify(tomorrow))))))

KRG\* 16  
Line(s) 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436  
do(request(specific(order ahead(command((date btn))))))

KRG\* 17  
Line(s) 313, 308, 172  
do(request(specific(investigation{select(other(minor list))}))

KRG\* 18  
Line(s) 499, 455, 450, 449, 441, 440, 423, 422, 404, 379, 375, 370, 368, 332, 142, 115, 101, 94, 63, 62, 37, 36, 26, 146, 153, 205, 206, 253, 254  
do(request(specific(investigation{select(other(major list))}))

KRG\* 19  
Line(s) 267, 234, 180, 124, 135, 289, 393, 291, 269, 396, 394, 331, 290, 137, 136, 128, 126, 235, 236, 268  
do(request(specific(investigation{select(FBC & U&E(additional))}))

KRG\* 20  
Line(s) 279, 211, 44  
do(request(specific(investigation{select(FBC & U&E(only))}))

KRG\* 21  
Line(s) 299, 355, 410, 356, 413, 412, 411, 300  
do(request(specific(investigation{select(FBC(with FBC))}))

KRG\* 22  
Line(s) 42  
do(request(specific(investigation{select(FBC(FBC only))}))

KRG\* 23  
Line(s) 183, 20, 461, 469, 489, 493, 491, 490, 474, 472, 471, 460, 21, 185  
do(request(specific(investigation{select(U&E(with U&E))}))

KRG\* 24  
Line(s) 527, 521, 514, 105, 15, 161, 542  
do(request(specific(investigation{select(U&E(U&E only))}))

KRG\* 25  
Line(s) 182  
do(request(specific(investigation{deselect((FBC & U&E))}))

KRG\* 26  
Line(s) 134, 43  
do(request(specific(investigation{deselect((FBC))}))

KRG\* 27  
Line(s) 210  
do(request(specific(investigation{deselect((FBC))}{select(FBC(FBC only))}))

KRG\* 28  
Line(s) 50, 38

do(request(specific(investigation{search((not found))})))

KRG\* 29

Line(s) 409, 288, 520, 498, 492, 473, 470, 468, 367, 330, 305, 127, 125, 123, 92, 179, 181, 252, 278

do(request(specific(investigation{consider(particular(choice))})))

KRG\* 30

Line(s) 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511

do(request(specific(investigation{consider((in general))})))

KRG\* 31

Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56, 49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513

do(request(general(((select)))))

KRG\* 32

Line(s) 406

do(request(general(((deselect)))))

KRG™ 1

Line(s) 525

do(leave system(((return)))))

KRG™ 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524

do(leave system(((leave system)))))

KRG™ 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199

do(list maintenance(((remove patient)))))

KRG™ 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512

do(list maintenance(((add patient)))))

KRG™ 5

Line(s) 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151, 144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58

do(request(print(((confirm)))))

KRG™ 6

Line(s) 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239, 213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293

do(request(print(((command)))))

KRG™ 7

Line(s) 163, 165

do(request(specific(special case((phone results)))))

KRG™ 8

Line(s) 162

do(request(specific(special case((urgent)))))

KRG™ 9

Line(s) 238, 237, 170, 171

do(request(specific(report(enter(current therapy)))))

KRG™ 10

Line(s) 17, 23, 29, 46, 120, 131, 139

do(request(specific(report(enter(working diagnosis)))))

KRG™ 11

Line(s) 233

do(request(specific(report(consider(current therapy)))))

KRG™ 12

Line(s) 204, 67, 184, 466, 467, 475

do(request(specific(report(consider(working diagnosis)))))

KRG™ 13

Line(s) 292, 93, 395

do(request(specific(order ahead((consider)))))

KRG™ 14

Line(s) 432, 421, 403, 354, 329, 149, 118, 100, 66, 190, 203, 266, 519, 262, 518, 265, 202, 189, 65, 99, 117, 148, 328, 353, 402, 420, 431, 539, 157, 276, 287, 439, 448, 535, 427, 426, 534, 447, 438, 286, 275, 156, 538, 537, 533, 446, 285, 274, 155, 425, 437

do(request(specific(order ahead(command(specify))))))

KRG™ 15

Line(s) 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436

do(request(specific(order ahead(command(date btn))))))

KRG™ 16

Line(s) 254, 253, 206, 205, 153, 146, 26, 36, 37, 62, 63, 94, 101, 115, 142, 332, 368, 370, 375, 379, 404, 422, 423, 440, 441, 449, 450, 455, 499, 172, 308, 313

do(request(specific(investigation{select(other)})))

KRG™ 17

Line(s) 44, 211, 279, 268, 236, 235, 126, 128, 136, 137, 290, 331, 394, 396, 269, 291, 393, 289, 135, 124, 180, 234, 267

do(request(specific(investigation{select(FBC & U&E)})))

KRG™ 18

Line(s) 42, 300, 411, 412, 413, 356, 410, 355, 299

do(request(specific(investigation{select(FBC)})))

KRG™ 19

Line(s) 542, 161, 15, 105, 514, 521, 527, 185, 21, 460, 471, 472, 474, 490, 491, 493, 489, 469, 461, 20, 183

do(request(specific(investigation{select(U&E)})))

KRG™ 20

Line(s) 182

do(request(specific(investigation{deselect(FBC & U&E)})))

KRG™ 21

Line(s) 134, 43

do(request(specific(investigation{deselect(FBC)})))

KRG™ 22

Line(s) 210

do(request(specific(investigation{deselect(FBC)} {select(FBC)})))

KRG™ 23

Line(s) 50, 38

do(request(specific(investigation{search(not found)})))

KRG™ 24

Line(s) 278, 252, 181, 179, 92, 123, 125, 127, 305, 330, 367, 468, 470, 473, 492, 498, 520, 288, 409

do(request(specific(investigation{consider(particular)})))

KRG™ 25

Line(s) 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511

do(request(specific(investigation{consider(in general)})))

KRG™ 26

Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56, 49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513

do(request(general(((select))))))

KRG™ 27

Line(s) 406

do(request(general(((deselect))))))

KRG™ 1

Line(s) 525

do(leave system(((return))))

KRG™ 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524

do(leave system(((leave system))))

KRG™ 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199

do(list maintenance(((remove patient))))

KRG™ 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512

do(list maintenance(((add patient))))

KRG™ 5

Line(s) 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151, 144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58

do(request(print(((confirm))))))

KRG™ 6

Line(s) 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239, 213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293  
do(request(print((command))))

KRG™ 7

Line(s) 163, 165  
do(request(specific(special case(phone results))))

KRG™ 8

Line(s) 162  
do(request(specific(special case(urgent))))

KRG™ 9

Line(s) 139, 131, 120, 46, 29, 23, 17, 171, 170, 237, 238  
do(request(specific(report(enter))))

KRG™ 10

Line(s) 475, 467, 466, 184, 67, 204, 233  
do(request(specific(report(consider))))

KRG™ 11

Line(s) 292, 93, 395  
do(request(specific(order ahead(consider))))

KRG™ 12

Line(s) 436, 430, 424, 401, 352, 327, 154, 147, 116, 98, 64, 188, 201, 258, 264, 273, 284, 419, 445, 517, 531, 536, 437, 425, 155, 274, 285, 446, 533, 537, 538, 156, 275, 286, 438, 447, 534, 426, 427, 535, 448, 439, 287, 276, 157, 539, 431, 420, 402, 353, 328, 148, 117, 99, 65, 189, 202, 265, 518, 262, 519, 266, 203, 190, 66, 100, 118, 149, 329, 354, 403, 421, 432  
do(request(specific(order ahead(command))))

KRG™ 13

Line(s) 183, 20, 461, 469, 489, 493, 491, 490, 474, 472, 471, 460, 21, 185, 527, 521, 514, 105, 15, 161, 542, 299, 355, 410, 356, 413, 412, 411, 300, 42, 267, 234, 180, 124, 135, 289, 393, 291, 269, 396, 394, 331, 290, 137, 136, 128, 126, 235, 236, 268, 279, 211, 44, 313, 308, 172, 499, 455, 450, 449, 441, 440, 423, 422, 404, 379, 375, 370, 368, 332, 142, 115, 101, 94, 63, 62, 37, 36, 26, 146, 153, 205, 206, 253, 254  
do(request(specific(investigation{select})))

KRG™ 14

Line(s) 210  
do(request(specific(investigation{deselect} {select})))

KRG™ 15

Line(s) 43, 134, 182  
do(request(specific(investigation{deselect})))

KRG™ 16

Line(s) 38, 50  
do(request(specific(investigation{search})))

KRG™ 17

Line(s) 511, 191, 303, 280, 212, 27, 106, 129, 297, 310, 314, 414, 418, 494, 270, 409, 288, 520, 498, 492, 473, 470, 468, 367, 330, 305, 127, 125, 123, 92, 179, 181, 252, 278  
do(request(specific(investigation{consider})))

KRG™ 18

Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56, 49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513  
do(request(general((select))))

KRG™ 19

Line(s) 406  
do(request(general((deselect))))

KRG™ 1

Line(s) 525  
do(leave system((return)))

KRG™ 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524  
do(leave system((leave system)))

KRG™ 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199  
do(list maintenance((remove patient)))

KRG™ 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512  
do(list maintenance((add patient)))

KRG™ 5

Line(s) 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151, 144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58  
do(request(print(confirm)))

KRG™ 6

Line(s) 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239, 213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293  
do(request(print(command)))

KRG™ 7

Line(s) 162, 165, 163  
do(request(specific(special case)))

KRG™ 8

Line(s) 233, 204, 67, 184, 466, 467, 475, 238, 237, 170, 171, 17, 23, 29, 46, 120, 131, 139  
do(request(specific(report)))

KRG™ 9

Line(s) 432, 421, 403, 354, 329, 149, 118, 100, 66, 190, 203, 266, 519, 262, 518, 265, 202, 189, 65, 99, 117, 148, 328, 353, 402, 420, 431, 539, 157, 276, 287, 439, 448, 535, 427, 426, 534, 447, 438, 286, 275, 156, 538, 537, 533, 446, 285, 274, 155, 425, 437, 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436, 395, 93, 292  
do(request(specific(order ahead)))

KRG™ 10

Line(s) 278, 252, 181, 179, 92, 123, 125, 127, 305, 330, 367, 468, 470, 473, 492, 498, 520, 288, 409, 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511, 50, 38, 182, 134, 43, 210, 254, 253, 206, 205, 153, 146, 26, 36, 37, 62, 63, 94, 101, 115, 142, 332, 368, 370, 375, 379, 404, 422, 423, 440, 441, 449, 450, 455, 499, 172, 308, 313, 44, 211, 279, 268, 236, 235, 126, 128, 136, 137, 290, 331, 394, 396, 269, 291, 393, 289, 135, 124, 180, 234, 267, 42, 300, 411, 412, 413, 356, 410, 355, 299, 542, 161, 15, 105, 514, 521, 527, 185, 21, 460, 471, 472, 474, 490, 491, 493, 489, 469, 461, 20, 183  
do(request(specific(investigation)))

KRG™ 11

Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56, 49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513  
do(request(general(select)))

KRG™ 12

Line(s) 406  
do(request(general(deselect)))

KRG™ 1

Line(s) 525  
do(leave system(return))

KRG™ 2

Line(s) 453, 407, 382, 257, 241, 215, 464, 458, 34, 48, 60, 524  
do(leave system(leave system))

KRG™ 3

Line(s) 70, 71, 72, 73, 74, 75, 76, 79, 77, 78, 80, 81, 82, 109, 110, 111, 112, 113, 175, 176, 177, 194, 195, 196, 197, 199  
do(list maintenance(remove patient))

KRG™ 4

Line(s) 391, 390, 389, 388, 387, 386, 385, 384, 383, 366, 365, 364, 363, 362, 361, 360, 359, 351, 350, 349, 348, 347, 346, 345, 344, 343, 342, 341, 340, 339, 338, 337, 336, 326, 325, 324, 323, 322, 321, 320, 319, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 31, 32, 33, 54, 55, 83, 84, 85, 86, 87, 88, 89, 90, 91, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 502, 503, 504, 505, 506, 507, 508, 509, 510, 512  
do(list maintenance(add patient))

KRG™ 5

Line(s) 293, 380, 397, 376, 357, 333, 16, 22, 28, 39, 45, 68, 95, 102, 107, 119, 130, 138, 143, 150, 158, 166, 167, 173, 186, 192, 207, 213, 239, 255, 271, 306, 415, 428, 433, 442, 451, 456, 476, 495, 500, 515, 528, 523, 540, 543, 371, 51, 57, 281, 301, 311, 316, 462, 58, 52, 187, 429, 541, 294, 398, 381, 377, 372, 358, 334, 317, 18, 24, 30, 40, 47, 53, 59, 69, 96, 103, 108, 121, 132, 140, 144, 151, 159, 168, 174, 193, 214, 240, 256, 272, 208, 282, 302, 307, 312, 416, 434, 443, 452, 457, 463, 477, 496, 501, 516, 529, 544  
do(request(print))

KRG™ 6

Line(s) 183, 20, 461, 469, 489, 493, 491, 490, 474, 472, 471, 460, 21, 185, 527, 521, 514, 105, 15, 161, 542, 299, 355, 410, 356, 413, 412, 411, 300, 42, 267, 234, 180, 124, 135, 289, 393, 291, 269, 396, 394, 331, 290, 137, 136, 128, 126, 235, 236, 268, 279, 211, 44, 313, 308, 172, 499, 455, 450, 449, 441, 440, 423, 422, 404, 379, 375, 370, 368, 332, 142, 115, 101, 94, 63, 62, 37, 36, 26, 146, 153, 205, 206, 253, 254, 210, 43, 134, 182, 38, 50, 511, 191, 303, 280, 212, 27, 106, 129, 297, 310, 314, 414, 418, 494, 270, 409, 288, 520, 498, 492, 473, 470, 468, 367, 330, 305, 127, 125, 123, 92, 179, 181, 252, 278, 292, 93, 395, 436, 430, 424, 401, 352, 327, 154, 147, 116, 98, 64, 188, 201, 258,

264, 273, 284, 419, 445, 517, 531, 536, 437, 425, 155, 274, 285, 446, 533, 537, 538, 156, 275, 286, 438, 447, 534, 426, 427, 535, 448, 439, 287, 276, 157, 539, 431, 420, 402, 353, 328, 148, 117, 99, 65, 189, 202, 265, 518, 262, 519, 266, 203, 190, 66, 100, 118, 149, 329, 354, 403, 421, 432, 139, 131, 120, 46, 29, 23, 17, 171, 170, 237, 238, 475, 467, 466, 184, 67, 204, 233, 163, 165, 162  
do(request(specific))

KRG<sup>7</sup>  
Line(s) 406, 513, 304, 277, 263, 200, 178, 169, 160, 152, 14, 19, 25, 35, 41, 49, 56, 61, 97, 104, 114, 122, 133, 141, 145, 283, 296, 309, 315, 374, 378, 399, 408, 417, 435, 444, 454, 459, 465, 497, 526, 530, 209  
do(request(general))

KRG<sup>1</sup>  
Line(s) 524, 60, 48, 34, 458, 464, 215, 241, 257, 382, 407, 453, 525  
do(leave system)

KRG<sup>2</sup>  
Line(s) 512, 510, 509, 508, 507, 506, 505, 504, 503, 502, 488, 487, 486, 485, 484, 483, 482, 481, 480, 479, 478, 91, 90, 89, 88, 87, 86, 85, 84, 83, 55, 54, 33, 32, 31, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 319, 320, 321, 322, 323, 324, 325, 326, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 359, 360, 361, 362, 363, 364, 365, 366, 383, 384, 385, 386, 387, 388, 389, 390, 391, 199, 197, 196, 195, 194, 177, 176, 175, 113, 112, 111, 110, 109, 82, 81, 80, 78, 77, 79, 76, 75, 74, 73, 72, 71, 70  
do(list maintenance)

KRG<sup>3</sup>  
Line(s) 209, 530, 526, 497, 465, 459, 454, 444, 435, 417, 408, 399, 378, 374, 315, 309, 296, 283, 145, 141, 133, 122, 114, 104, 97, 61, 56, 49, 41, 35, 25, 19, 14, 152, 160, 169, 178, 200, 263, 277, 304, 513, 406, 162, 165, 163, 233, 204, 67, 184, 466, 467, 475, 238, 237, 170, 171, 17, 23, 29, 46, 120, 131, 139, 432, 421, 403, 354, 329, 149, 118, 100, 66, 190, 203, 266, 519, 262, 518, 265, 202, 189, 65, 99, 117, 148, 328, 353, 402, 420, 431, 539, 157, 276, 287, 439, 448, 535, 427, 426, 534, 447, 438, 286, 275, 156, 538, 537, 533, 446, 285, 274, 155, 425, 437, 536, 531, 517, 445, 419, 284, 273, 264, 258, 201, 188, 64, 98, 116, 147, 154, 327, 352, 401, 424, 430, 436, 395, 93, 292, 278, 252, 181, 179, 92, 123, 125, 127, 305, 330, 367, 468, 470, 473, 492, 498, 520, 288, 409, 270, 494, 418, 414, 314, 310, 297, 129, 106, 27, 212, 280, 303, 191, 511, 50, 38, 182, 134, 43, 210, 254, 253, 206, 205, 153, 146, 26, 36, 37, 62, 63, 94, 101, 115, 142, 332, 368, 370, 375, 379, 404, 422, 423, 440, 441, 449, 450, 455, 499, 172, 308, 313, 44, 211, 279, 268, 236, 235, 126, 128, 136, 137, 290, 331, 394, 396, 269, 291, 393, 289, 135, 124, 180, 234, 267, 42, 300, 411, 412, 413, 356, 410, 355, 299, 542, 161, 15, 105, 514, 521, 527, 185, 21, 460, 471, 472, 474, 490, 491, 493, 489, 469, 461, 20, 183, 544, 529, 516, 501, 496, 477, 463, 457, 452, 443, 434, 416, 312, 307, 302, 282, 208, 272, 256, 240, 214, 193, 174, 168, 159, 151, 144, 140, 132, 121, 108, 103, 96, 69, 59, 53, 47, 40, 30, 24, 18, 317, 334, 358, 372, 377, 381, 398, 294, 541, 429, 187, 52, 58, 462, 316, 311, 301, 281, 57, 51, 371, 543, 540, 523, 528, 515, 500, 495, 476, 456, 451, 442, 433, 428, 415, 306, 271, 255, 239, 213, 207, 192, 186, 173, 167, 166, 158, 150, 143, 138, 130, 119, 107, 102, 95, 68, 45, 39, 28, 22, 16, 333, 357, 376, 397, 380, 293  
do(request)

##%545  
1  
##+1  
2 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
3 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
4 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
5 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
6 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
7 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
8 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
9 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
10 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
11 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
12 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
13 KRG<sup>2</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup> KRG<sup>4</sup>  
##-1  
##+2  
14 KRG<sup>3</sup> KRG<sup>7</sup> KRG<sup>11</sup> KRG<sup>18</sup> KRG<sup>26</sup> KRG<sup>31</sup> KRG<sup>37</sup> KRG<sup>44</sup>  
15 KRG<sup>3</sup> KRG<sup>6</sup> KRG<sup>10</sup> KRG<sup>13</sup> KRG<sup>19</sup> KRG<sup>24</sup> KRG<sup>30</sup> KRG<sup>37</sup>  
16 KRG<sup>3</sup> KRG<sup>5</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>8</sup>  
17 KRG<sup>3</sup> KRG<sup>6</sup> KRG<sup>8</sup> KRG<sup>9</sup> KRG<sup>10</sup> KRG<sup>10</sup> KRG<sup>10</sup> KRG<sup>13</sup>  
18 KRG<sup>3</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>7</sup>  
##-2  
##+3  
19 KRG<sup>3</sup> KRG<sup>7</sup> KRG<sup>11</sup> KRG<sup>18</sup> KRG<sup>26</sup> KRG<sup>31</sup> KRG<sup>37</sup> KRG<sup>44</sup>  
20 KRG<sup>3</sup> KRG<sup>6</sup> KRG<sup>10</sup> KRG<sup>13</sup> KRG<sup>19</sup> KRG<sup>23</sup> KRG<sup>29</sup> KRG<sup>36</sup>  
21 KRG<sup>3</sup> KRG<sup>6</sup> KRG<sup>10</sup> KRG<sup>13</sup> KRG<sup>19</sup> KRG<sup>23</sup> KRG<sup>28</sup> KRG<sup>35</sup>  
22 KRG<sup>3</sup> KRG<sup>5</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>6</sup> KRG<sup>8</sup>  
23 KRG<sup>3</sup> KRG<sup>6</sup> KRG<sup>8</sup> KRG<sup>9</sup> KRG<sup>10</sup> KRG<sup>10</sup> KRG<sup>10</sup> KRG<sup>13</sup>  
24 KRG<sup>3</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>5</sup> KRG<sup>7</sup>  
##-3

### A3.1 KRG sentences selected for detailed analysis

KRG	Mnemonic	Task type
63	Remove pat	1
64	Add pat	2
25,27,31	minor list	3
26,28,32,35	major list	4
29,30,38	Double btn	5
33,34,39,40	FBC	6
36,37	U&E	7
22	leave system	8
49	enter report	9
410	consider report	10
417	consider investig	11
59	order ahead	12
511, 512	general select	13
65	print	14
61	special case	15

# Appendix B

## Prototype source code

### FIELD SCRIPTS

#### SCRIPT OF CD FLD SHORTPAT

-- PATIENT SELECTION

ON MOUSEUP

timeout

IF the backcolor of the target = 247 then

  errormessage

  EXIT MOUSEUP

ENDIF

tripleclick

put the selectedtext into pat

IF the number of chars in pat < 2 then

  set the locktext of card fld shortpat to true

  EXIT MOUSEUP

ENDIF

set the cursor to "watch"

put first word of pat into hospno

REPEAT WITH i = 1 to the number of lines in cd fld biglist

  IF item 2 of line i of cd fld biglist = hospno THEN

    put i into lineno

    EXIT REPEAT

  ENDIF

END REPEAT

-- REMOVE PATIENT

IF the forecolor of card btn "Remove patient" is 216 THEN

  delete last char of pat

  answer "Remove " & pat && "from list ?" with "OK" or "Cancel"

  lock screen

  IF it is "OK" THEN

    delete line (clickline()) of card fld shortpat

    set the scroll of me to 1

    delete line lineno of card fld biglist

  ENDIF

  blackbuttons 2,4,6,7,8,14,15,20,49,50,51,52,53

  blackfields 2

  blackPlusMinus 11,12,13

-- END REMOVE PAT

ELSE

  lock screen

  getDetails lineno

  hide card drw bottom

  hideshortpat

  set the name of the card btn 9 to "SELECTED PATIENT"

  show card btn "Show Patient list"

  showfields

ENDIF

set the locktext of card fld shortpat to true

END MOUSEUP

ON getDetails lineno

  put (the number of cd fld Nam) - 1 into diff

  put line lineno of card fld biglist into rawpat

  REPEAT WITH i = 1 to 8

    IF i = 3 THEN

      IF char 1 of item i of rawpat = F THEN

        put "Female " into card fld (i + diff)

      ELSE

        put "Male " into card fld (i + diff)

      ENDIF

    ENDIF

  IF i > 6 THEN

    REPEAT WITH letter = 1 to the number of chars in item i of rawpat

      IF char letter of item i of rawpat = "/" THEN

        put return into char letter of item i of rawpat

      ENDIF

```

    END REPEAT
  END IF
  put item i of rawpat into cd fld (i + diff)
END REPEAT
put the ticks into line 2 of cd fld secs
END getDetails

```

---

## SCRIPT OF CD FLD TESTS

### -- TEST SELECTION

```

ON MOUSEUP
  timeout
  IF the backcolor of the target = 247 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  IF cd fld testtotal = 6 THEN
    beep
    answer "Please print this request out before ordering any more" with "OK"
    EXIT MOUSEUP
  ENDIF
  tripleclick
  put the selectedtext into test
  delete last char of test
  IF char 1 to 3 of test = "CEP" THEN
    IF alreadyCEP (test) THEN
      answer "Please print before requesting further CEPs"
      set the locktext of the target to true
      EXIT MOUSEUP
    ENDIF
  ENDIF
  lock screen
  IF test <> "" THEN
    find string test in card fld testdata
    put word 2 of the foundline into lineno
    put item 1 of line lineno of cd fld testdata into testcode
    put item 2 of line lineno of cd fld testdata into btnname
    REPEAT until btnname = test
      add 1 to lineno
      put item 1 of line lineno of cd fld testdata into testcode
      put item 2 of line lineno of cd fld testdata into btnname
    END REPEAT
    REPEAT WITH i = 1 to the number of words in cd fld output
      IF testcode = word i of cd fld output THEN
        click at the loc of cd btn btnname
        set the locktext of cd fld tests to true
        EXIT MOUSEUP
      ENDIF
    END REPEAT
    recordTestCode lineNo,testcode
    add 1 to line 1 of card fld testtotal
    showSelectedTest test
  END IF
  set the locktext of the target to true
END MOUSEUP

ON showSelectedTest test
  put test into choice
  choose button tool
  set the userlevel to 4
  select card btn master
  domenu copy button
  domenu paste button
  choose browse tool
  set the userlevel to 2
  put the number of card buttons into total
  set the name of card button total to choice
  set the visible of card button total to true
  set the rect of card btn total to the rect of card btn "U&E"
  set the top of card btn total to the bottom of card btn "U&E" --+ 1
  IF line 1 of card fld testtotal >1 THEN
    set the top of card btn total to (the bottom of card btn (total-1)) --+ 1
  END IF
  IF (the number of chars in choice > 12) AND (the number of chars in choice <=16) THEN
    set the textsize of card btn total to 18
  ELSE
    --test <> empty
    --card fld testtotal

```

```

IF (the number of chars in choice > 16) THEN
  set the textsize of card btn total to 14
  set the textstyle of card btn total to plain
ENDIF
END IF
END showSelectedTest

```

--number of chars in choice

```

ON recordTestCode lineNo,testcode
IF item 3 of line lineno of cd fld testdata = "H" THEN
  put testcode & " " after line 5 of cd fld output
ELSE
  IF item 3 of line lineno of cd fld testdata = "C" THEN
    put testcode & " " after line 6 of cd fld output
  ELSE
    IF item 3 of line lineno of cd fld testdata = "U" THEN
      put testcode & " " after line 7 of cd fld output
    ELSE
      IF item 3 of line lineno of cd fld testdata = "F" THEN
        put testcode & " " after line 8 of cd fld output
      ELSE
        IF item 3 of line lineno of cd fld testdata = "K" THEN
          put testcode & " " after line 9 of cd fld output
        ELSE
          IF item 3 of line lineno of cd fld testdata = "I" THEN
            put testcode & " " after line 10 of cd fld output
          ELSE
            IF item 3 of line lineno of cd fld testdata = "R" THEN
              put testcode & " " after line 11 of cd fld output
            ENDIF
          ENDIF
        ENDIF
      ENDIF
    ENDIF
  ENDIF
END recordTestCode

```

--Respiratory unit  
--Immunology  
--K coag lab  
--Faeces  
--Urine  
--Clin chem  
--Haematology

```

FUNCTION alreadyCEP test
find "CEP" in cd fld output
IF the foundtext = "" THEN
  return false
ELSE
  IF char 5 of the foundtext <> char 5 of test THEN
    return true
  ELSE
    return false
  ENDIF
ENDIF
END alreadyCEP

```

---

## SCRIPT OF CD WPF RARETESTS

-- TEST SELECTION, MINOR LIST

```

ON MOUSELEAVE
REPEAT until (the mouseH < the left of me) or (the mouseV < the top of me)
  show me
  IF the mouseloc is within the rect of me THEN EXIT mouseleave
END REPEAT
hide me
set the scroll of me to 1
END MOUSELEAVE

```

```

ON MOUSEUP
timeout
IF the backcolor of the target = 247 THEN
  errorMessage
  EXIT MOUSEUP
ENDIF
IF cd fld testtotal = 6 THEN
  beep
  answer "Please print this request out before ordering any more" with "OK"
  EXIT MOUSEUP
ENDIF
tripleclick
put the selectedtext into test
delete last char of test

```

```

IF the backcolor of card btn "Remove test" = 216 THEN
  removetest test
ELSE
  lock screen
  IF test <> "" THEN
    find string test in card fld testdata
    put word 2 of the foundline into lineno
    put item 1 of line lineno of cd fld testdata into testcode
    put item 2 of line lineno of cd fld testdata into btnname
    REPEAT until btnname = test
      add 1 to lineno
      put item 1 of line lineno of cd fld testdata into testcode
      put item 2 of line lineno of cd fld testdata into btnname
    END REPEAT
    REPEAT WITH i = 1 to the number of words in cd fld output
      IF testcode = word i of cd fld output THEN
        click at the loc of cd btn btnname
        set the locktext of cd wpf raretests to true
        EXIT MOUSEUP
      ENDIF
    END REPEAT
    recordTestCode lineNo,testcode
    add 1 to line 1 of card fld testtotal
    showSelectedTest test
    END IF --test <> empty
    set the locktext of the target to true
  ENDIF
END MOUSEUP
--remove btn chosen

ON removetest test
IF test is NOT empty THEN
  answer "Remove" && test && "from list ?" with "OK" or "Cancel"
  IF it is "OK" THEN
    REPEAT WITH i = 1 to the number of lines in card fld tests
      IF line i of card fld tests = test THEN
        delete line i of card fld tests
      END IF
    END REPEAT
  END IF
  set the backcolor of card btn "Remove test" to 44
  set the locktext of the target to true
ENDIF
END removetest

ON showSelectedTest test
put test into choice
set the userlevel to 4
choose button tool
select card btn master
domenu copy button
domenu paste button
choose browse tool
set the userlevel to 2
put the number of card buttons into total
set the name of card button total to choice
set the visible of card button total to true
set the rect of card btn total to the rect of card btn "U&E"
set the top of card btn total to the bottom of card btn "U&E" --+ 1
IF line 1 of card fld testtotal > 1 THEN
  set the top of card btn total to (the bottom of card btn (total-1)) --+ 1
ENDIF --card fld testtotal
IF (the number of chars in choice > 12) AND (the number of chars in choice <=16) THEN
  set the textsize of card btn total to 18
ELSE
  IF (the number of chars in choice > 16) THEN
    set the textsize of card btn total to 14
    set the textstyle of card btn total to plain
  ENDIF
ENDIF --number of chars in choice
END showSelectedTest

ON recordTestCode lineNo,testcode
IF item 3 of line lineno of cd fld testdata = "H" THEN
  put testcode & " " after line 5 of cd fld output
ELSE
  IF item 3 of line lineno of cd fld testdata = "C" THEN
    put testcode & " " after line 6 of cd fld output
  ELSE
    IF item 3 of line lineno of cd fld testdata = "U" THEN

```

```

put testcode & " " after line 7 of cd fld output
ELSE
IF item 3 of line lineno of cd fld testdata = "F" THEN
put testcode & " " after line 8 of cd fld output
ELSE
IF item 3 of line lineno of cd fld testdata = "K" THEN
put testcode & " " after line 9 of cd fld output
ELSE
IF item 3 of line lineno of cd fld testdata = "I" THEN
put testcode & " " after line 10 of cd fld output
ELSE
IF item 3 of line lineno of cd fld testdata = "R" THEN
put testcode & " " after line 11 of cd fld output
ENDIF
ENDIF
ENDIF
ENDIF
ENDIF
ENDIF
ENDIF
ENDIF

```

--Respiratory unit  
--Immunology  
--K coag lab  
--Faeces  
--Urine  
--Clin chem  
--Haematology

END recordTestCode

---

## SCRIPTS FOR PATIENT DETAILS FIELDS

### SCRIPT OF CD FLD NAM

```

ON openfield
hide cd fld theraps
END openfield
ON closefield
timeout
removecommas the number of target
truncate the number of the target, the number of chars in target, 23
set the scroll of the target to 1
END closefield

```

---

### SCRIPT OF CD FLD HOS

```

ON openfield
global previousnum
put cd fld hos into previousnum
END openfield

ON closefield
global previousnum
timeout
REPEAT WHILE NOT uniqueHosNum(cd fld hos) AND the number of chars in cd fld hos = 6 AND previousnum <> cd fld hos
ask "Number already exists. Please re-enter."
put it into cd fld hos
END REPEAT
REPEAT WHILE NOT validinput(cd fld hos)
ask "Enter hospital number in the form: AA1111" with cd fld hos
REPEAT WHILE NOT uniqueHosNum(it) AND the number of chars in it = 6 AND previousnum <> it
ask "Number already exists. Please re-enter."
put it into cd fld hos
END REPEAT
put uppercase(it) into cd fld hos
IF it is "" THEN
put "Temp" & random(9999) into cd fld hos
EXIT REPEAT
ENDIF
END REPEAT
put uppercase(cd fld hos) into cd fld hos
END closefield

FUNCTION validinput num
put "ok" into flag
REPEAT WITH i = 1 to 2
IF NOT (((chartonum(char i of num) >= 65 ) AND (chartonum(char i of num) <=90)) ^
or ((chartonum(char i of num) >= 97) AND (chartonum(char i of num) <=122))) THEN
put "crap" into flag
ENDIF
END REPEAT
REPEAT WITH i = 3 to 6

```

```

IF NOT (((chartonum(char i of num) >=48) AND (chartonum(char i of num) <= 57))) THEN
  put "crap" into flag
ENDIF
END REPEAT
IF the number of chars in num > 6 THEN put "crap" into flag
IF flag = "crap" THEN
  return false
ELSE
  return true
ENDIF
END validinput

FUNCTION uniqueHosNum num
find chars num in cd fld biglist
IF the foundtext <> "" THEN
  return false
ELSE
  return true
ENDIF
END uniqueHosNum

```

---

## SCRIPT OF CD FLD SEX

```

ON closefield
  timeout
  put uppercase(target) into the target
  REPEAT WHILE (cd fld sex <> "M") AND (cd fld sex <> "m") AND (cd fld sex <> "f") AND (cd fld sex <> "F")
    ask "Type M or F Only"
    put uppercase(it) into cd fld sex
  END REPEAT
  truncate the number of the target, the number of chars in target, 1
  set the scroll of the target to 1
END closefield

```

---

## SCRIPT OF CD FLD DOB

```

ON closefield
  timeout
  removeconmas the number of the target
  truncate the number of the target, the number of chars in target, 10
  set the scroll of the target to 1
END closefield

```

---

## SCRIPT OF CD FLD WAR

```

ON closefield
  timeout
  removeconmas the number of the target
  truncate the number of the target, the number of chars in target, 4
  set the scroll of the target to 1
END closefield

```

---

## SCRIPT OF CD FLD CON

```

ON openfield
  show cd fld conlist
END openfield

ON tabKey
  hide cd fld conlist
END tabKey

ON returnInField
  hide cd fld conlist
  send tabkey to cd fld cli
END returnInField

ON closefield

```

```
timeout
put uppercase(cd fld con) into cd fld con
removecommas the number of the target
truncate the number of the target, the number of chars in target, 10
set the scroll of the target to 1
hide cd fld conlist
END closefield
```

---

## SCRIPT OF CD FLD CONLIST

```
ON MOUSEUP
tripleclick
put last word of the selectedtext into consultant
IF chartonum(last char of consultant) = 13 THEN delete last char of consultant
IF consultant = cd fld con THEN
  put "" into cd fld con
ELSE
  put consultant into cd fld con
ENDIF
set the locktext of me to true
send closefield to cd fld con
END MOUSEUP
```

---

## SCRIPT OF CD FLD CLI

```
ON openfield
hide cd fld conlist
END openfield

ON closefield
timeout
removecommas the number of the target
removeEmptyLines the number of the target
END closefield
```

---

## SCRIPT OF CD FLD CUR

```
ON tabKey
hide cd fld theraps
END tabKey

ON returnInField
hide cd fld theraps
END returnInField
ON openfield
timeout
IF the bgcolor of me = 180 THEN
  show cd fld theraps
END IF
END openfield

ON closefield
lock screen
removecommas the number of the target
REPEAT WITH i = 1 to the number of lines in target
  REPEAT until the number of chars in line i of target < 15
    delete last char of line i of target
  END REPEAT
END REPEAT
IF the number of lines in target >3 THEN
  set the style of the target to scrolling
  set the scroll of the target to 1
ELSE
  set the style of the target to rectangle
ENDIF
removeEmptyLines the number of the target
END closefield

ON MOUSEUP
tripleclick
lock screen
```

```

put the selectiON into choice
IF the number of chars in choice > 2 THEN
  IF chartonum(last char of choice) = 13 THEN delete last char of choice
  find choice in cd fld extras
  IF the foundtext = "" THEN
    put choice & return after cd fld extras
  ELSE
    put word 2 of the foundline into lineno
    delete line lineno of cd fld extras
    IF cd fld extras = "" THEN
      closeExtras
    ENDIF
  END IF
ENDIF
END IF
set the locktext of the target to true
set the forecolor of cd btn "Include Therapy" to 255
END MOUSEUP

```

---

## SCRIPT OF CD FLD THERAPS

```

ON MOUSEUP
tripleclick
put the selectedtext into drug
IF chartonum(last char of drug) = 13 THEN delete last char of drug
find drug in cd fld cur
IF the foundtext = "" THEN
  IF chartonum(last char of cd fld cur) <> 13 THEN
    put return after cd fld cur
  ENDIF
  put drug & return after cd fld cur
ELSE
  delete line (word 2 of the foundline) of cd fld cur
ENDIF
set the locktext of me to true
send closefield to cd fld cur
set the scroll of cd fld cur to 1
END MOUSEUP

```

---

## SCRIPT OF CD DBF LOGIN

```

ON returnInField
put "" into the target
find chars cd fld secret in cd WPF list
IF the foundtext = cd fld secret AND the number of chars in the foundtext > 3 AND the foundtext <> "_____" THEN
  put item 2 of line (secONd word of (the foundline)) of cd wpf list into doctor
  put item 3 of line (secONd word of (the foundline)) of cd wpf list into bleepno
  delete line 1 of cd fld secret
  set cursor to 0
  lock screen
  IF the foundtext = "Prasio" THEN
    show cd btn algae
  ELSE
    IF the foundtext = "FINISH" THEN
      executeRemote "[Filesave]" application "winword" topic "c:\plus\form.doc"
      executeRemote "[FileEXIT]" application "winword" topic "c:\plus\form.doc"
      domenu quit
    ELSE
      hide cd btn algae
    ENDIF
  ENDIF
ENDIF
go cd 1
IF the foundtext = "Prasio" THEN
  show cd btn spare
  set the userlevel to 5
ELSE
  hide cd btn spare
  set the userlevel to 2
ENDIF
resettests
put the seconds into line 1 of cd fld secs
put the ticks into line 2 of cd fld secs
put doctor into cd fld doc
put bleepno into cd fld bleep
put the abbrev date into cd fld datetime of cd 1
truncateDate

```

```

IF the forecolor of cd btn 4 = 216 THEN
  click at the loc of cd btn 4
ENDIF
ELSE
  answer "Password incorrect. Please try again"
  delete line 1 of cd fld secret
  click at the loc of cd dbf login
END IF
END returnInField

```

```

ON keyPressed a
  put "*" after cd dbf login
  put the number of chars in cd dbf login into num
  put a into char num of cd fld secret
  IF the number of chars in card fld secret > 6 THEN delete last char of cd fld secret
END keyPressed

```

## BUTTON SCRIPTS

### SCRIPT OF CD BTN FBC & U&E

```

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEDOWN
  ENDIF
  IF the forecolor of the target = 255 THEN
    set the forecolor of the target to 216--red
    IF the forecolor of cd btn fbc = 216 THEN
      set the forecolor of cd btn fbc to 255
    ELSE
      put "FBC " after line 5 of cd fld output
    END IF
  IF the forecolor of cd btn "U&E" = 216 THEN
    set the forecolor of cd btn "U&E" to 255
  ELSE
    put "UE " after line 6 of cd fld output
  END IF
  ELSE
    set the forecolor of the target to 255 --black
    lock screen
    find "FBC" in cd fld output
    put the foundchunk into place
    put word 2 of place into start
    put word 4 of place into finish
    delete char start to (finish + 1) of cd fld output
    find "UE" in cd fld output
    put the foundchunk into place
    put word 2 of place into start
    put word 4 of place into finish
    delete char start to (finish + 1) of cd fld output
  ENDIF
END MOUSEDOWN

```

### SCRIPT OF CD BTN FBC

```

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEDOWN
  ENDIF
  IF the forecolor of the target = 255 THEN
    set the forecolor of the target to 216--red
    IF the forecolor of cd btn "FBC & U&E" = 216 THEN
      set the forecolor of cd btn "FBC & U&E" to 255
      lock screen
      find "UE" in cd fld output
    END IF
  END IF

```

```

    put the foundchunk into place
    put word 2 of place into start
    put word 4 of place into finish
    delete char start to (finish + 1) of cd fld output
ELSE
    put "FBC " after line 5 of cd fld output
ENDIF
ELSE
    set the forecolor of the target to 255 --black
    lock screen
    find "FBC" in cd fld output
    put the foundchunk into place
    put word 2 of place into start
    put word 4 of place into finish
    delete char start to (finish + 1) of cd fld output
ENDIF
END MOUSEDOWN

```

---

## SCRIPT OF CD BTN U&E

```

ON MOUSEDOWN
    timeout
    IF the forecolor of the target = 249 THEN
        errorMessage
        EXIT MOUSEDOWN
    ENDIF
    IF the forecolor of the target = 255 THEN
        set the forecolor of the target to 216--red
        IF the forecolor of cd btn "FBC & U&E" = 216 THEN
            set the forecolor of cd btn "FBC & U&E" to 255
            lock screen
            find "FBC" in cd fld output
            put the foundchunk into place
            put word 2 of place into start
            put word 4 of place into finish
            delete char start to (finish + 1) of cd fld output
        ELSE
            put "UE " after line 6 of cd fld output
        ENDIF
    ELSE
        set the forecolor of the target to 255 --black
        find "UE" in cd fld output
        put the foundchunk into place
        put word 2 of place into start
        put word 4 of place into finish
        delete char start to (finish + 1) of cd fld output
    ENDIF
END MOUSEDOWN

```

---

## SCRIPT OF CD BTN SET DATE/TIME

```

ON MOUSEENTER
    exclusiveRed 12,16,17,18,19,21,45,47,48
END MOUSEENTER

ON MOUSEDOWN
    IF the forecolor of the target = 249 THEN
        errorMessage
        EXIT MOUSEDOWN
    ENDIF
    IF the forecolor of the target = 216 THEN
        set the forecolor of the target to 255
    ELSE
        set the forecolor of the target to 216
    ENDIF
END MOUSEDOWN

ON MOUSEUP
    timeout
    IF the forecolor of the target = 249 THEN
        errorMessage
        EXIT MOUSEUP
    ENDIF

```

```

set the textcolor of cd fld dateTime to 0
IF the forecolor of the target = 216 THEN
  put "" into cd fld datetime
  put the abbrev date into line 4 of cd fld datetime
  lock screen
  greyoutbuttons 2,4,8,11,12,14,15,16,17,18,19,20,21,45,47,48,50,51,52,53
  hide cd btn 49 --fbc & ue
  greyoutfields 1,2
  greypusminus 11,12,13
  IF cd fld testtotal > 0 THEN
    REPEAT WITH i = ((the number of cd btns - cd fld testtotal)+ 1) to the number of cd btns
      hide cd btn i
    END REPEAT
  ENDIF
  showclock
  blacktimes 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981,1970,-
    1978,1971,1985,1972,1982,1974
ELSE
  hideclock
ENDIF
END MOUSEUP

ON mouseLeave
  IF the forecolor of the target = 249 THEN EXIT mouseleave
  set the forecolor of the target to 255
END mouseLeave

ON blacktimes
  REPEAT WITH i = 1 to the paramcount
    set the forecolor of cd btn id param(i) to 255
  END REPEAT
END blacktimes

```

---

## SCRIPT OF CD BTN ADD PATIENT

```

ON mouseLeave
  IF the forecolor of the target = 249 THEN EXIT mouseLeave
  IF the forecolor of the target = 216 THEN set the forecolor of the target to 255
  followcolorplusminus 11,12
END mouseLeave
ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
  set the forecolor of the target to 216
  followcolorPlusMinus 11,12
END MOUSEDOWN

ON MOUSEUP
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  set the forecolor of the target to 216
  followcolorPlusMinus 11,12
  put 1 into cd fld add
  lock screen
  hideshortpat
  changeFieldsMode the number of cd fld Nam, the number of cd fld cur, false,180,255,empty
  put "P1" into cd fld war
  showfields
  show cd fld theraps
  set the name of cd btn 21 to "Save details"
  set the name of the card btn 9 to "NEW PATIENT"
  resizeclinback 1.4
  show cd fld clindetlab
  show cd fld cur
  show card btn "show patient list"
  greyoutbuttons 6,7,8,12,14,15,16,17,18,19,20,47,48,49,50,51,52,53
  greyoutfields 2
  click at the loc of cd fld nam
  blackPlusMinus 11,12
END MOUSEUP

```

---

## SCRIPT OF CD BTN REMOVE PATIENT

```
ON MOUSEENTER
  exclusiveRed 2
END MOUSEENTER

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN
    errormessage
    EXIT MOUSEDOWN
  ENDIF
  IF the forecolor of the target = 255 THEN
    set the forecolor of the target to 216
    followcolorPlusMinus 13
    lock screen
    greyoutbuttons 2,6,7,8,14,15,20,49,50,51,52,53
    greyoutfields 2
    greyPlusMinus 11,12
  ELSE
    lock screen
    set the forecolor of the target to 255
    followcolorPlusMinus 13
    blackbuttons 2,6,7,8,14,15,20,49,50,51,52,53
    restoreRedTests
    blackfields 2
    blackPlusMinus 11,12
  ENDIF
END MOUSEDOWN
```

---

## SCRIPT OF CD BTN EXIT

```
ON MOUSEENTER
  exclusiveRed 11,17,18,19,21,20,45,47,48
END MOUSEENTER

ON MOUSELEAVE
  IF the forecolor of the target = 249 THEN EXIT MOUSELEAVE
  set the forecolor of the target to 255
  followcolor 2596
END MOUSELEAVE

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
  set the forecolor of the target to 216
  followcolor 2596
END MOUSEDOWN

ON MOUSEUP
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  set the forecolor of the target to 216
  lock screen
  IF the visible of cd btn "Show patient list" = true THEN click at the loc of cd btn "Show patient list"
  set the forecolor of the target to 255
  followcolor 2596
  resetUrgentbar 14,15,8
  go next
  click at the loc of cd dbf login
END MOUSEUP

ON resetUrgentbar
  REPEAT WITH i = 1 to the paramcount
    IF the forecolor of cd btn param(i) = 216 THEN set the forecolor of cd btn param(i) to 255
  END REPEAT
END resetUrgentbar
```

---

## SCRIPT OF CD BTN URGENT

```
ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN
```

```
errorMessage
EXIT MOUSEDOWN
ENDIF
IF the forecolor of the target = 255 THEN
  set the forecolor of the target to 216
ELSE
  set the forecolor of the target to 255
ENDIF
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN PHONE

```
ON MOUSEDOWN
timeout
IF the forecolor of the target = 249 THEN
  errorMessage
  EXIT MOUSEDOWN
ENDIF
IF the forecolor of the target = 255 THEN
  set the forecolor of the target to 216
  answer "Results will be returned by telephone"
ELSE
  set the forecolor of the target to 255
ENDIF
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN OUTLIER

```
ON MOUSEDOWN
timeout
IF the forecolor of the target = 249 THEN
  errorMessage
  EXIT MOUSEDOWN
ENDIF
IF the forecolor of the target = 255 THEN
  set the forecolor of the target to 216
  ask "Return results to ward ....."
  IF it is NOT "" THEN
    put it into line 1 of cd fld output
  ELSE
    set the forecolor of the target to 255
  ENDIF
ELSE
  put "" into line 1 of cd fld output
  set the forecolor of the target to 255
ENDIF
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN MORE

```
ON MOUSELEAVE
IF the forecolor of the target = 216 THEN
  set the forecolor of the target to 255
  followcolor 2476
ENDIF
IF the mouseloc is NOT within the rect of cd wpf raretests THEN hide cd wpf raretests
END MOUSELEAVE
```

```
ON MOUSEDOWN
timeout
IF the forecolor of the target = 249 THEN
  errormessage
  EXIT MOUSEDOWN
ENDIF
IF the forecolor of the target = 255 THEN
  set the forecolor of the target to 216
  followcolor 2476
  lock screen
  IF the visible of cd wpf raretests = true THEN
    hide cd wpf raretests
  ELSE
    show cd wpf raretests
  ENDIF
ENDIF
```

```

END IF
ELSE
  set the forecolor of the target to 255
ENDIF
END MOUSEDOWN

ON MOUSEUP
  set the forecolor of the target to 255
  followcolor 2476
END MOUSEUP

ON MOUSELEAVE
  IF (the mouseloc is NOT within the rect of cd wpf raretests) AND (the visible of cd wpf raretests = true)
  THEN
    hide cd wpf raretests
  END IF
END MOUSELEAVE

```

---

## SCRIPT OF CD BTN PRINT REQUEST

```

ON MOUSEUP
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  set the forecolor of the target to 216
  followcolor 1295
  REPEAT WHILE workingDiagnosis() = false
    beep
    ask "Please enter a working diagnosis"
    addDetail it,(the number of cd fld cli)
  END REPEAT
  put line 5 of cd fld output into haems
  put line 6 of cd fld output into clins
  put line 7 of cd fld output into urine
  put line 8 of cd fld output into faeces
  put line 9 of cd fld output into clots
  put line 10 of cd fld output into immun
  put line 11 of cd fld output into resp
  put haems & clins & urine & faeces & clots & immun & resp into allTests
  IF allTests = "" THEN
    beep
    answer "No tests have been requested" with "OK" or "HAND written"
  END IF
  IF it is "HAND written" or allTests <> "" THEN
    answer "Print this request ?" with "Cancel" or "OK"
    IF it is "OK" THEN
      set the cursor to watch
      lock screen
      prepareform
      IF haems <> empty THEN
        printform haems
      ENDIF
      IF clins <> empty THEN
        printform clins
      ENDIF
      IF immun <> empty THEN
        printform immun
      ENDIF
      IF resp <> empty THEN
        setremote spec to "AB" application winword topic "c:\plusform.doc"
        printform resp
      ENDIF
      IF clots <> empty THEN
        printform clots
      ENDIF
      IF urine <> empty THEN
        setremote spec to "Urine" application winword topic "c:\plusform.doc"
        printform urine
      ENDIF
      IF faeces <> empty THEN
        setremote spec to "Faeces" application winword topic "c:\plusform.doc"
        printform faeces
      ENDIF
      IF allTests = empty THEN
        put "" into Notest
        printform Notest
      ENDIF
    END IF
  END IF

```

```

ENDIF
domenu compact stack
put line 1 of cd fld datetime into oldtime           --so that cd wpf record has chosen time
put cd fld cli into oldclins                         --ditto
put cd fld extras into oldext                       --ditto
put "" into cd fld output
put "" into cd fld extras
set the forecolor of the target to 255
click at the loc of cd btn "Show Patient list"
ENDIF
ENDIF
set the forecolor of the target to 255
followcolor 1295
put round((the ticks - line 2 of cd fld secs)/ 60) & tab & oldtime & tab & the time & tab & cd fld doc & tab &
    CD FLD NAM & tab & allTests & oneline(oldclins) & "/"
    & oneline(oldext) & return after cd wpf record    --maintains software log
END MOUSEUP

ON prepareform                                     --completes form in Word for Windows
urgent
pleasePhone
outlier
hosNo
setremote dob to cd fld dob application winword topic "c:\plus\form.doc"
setremote nam to cd fld nam application winword topic "c:\plus\form.doc"
setremote spec to "VB" application winword topic "c:\plus\form.doc"
setremote sex to cd fld sex application winword topic "c:\plus\form.doc"
setremote date to line 1 of cd fld datetime application winword topic "c:\plus\form.doc"
setremote war to cd fld war application winword topic "c:\plus\form.doc"
setremote con to cd fld con application winword topic "c:\plus\form.doc"
setremote cli to cd fld cli application winword topic "c:\plus\form.doc"
setremote ext to cd fld extras application winword topic "c:\plus\form.doc"
setremote bleep to cd fld bleep application winword topic "c:\plus\form.doc"
setremote doc to cd fld doc && cd fld bleep application winword topic "c:\plus\form.doc"
END prepareform

ON printForm lab                                   --command to print form
setremote inv to lab application winword topic "c:\plus\form.doc"
executeRemote "[fileprint]" application winword topic "c:\plus\form.doc"
END printForm

FUNCTION workingDiagnosis                          --checks for presence of working diagnosis
put false into diag
IF cd fld cli = "" THEN
    put false into diag
ELSE
    put true into diag
END IF
return diag
END workingDiagnosis

ON urgent
IF the forecolor of cd btn 14 = 216 THEN
    put "URGENT" into urgent
ELSE
    put "" into urgent
END IF
setremote urg to urgent application winword topic "c:\plus\form.doc"
END urgent

ON pleasePhone
IF the forecolor of cd btn 15 = 216 THEN
    setremote pho to "PLEASE PHONE" application winword topic "c:\plus\form.doc"
ELSE
    setremote pho to "" application winword topic "c:\plus\form.doc"
ENDIF
END pleasePhone

ON outlier
IF the forecolor of cd btn 8 = 216 THEN
    setremote out to line 1 of cd fld output application winword topic "c:\plus\form.doc"
ELSE
    setremote out to "" application winword topic "c:\plus\form.doc"
ENDIF
END outlier

ON hosNo
IF char 1 to 4 of cd fld hos <> "Temp" THEN
    setremote hos to cd fld hos application winword topic "c:\plus\form.doc"

```

```

ELSE
  setremote hos to "" application winword topic "c:\plus\form.doc"
ENDIF
END hosNo

```

```

FUNCTION oneline allText --condenses
  put alltext into blob
  REPEAT WITH i = 1 to the number of chars in blob
    IF char i of blob = return THEN put ", " into char i of blob
  END REPEAT
  return blob
END oneline

```

---

## SCRIPT OF CD BTN CHANGE DETAILS

```

ON MOUSELEAVE
  IF (the forecolor of the target = 249) THEN EXIT MOUSELEAVE
  IF (the backcolor of cd fld nam = 0) THEN
    set the forecolor of the target to 255
    followcolor 2230
  ENDIF
END MOUSELEAVE

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
  set the forecolor of the target to 216
  followcolor 2230
END MOUSEDOWN

ON MOUSEUP
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  IF the backcolor of cd fld nam = 0 THEN -- IF BTN NAME IS "CHANGE DETAILS"
    lock screen
    show cd fld theraps
    show cd fld clindetlab
    set the width of cd fld extras to the width of cd btn Note * 1.1
    set the left of cd fld extras to the left of cd btn Note
    set the forecolor of the target to 255
    followcolor 2230 -- icon
    IF the forecolor of cd btn "Add Patient" = 216 THEN set the forecolor of cd btn "Add Patient" to 255
    greyoutbuttons 6,7,8,11,12,14,15,16,17,18,19,20,47,48,49,50,51,52,53
    greyoutfields 2
    IF (the visible of cd fld extras = false) THEN
      showClinBottom
    ELSE
      END IF
    changeFieldsMode the number of cd fld Nam, the number of cd fld cur, false,180,255,"Leave alone"
    set the name of the target to "Save Details"
    put savedpatient() into cd fld keeper
  ELSE
    ensureminimumdata
    set cursor to "watch"
    lock screen
    hide cd fld theraps
    hide cd fld clindetlab
    set the width of cd fld extras to (the width of cd btn Note * 1.75)
    set the left of cd fld extras to (the left of cd btn Note )
    changeFieldsMode the number of cd fld Nam, the number of cd fld cur, true,0,216,"Leave alone"
    set the backcolor of cd fld cur to 194
    set the textcolor of cd fld cur to 255
    hide cd fld clindetlab
    IF cd fld add = 1 THEN --IF NEW PATIENT
      appENDPatient
      put 0 into cd fld add
    ELSE
      find chars cd fld keeper in cd fld biglist
      put word 2 of the foundline into biglistPos
      find chars cd fld keeper in cd fld shortpat
      put word 2 of the foundline into shortpatPos
      updateLists biglistPos, shortpatPos
    END IF
    set the forecolor of the target to 255
    followcolor 2230 -- icon
    set the name of the target to "Change Details"
  END IF

```

```

IF the visible of cd fld extras = false THEN hideClinBottom
blackbuttons 6,7,8,11,12,14,15,16,17,18,19,20,47,48,49,50,51,52,53
restoreRedTests
blackfields 2
END IF
END MOUSEUP

```

```

FUNCTION savedpatient
IF the number of chars in cd fld hos < 2 THEN
return cd fld nam
ELSE
return cd fld hos
ENDIF
END savedpatient

```

```

ON appendPatient
REPEAT WITH num = (the number of cd fld Nam) to (the number of cd fld cur)
IF num > the number of cd fld con THEN
put insertedstrokes(num) into item num - ((the number of cd fld Nam) - 1) of patient
ELSE
put card fld num into item num - ((the number of cd fld Nam) - 1) of patient
ENDIF
END REPEAT
put patient & return after cd fld biglist
put 1 into i
REPEAT until the number of chars in line i of cd fld shortpat < 2
add 1 to i
END REPEAT
put item 2 of patient && item 1 of patient & return into line i of cd fld shortpat
END appendPatient

```

```

ON updateLists biglistPos, shortpatPos
REPEAT WITH num = (the number of cd fld Nam) to (the number of cd fld cur)
IF num <= the number of cd fld con THEN
put card fld num into item num - ((the number of cd fld Nam) - 1) of patient
ELSE
put "" into detail
REPEAT WITH lineno = 1 to the number of lines in cd fld num
put detail & line lineno of card fld num & "/" into detail
END REPEAT
put detail into item num - ((the number of cd fld Nam) - 1) of patient
ENDIF
END REPEAT
put patient into line biglistPos of cd fld biglist
put item 2 of patient && item 1 of patient into line shortpatPos of cd fld shortpat
domenu save
END updateLists

```

```

ON showClinBottom
resizeclinback 1.4
show cd fld clindetlab
show cd fld cur
END showClinBottom

```

```

ON hideClinBottom
resizeclinback 1/1.4
hide cd fld clindetlab
hide cd fld cur
END hideClinBottom

```

---

## SCRIPT OF CD BTN SHOW PATIENT LIST

```

ON MOUSEENTER
exclusiveRed 12,16,17,18,19,21,20,45,47,48
END MOUSEENTER

```

```

ON MOUSELEAVE
IF the forecolor of the target = 249 THEN EXIT MOUSELEAVE
set the forecolor of the target to 255
set the textcolor of cd fld mini to 255
set the style of cd fld mini to shadow
END MOUSELEAVE
ON MOUSEDOWN
timeout

```

```

IF the forecolor of the target = 249
THEN
EXIT MOUSEDOWN
ELSE
set the forecolor of the target to 216
set the textcolor of cd fld mini to 216
set the style of cd fld mini to transparent
ENDIF
END MOUSEDOWN

ON MOUSEUP
IF the forecolor of the target = 249 THEN
errorMessage
EXIT MOUSEUP
ENDIF
IF cd fld add = 1 AND the backcolor of cd fld nam = 180 THEN
answer "Any new informatiON will NOT be saved in the computer" with "Show list" or "Cancel"
ENDIF
IF it is "Cancel" THEN
set the forecolor of cd btn "Show Patient List" to 255
set the textcolor of cd fld mini to 255
set the style of cd fld mini to shadow
ELSE
set cursor to watch
lock screen
set the forecolor of the target to 255
set the name of card btn 9 to "PATIENTS"
hide me
IF (the visible of cd fld extras = true) or (the visible of cd fld cur = true) THEN resizeclinback 1/1.4
put the abbrev date into cd fld datetime of cd 1
truncateDate
resetTests
blackbuttons 8,14,15
showshortpat
hidefields
hide cd fld theraps
IF cd fld add = 1 THEN --new patient
blackbuttons 6,7,8,12,15,16,17,18,19,20,21,45,47,48,49,50,51,52,53
blackfields 2
set the name of cd btn 21 to "Change Details"
ENDIF
set the forecolor of cd btn 2 to 255
put 0 into cd fld add
blackPlusMinus 11,12
set the textcolor of cd fld mini to 255
set the style of cd fld mini to shadow
changeFieldsMode the number of cd fld Nam, the number of cd fld cli, true,0,216,"Leave alone"
set the backcolor of cd fld cur to 194
ENDIF
END MOUSEUP

```

---

## SCRIPT OF CD BTN NOTE

```

ON MOUSEENTER
exclusiveRed 11,12,16,17,19,20,21,45,48
END MOUSEENTER

```

```

ON MOUSELEAVE
IF the forecolor of the target = 216 THEN
set the forecolor of the target to 255
followcolor 2289
ENDIF
END MOUSELEAVE

```

```

ON MOUSEDOWN
timeout
IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
set the forecolor of the target to 216
followcolor 2289
END MOUSEDOWN

```

```

ON MOUSEUP
IF the forecolor of the target = 249 THEN
errorMessage
EXIT MOUSEUP
ENDIF

```

```

followcolor 2289
ask "Other information"
IF it is NOT "" THEN
  IF the visible of cd fld extras = false THEN
    lock screen
    put "" into cd fld extras
    resizeClinBack 1.4
    show cd fld extras
  END IF
  put it & return after cd fld extras
ENDIF
set the forecolor of the target to 255
followcolor 2289
END MOUSEUP

```

---

## SCRIPT OF CD BTN QUERY

```

ON MOUSEENTER
  exclusiveRed 11,12,16,18,19,20,21,45,47
END MOUSEENTER

```

```

ON MOUSELEAVE
  IF the forecolor of the target = 216 THEN
    set the forecolor of the target to 255
    followcolor 2299
  ENDIF
END MOUSELEAVE

```

```

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
  set the forecolor of the target to 216
  followcolor 2299
END MOUSEDOWN

```

```

ON MOUSEUP
  IF the forecolor of the target = 249 THEN
    errorMessage
    EXIT MOUSEUP
  ENDIF
  followcolor 2299
  ask "Enter query or suggestion"
  IF it <> "" THEN
    lock screen
    IF the visible of cd fld extras = false THEN
      put "" into cd fld extras
      resizeClinBack 1.4
      show cd fld extras
    END IF
    put "?" && it & return after cd fld extras
  ELSE
    END IF
  set the forecolor of the target to 255
  followcolor 2299
END MOUSEUP

```

---

## SCRIPT OF CD BTN INCLUDE THERAPY

```

ON MOUSEENTER
  exclusiveRed 11,12,16,17,18,20,21,45,47,48
END MOUSEENTER

```

```

ON MOUSELEAVE
  IF (the forecolor of the target = 216) AND the backcolor of cd fld cur <> 180 THEN
    set the forecolor of the target to 255
  ENDIF
END MOUSELEAVE

```

```

ON MOUSEDOWN
  timeout
  IF the forecolor of the target = 249 THEN EXIT MOUSEDOWN
  IF the forecolor of the target = 255 THEN
    set the forecolor of the target to 216
  ELSE
    set the forecolor of the target to 255
  END IF

```

```
ENDIF
END MOUSEDOWN
```

```
ON MOUSEUP
IF the forecolor of the target = 249 THEN
  errorMessage
  EXIT MOUSEUP
ENDIF
lock screen
set the locktext of cd fld cur to true
IF the number of chars in cd fld cur < 2 THEN
  REPEAT WHILE the number of chars in cd fld cur < 2
    ask "Enter therapy to include"
    IF it is "" THEN EXIT MOUSEUP
    ELSE
      addDetail it, (the number of cd fld cur)
      REPEAT until the number of chars in line 1 of cd fld cur < 15
        delete last char of cd fld cur
      END REPEAT
    END IF
  END REPEAT
ENDIF
show cd fld cur
IF the visible of cd fld extras = false THEN
  put "" into cd fld extras
  resizeinback 1.4
ENDIF
set the forecolor of the target to 255
REPEAT WITH i = 1 to the number of lines in cd fld cur
  IF the number of chars in line i of cd fld cur > 1 THEN
    add 1 to numlines
  ENDIF
END REPEAT
IF numlines = 1 THEN
  put cd fld cur into onlytest
  IF charcount(last char of onlytest) = 13 THEN delete last char of onlytest
  find onlytest in cd fld extras
  IF the foundtext = "" THEN
    put onlytest & return after cd fld extras
  ENDIF
ENDIF
IF numlines > 3 THEN
  set the style of cd fld cur to scrolling
ELSE
  set the style of cd fld cur to rectangle
ENDIF
click at 0,0
show cd fld extras
END MOUSEUP
```

---

## SCRIPT OF CD BTN PIN

```
ON MOUSEENTER
exclusiveRed 11,12,16,17,19,20,21,45,48
END MOUSEENTER
```

```
ON MOUSEDOWN
IF the forecolor of the target = 249 THEN
  click at the loc of cd btn "Note"
  EXIT MOUSEDOWN
ENDIF
IF the forecolor of the target = 255 THEN
  set the forecolor of the target to 216
  click at the loc of cd btn "Note"
ENDIF
IF the forecolor of the target = 216 THEN
  set the forecolor of the target to 255
ENDIF
END MOUSEDOWN
```

---

## SCRIPT OF CD BTN "?"

```
ON MOUSEENTER
exclusiveRed 11,12,16,18,19,20,21,45,47
```

END MOUSEENTER

ON MOUSEDOWN

IF the forecolor of the target = 249 THEN

click at the loc of cd btn "query"

EXIT MOUSEDOWN

ENDIF

IF the forecolor of the target = 255 THEN

set the forecolor of the target to 216

click at the loc of cd btn "query"

ENDIF

IF the forecolor of the target = 216 THEN

set the forecolor of the target to 255

ENDIF

END MOUSEDOWN

---

## SCRIPT OF CD BTN PRINTICON

ON MOUSEENTER

exclusiveRed 11,17,18,19,21,20,45,47,48

END MOUSEENTER

ON MOUSEDOWN

IF the forecolor of the target = 249 THEN

click at the bottomright of cd btn "Print request "

EXIT MOUSEDOWN

ENDIF

IF the forecolor of the target = 255 THEN

set the forecolor of the target to 216

click at the loc of cd btn "Print Request "

ENDIF

IF the forecolor of the target = 216 THEN

set the forecolor of the target to 255

ENDIF

END MOUSEDOWN

---

## SCRIPT OF CD BTN WRITER

ON MOUSEENTER

exclusiveRed 11,12,16,17,18,19,20,47,48

END MOUSEENTER

ON MOUSEDOWN

IF the forecolor of the target = 249 THEN

click at the loc of cd btn "Change details"

EXIT MOUSEDOWN

ENDIF

IF the forecolor of the target = 255 THEN

set the forecolor of the target to 216

click at the loc of cd btn 21

--"Change details"

ELSE

click at the loc of cd btn 21

--"Save details"

set the forecolor of the target to 255

ENDIF

END MOUSEDOWN

---

## SCRIPT OF CD FLD MINI

ON MOUSEENTER

REPEAT WITH i = 1 to 4

put char 4 to 11 of line i of cd fld shortpat into line i of cd fld mini

END REPEAT

END MOUSEENTER

ON MOUSEDOWN

IF the textcolor of the target = 249 THEN

click at the loc of cd btn id 1214

-- pat list

EXIT MOUSEDOWN

ENDIF

set the style of the target to transparent

```
IF the textcolor of the target = 255 THEN
  set the textcolor of the target to 216
  click at the loc of cd btn "Show Patient List"
ENDIF
set the textcolor of the target to 255
set the style of the target to shadow
END MOUSEDOWN
```

```
ON MOUSEUP
  set the style of cd fld mini to shadow
```

```
END MOUSEUP
```

---

## SCRIPTS FOR SETTING DATE AND TIME

### SCRIPT OF CD BTN 1

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 2

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 3

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 4

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 5

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 6

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

### SCRIPT OF CD BTN 7

```
ON MOUSEDOWN
  single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981
  writehour
END MOUSEDOWN
```

---

## SCRIPT OF CD BTN 8

ON MOUSEDOWN  
single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981  
writehour  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 9

ON MOUSEDOWN  
single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981  
writehour  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 10

ON MOUSEDOWN  
single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981  
writehour  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 11

ON MOUSEDOWN  
single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981  
writehour  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 12

ON MOUSEDOWN  
single id of the target, 1964,1975,1965,1980,1966,1976,1967,1983,1968,1977,1969,1981  
writehour  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 15

ON MOUSEDOWN  
single id of the target, 1970,1978,1971  
writeminutes 15  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 30

ON MOUSEDOWN  
single id of the target, 1970,1978,1971  
writeminutes 30  
END MOUSEDOWN

---

## SCRIPT OF CD BTN 45

ON MOUSEDOWN  
single id of the target, 1970,1978,1971  
writeminutes 45  
END MOUSEDOWN

---

## SCRIPT OF CD BTN TOMORROW

ON MOUSEDOWN  
timeout  
IF the foreground of the target = 255 THEN

```

IF the forecolor of cd btn "further ahead" = 216 THEN
  set the forecolor of cd btn "further ahead" to 255
  hide cd fld hence
END IF
set the forecolor of the target to 216
addDay
ELSE
  put the abbrev date into line 4 of cd fld datetime
  set the forecolor of the target to 255
END IF
END MOUSEDOWN

```

```

ON addDay
  put the date into today
  convert today to secONds
  put today + (24 * 3600) into tomorrow
  convert tomorrow to abbrev date
  put tomorrow into line 4 of cd fld datetime
END addDay

```

---

## SCRIPT OF CD BTN FURTHER AHEAD

```

ON MOUSEDOWN
  timeout
  set the forecolor of the target to 216
END MOUSEDOWN

```

```

ON MOUSEUP
  IF the forecolor of the target = 216 THEN
    IF the forecolor of cd btn tomorrow = 216 THEN set the forecolor of cd btn tomorrow to 255
    put "" into cd fld hence
    ask "How many days ?"
    put it into days
    REPEAT WHILE invalid (days) = true
      ask "Numbers Only please"
      put it into days
    END REPEAT
    IF it is "" THEN
      set the forecolor of the target to 255
      hide cd fld hence
      put the abbrev date into line 4 of cd fld datetime
      EXIT MOUSEUP
    ENDIF
    addDay days
    show cd fld hence
  ELSE
    set the forecolor of the target to 255
  END IF
END MOUSEUP

```

```

ON addDay days
  put days & " " before cd fld hence
  IF days = 1 THEN
    put "day" after cd fld hence
  ELSE
    put "days" after cd fld hence
  ENDIF
  put the date into today
  cONvert today to secONds
  put today + (days * 24 * 3600) into newdate
  cONvert newdate to abbrev date
  put newdate into line 4 of cd fld datetime
END addDay

```

```

FUNCTION invalid days
  REPEAT WITH i = 1 to the number of chars in days
    IF charonum(char i of days) < 48 or charonum(char i of days) > 57 THEN return true
  END REPEAT
END invalid

```

---

## SCRIPT OF CD BTN OK

```

ON MOUSELEAVE
  IF the forecolor of the target = 216 THEN set the forecolor of the target to 255
END MOUSELEAVE

```

```

ON MOUSEDOWN
  timeout
  set the forecolor of the target to 216
END MOUSEDOWN

```

```

ON MOUSEUP
  set cursor to watch
  lock screen
  transfertime
  IF line 1 of cd fld datetime <> "" THEN put " " after line 1 of cd fld datetime
  put line 4 of cd fld datetime after line 1 of cd fld datetime
  truncateDate
  set the forecolor of the target to 255
  set the forecolor of cd btn id 1406 to 255
  set the textcolor of cd fld datetime to 216
  hideclock
  blackbuttons 2,4,8,11,12,14,15,16,17,18,19,20,21,45,47,48,50,51,52,53
  restoreRedTests
  blackfields 1,2
  blackPlusMinus 11,12,13
  show cd btn 49
  IF cd fld testtotal > 0 THEN
    REPEAT WITH i = ((the number of cd btns - cd fld testtotal) + 1) to the number of cd btns
      show cd btn i
    END REPEAT
  ENDIF
END MOUSEUP

```

--"set date/time" btn

--fbc & ue

```

ON transfertime
  IF (line 1 of cd fld datetime = "" ) THEN
    put line 3 of cd fld datetime into finaltime
  ELSE
    put line 1 of cd fld datetime into finaltime
    IF line 2 of cd fld datetime = "" THEN
      put "00" after finaltime
    ELSE
      put line 2 of cd fld datetime after finaltime
    END IF
    put line 3 of cd fld datetime after finaltime
  END IF
  IF (line 3 of cd fld datetime = "") AND (line 1 of cd fld datetime <> "") THEN
    answer "Time of day ? " with " am " or " pm "
    put it after finaltime
  END IF
  put finaltime into line 1 of cd fld dateTme
END transfertime

```

---

## SCRIPT OF CD BTN CANCEL

```

ON MOUSELEAVE
  IF the forecolor of the target = 216 THEN set the forecolor of the target to 255
END MOUSELEAVE

```

```

ON MOUSEDOWN
  timeout
  set the forecolor of the target to 216
END MOUSEDOWN

```

```

ON MOUSEUP
  lock screen
  blackbuttons 2,4,8,11,12,14,15,16,17,18,19,20,21,45,47,48,50,51,52,53
  restoreRedTests
  blackfields 1,2
  blackPlusMinus 11,12,13
  put the abbrev date into cd fld datetime
  truncateDate
  hideclock
  set the forecolor of the target to 255
  set the textcolor of cd fld datetime to 216
  show cd btn 49
  IF cd fld testtotal > 0 THEN
    REPEAT WITH i = ((the number of cd btns - cd fld testtotal) + 1) to the number of cd btns
      show cd btn i
    END REPEAT
  ENDIF
END MOUSEUP

```

--fbc & ue

**CARD LEVEL SCRIPTS**

- HANDLERS
- tripleclick
- showfields
- hidefields
- showshortpat
- hideshortpat
- ensureMinimumData
- resizeClinBack num
- removeCommas num
- insertstrokes num
- greayoutbuttons
- blackbuttons
- restoreRedTests
- greayoutfields num
- greyPlusMinus
- blackfields num
- blackPlusMinus
- resetTests
- showclock
- hideclock
- single
- writehour
- writeminutes mins
- followcolor sub
- followcolorPlusMinus
- closeExtras
- errorMessage btnNo
- exclusiveRed
- addDetail
- timeout
- changeFieldsMode
- truncate
- truncateDate
- uppercase
- removeEmptyLines

ON tripleclick --simulates three mouseclicks for selecting text  
 set the locktext of the target to false  
 REPEAT 3 times  
   click at the clickloc  
 END REPEAT  
 END tripleclick

ON showfields --to go from patient list screen to patient details screen  
 REPEAT WITH num = (the number of cd fld Nam) to ( the number of cd fld cli)  
   IF the forecolor of cd btn "Add Patient" is 216 THEN  
     set the locktext of cd fld num to false  
   END IF  
   show card fld num  
 END REPEAT  
 show cd fld sexlab  
 show card fld lab  
 show cd drv namback  
 show cd drv clinback  
 show card fld curtherlab --"Working diagnosis"  
 show card fld cli -- working diagnosis  
 show cd btn id 1355 --"Current therapy"  
 show cd btn id 1416 -- "Change Details  
 show cd btn id 1226 --print commAND  
 show cd btn id 1295 -- prnticon  
 show cd btn id 2230 -- change details icon  
 show cd fld id 2244 --mini  
 show cd btn id 1214 --patient list  
 show cd drv id 1392 --menuback  
 show cd btn id 1879 --clindetsheading  
 show cd btn id 1305 -- s/query  
 show cd btn id 1310 -- additional dets  
 show cd btn id 2299 --Note icon  
 END showfields

ON hidefields --to go from patient details screen to patient list screen  
 REPEAT WITH num = (the number of cd fld Nam) to ( the number of cd fld cli)  
   set the locktext of cd fld num to true

```

hide card fld num
END REPEAT
hide cd fld sexlab
hide card fld lab
hide cd drw namback
hide cd drw clinback
hide card fld clindetlab
hide card fld curtherlab
hide card fld cli
hide card fld cur
hide cd btn id 1355
hide cd btn id 1416
hide cd btn id 1879
hide cd btn id 1305
hide cd btn id 1310
hide cd btn id 1226
hide cd btn id 1214
hide cd btn id 1295
hide cd btn id 2230
hide cd fld id 2244
hide cd btn id 2299
hide cd btn id 2289
hide cd fld extras
hide cd drw id 1392
END hidefields

```

```

--clin dets
--current therapy

```

```

--"Current therapy"
-- "Change Details
--clindetsheading
--s/query
-- additional dets
--printer
--patient list
-- prnticon
-- change details icon
--mini
--queryicon
--Note icon

--menuback

```

```

ON showshortpat
show card fld shortpat
show card btn id 5
show card btn id 6
set the forecolor of cd btn 14 to 255
show card drw nameback
show cd drw addback
REPEAT WITH i = 11 to 13
  show cd drw i
END REPEAT
END showshortpat

```

```

--shows cds & btns for pat list screen

```

```

--Urgent button

```

```

ON hideshortpat
hide card fld shortpat
hide card btn id 5
hide card btn id 6
REPEAT WITH i = 11 to 13
  hide cd drw i
END REPEAT
hide cd drw nameback
hide cd drw addback
END hideshortpat

```

```

--hides cds & btns for pat list screen

```

```

ON ensureMinimumData
REPEAT WHILE (the number of chars in cd fld nam < 2) AND (the number of chars in cd fld hos < 2)
  answer "You must enter a name or hospital number" with "Hosp No" or "Name"
  put it into place
  IF it is "Name" THEN
    ask "Enter name"
  ELSE
    ask "Enter Hospital Number"
  END IF
  IF place is "Name" THEN
    put it into cd fld nam
  ELSE
    put it into cd fld hos
    send closefield to cd fld hos
  ENDIF
END REPEAT
IF cd fld hos = "" THEN put "Temp" & the random of 9999 into cd fld hos
END ensureMinimumData

```

```

--on entry of newpat

```

```

ON resizeClinBack num
put the top of cd drw clinback into place
set the height of cd drw clinback to ((the height of cd drw clinback) * num)
set the top of cd drw clinback to place
END resizeClinBack

```

```

--resizes background shape behind clin dets

```

```

ON removeConumas num

```

```

REPEAT WITH i = 1 to the number of chars in card fld num
  IF char i of cd fld num = "," THEN
    put "," into char i of card fld num
  END IF
END REPEAT
END removeCommas

ON insertstrokes num
  put empty into detail
  REPEAT WITH lineno = 1 to the number of lines in card fld num
    put detail && line lineno of card fld num && "/" into detail
  END REPEAT
  put detail into cd fld num
END insertstrokes

ON greyoutbuttons
  put "" into cd fld redtests
  IF the forecolor of cd btn fbc = 216 THEN put the number of cd btn fbc & return after cd fld redtests
  IF the forecolor of cd btn "U&E" = 216 THEN put the number of cd btn "U&E" & return after cd fld redtests
  IF the forecolor of cd btn "fbc & U&E" = 216 THEN put the number of cd btn "FBC & U&E" & return after cd fld redtests
  put "" into line 1 of cd fld output ---for outliers
  REPEAT WITH i = 1 to the paramcount
    set the forecolor of cd btn param(i) to 249
  END REPEAT
  IF cd fld testtotal > 0 THEN
    REPEAT WITH i = ((the number of cd btns - cd fld testtotal) + 1) to the number of cd btns
      put the number of cd btn i & return after cd fld redtests
      set the forecolor of cd btn i to 249
    END REPEAT
  ENDIF
  IF the forecolor of cd btn "Show Patient List" <> 255 THEN
    IF the textcolor of cd fld mini = 255 THEN
      set the textcolor of cd fld mini to 249
      set the backcolor of cd fld mini to 247
    ENDIF
    set the style of cd fld mini to opaque
  ENDIF
END greyoutbuttons

ON blackbuttons
  REPEAT WITH i = 1 to the paramcount
    set the forecolor of cd btn param(i) to 255
  END REPEAT
  IF the textcolor of cd fld mini = 249 THEN
    set the textcolor of cd fld mini to 255
    set the backcolor of cd fld mini to 0
    set the style of cd fld mini to shadow
  ENDIF
END blackbuttons

ON restoreRedTests
  REPEAT WITH i = 1 to the number of lines in cd fld redtests
    set the forecolor of cd btn (line i of cd fld redtests) to 216
  END REPEAT
END restoreRedTests

ON greyoutfields
  REPEAT WITH i = 1 to the paramcount
    set the textcolor of cd fld param(i) to 249
    set the backcolor of cd fld param(i) to 247
  END REPEAT
END greyoutfields

ON greyPlusMinus
  REPEAT WITH i = 1 to the paramcount
    set the forecolor of cd drw param(i) to 249
  END REPEAT
END greyplusminus

ON blackfields
  REPEAT WITH i = 1 to the paramcount
    set the textcolor of cd fld param(i) to 255
    set the backcolor of cd fld param(i) to 194
  END REPEAT
END blackfields

ON blackPlusMinus
  REPEAT WITH i = 1 to the paramcount
    set the forecolor of cd drw param(i) to 255

```

END REPEAT  
END blackPlusMinus

ON resetTests  
IF the forecolor of cd btn fbc = 216 THEN click at the loc of cd btn fbc  
IF the forecolor of cd btn "U&E" = 216 THEN click at the loc of cd btn "U&E"  
IF the forecolor of cd btn "FBC & U&E" = 216 THEN click at the loc of cd btn "FBC & U&E"  
IF cd fld testtotal > 0 THEN  
    REPEAT (cd fld testtotal) times  
        click at the loc of cd btn (the number of cd btns)  
    END REPEAT  
ENDIF  
END resetTests

ON showclock  
lock screen  
REPEAT WITH i = (the number of cd btn id 1964) to (the number of cd btn "am")  
    show cd btn i  
END REPEAT  
show cd drw clockback  
show cd btn cancel  
END showclock

ON hideclock  
lock screen  
REPEAT WITH i = (the number of cd btn id 1964) to (the number of cd btn "am")  
    hide cd btn i  
END REPEAT  
hide cd drw clockback  
hide cd btn cancel  
hide cd fld hence  
END hideclock

ON single --ensures only one hour/minute button is selected  
timeout  
put param(1) into chosen  
IF the forecolor of cd btn id chosen is 255 THEN  
    set the forecolor of cd btn id chosen to 216  
    REPEAT WITH i = 2 to the paramcount  
        IF param (i) <> chosen THEN  
            set the forecolor of cd btn id param(i) to 255  
        ENDIF  
    END REPEAT  
ELSE  
    set the forecolor of cd btn id chosen to 255  
ENDIF  
END single

ON writeHour  
IF the forecolor of the target = 216 THEN  
    put last word of the name of the target into hour  
    delete last char of hour  
    delete first char of hour  
    put hour & ":" into line 1 of cd fld datetime  
ELSE  
    put "" into line 1 of cd fld datetime  
ENDIF  
END WriteHour

ON writeMinutes mins  
IF the forecolor of the target is 216 THEN  
    put mins into line 2 of cd fld datetime  
ELSE  
    put "" into line 2 of cd fld datetime  
ENDIF  
END WriteMinutes

ON followcolor sub  
set the forecolor of cd btn id sub to the forecolor of the target  
END followcolor

ON followcolorPlusMinus  
REPEAT WITH i = 1 to the paramcount  
    set the forecolor of cd drw param(i) to the forecolor of the target  
END REPEAT  
END followcolorPlusMinus

ON closeExtras

```

IF the visible of cd fld extras = true THEN
  hide cd fld extras
  hide cd fld cur
  resizeclinback 1/1.4
ENDIF
END closeextras

```

```

ON errorMessage
  beep
  IF the forecolor of cd btn "Remove patient" = 216 THEN
    answer "Select patient for removal first"
  ELSE
    IF the visible of cd drw clockback = true THEN
      answer "Set date or time first"
    ELSE
      IF the forecolor of cd btn id 1416 = 255 THEN
        answer "Save details first"
      ELSE
        answer "Go back to patient list first"
      END IF
    END IF
  END IF
END errorMessage

```

```

ON exclusiveRed
  REPEAT WITH i = 1 to the paramcount
    IF the forecolor of cd btn param(i) = 216 THEN set the forecolor of cd btn param(i) to 255
  END REPEAT
  set the textcolor of cd fld mini to the forecolor of cd btn 11
END exclusiveRed

```

```

ON addDetail detail, cardnum
  REPEAT WITH i = 1 to the number of chars in detail
    IF char i of detail = "," THEN put "," into char i of detail
  END REPEAT
  put detail & return into cd fld cardnum
  find chars cd fld hos in cd fld biglist
  IF the foundtext = "" THEN find string cd fld nam in cd fld biglist
  put word 2 of the foundline into lineno
  put detail into item(the number of cd fld cardnum - the number of cd fld nam) + 1 of line lineno of cd fld biglist
END addDetail

```

```

ON timeout
  put the seconds into line 1 of cd fld secs
END timeout

```

```

ON changeFieldsMode a,b,locktxt,backcolour,textcolour,content
  REPEAT WITH num = (the number of cd fld a) to (the number of cd fld b)
    set the locktext of cd fld num to locktxt
    set the backcolor of cd fld num to backcolour
    set the textcolor of cd fld num to textcolour
    IF cONtent = empty THEN put "" into cd fld num
  END REPEAT
  IF the visible of cd fld conlist = true THEN hide cd fld conlist
  IF the visible of cd fld theraps = true THEN hide cd fld theraps
END changeFieldsMode

```

```

ON truncate cardno, actual, charLimit
  IF actual > charLimit THEN
    lock screen
    put actual - charLimit into excess
    REPEAT until excess = 0
      delete char charLimit + excess of cd fld cardno
      subtract 1 from excess
    END REPEAT
  END IF
END truncate

```

--truncates strings too long for selected field

```

ON truncateDate
  put the number of chars in line 1 of cd fld dateTime into max
  REPEAT 6 times
    delete last char of line 1 of cd fld dateTime
  END REPEAT
END truncateDate

```

```

FUNCTION upperCase anyString
  REPEAT WITH ndx = 1 to length(anyString)
    put Chartonum(char ndx of anyString) into ASCIIValue
  END REPEAT
END FUNCTION

```

```

IF ASCIIValue > 96 AND ASCIIValue < 123 THEN
  subtract 32 from ASCIIValue
  put numToChar(ASCIIValue) into char ndx of anyString
END IF
END REPEAT
return anyString
END upperCase

```

```

ON removeEmptyLines num
  put 1 into pos
  REPEAT WITH i = 1 to the number of lines in cd fld num
    IF the number of chars in line i of cd fld num < 2 THEN
      put i into item pos of emptyList
      add 1 to pos
    END IF
  END REPEAT
  put pos -1 into lineno
  REPEAT pos -1 times
    delete line(item lineno of emptyList) of cd fld num
    subtract 1 from lineno
  END REPEAT
END removeEmptyLines

```

\*\*\*\*\*

## STACK LEVEL SCRIPTS

```

ON openstack
  lock recent
  set blindtyping to false
  set textarrows to true
  lock screen
  domenu large view
  put the date into cd fld datetime of cd 1
  go cd 2
  click at the loc of cd dbf login
  open "c:\plus\form.doc" with "winword"
  executeRemote "[appminimize]" application "winword" topic "c:\plus\form.doc"
  set the userlevel to 2
  hide menubar
  hide tool box
END openstack

```

```

ON idle
  IF the optionkey is down THEN answer "The alt key is disabled" at 0,0
  IF the commandkey is down THEN answer "The control key is disabled" at 0,0
  hide menubar
  hide tool box
  IF the number of this card = 1 THEN
    IF the visible of cd wpf raretests = true THEN
      IF (the mouseH < the left of cd wpf raretests) or (the mouseV < the top of cd wpf raretests) THEN
        hide cd wpf raretests
        set the scroll of cd wpf raretests to 1
      END IF
    ENDIF
    put (the ticks - line 2 of cd fld secs) / 60 into cd dbf secs
    IF the seconds - line 1 of cd fld secs > 180 THEN
      IF the visible of cd btn "Show Patient List" = true THEN
        IF the backcolor of cd fld nam = 180 THEN
          click at the loc of cd btn "Save details"
        END IF
        click at the loc of cd btn "Show Patient List"
      ENDIF
      visual effect zoom out
      go card 2
      click at the loc of cd dbf login
    ENDIF
  ENDIF
END idle

```

---

## SCRIPT OF CD BTN ALGAE

```

ON MOUSEENTER
  IF the visible of cd wpf list = true THEN
    hide cd wpf list

```

--for adding passwords

```
hide cd fld secret
hide cd btn 1
hide cd btn "Add password"
ELSE
show cd btn "Add password"
show cd wpf list
show cd fld secret
show cd btn 1
ENDIF
END MOUSEENTER
```

---

## SCRIPT OF CD BTN SPARE

```
ON MOUSEUP                                --tools for stack and log maintenance
edit the script of 3backup.sta
END MOUSEUP
ON MOUSEENTER
IF the visible of cd btn 1 is true THEN
hide cd btn 1
hide cd wpf record
hide cd btn "remove test"
hide cd btn nowt
ELSE
show cd wpf record
show cd btn 1
show cd btn 15
domenu "compact stack"
ENDIF
END MOUSEENTER
```

# Appendix C

## Analysis of the evaluation data

### C1 Software log recorded by prototype

Items in log:

- 1 Duration of transaction (secs)
- 2 Date on form
- 3 Time of request
- 4 Doctor
- 5 Patient
- 6 Tests requested
- 7 Clinical details
- 8 Annotations: v = video recorded; +6 = extra time (secs) taken to add signature; plus remarks

Note that early records omit some items.

38	Mon 1	14:16	Westb	UE	v +6.2	please added
36	Mon 1	14:17	Westbr	UE LFT	v + 11.5	please added
326	Mon 1	14:18	Westbr	KCCT	v + 7.0	time added
52	Mon 1	16:04	McFn	RBS		
66	Mon 1	16:54	Westbr	FBC		crossed out date, put tomorrow'
25	Mon 1	16:55	Westbr	iron studies		not in list, handwritten
61	Mon 1	17:48	McFn	UE RBS		showing other SHO, therefore slower
349	Mon 1	17:53	McFn	UE RBS BICARB		--New patient
40	Tue 2	09:31	Hough	P Oakley	FBC ESR	didn't know about multiple forms
20	Tue 2	09:31	Hough	P Oakley	UE RBS LFT	Was informed. v + 18.3,(3) forms. + please 1 test added to one.
45	Tue 2	09:33	Hough	P Oakley	INR KCCT	v
40	Tue 2	10:37	Hough	P Oakley	immunology	added extra dets by hand v
+31.4 (2)						
40	Tue 2	10:39	Hough	P Oakley	immunology	ditto v
32	Tue 2	17:07	McFn	BMcNult	INR KCCT	Period just before print
btn spent					reading over screen. not signed v	
17	Wed 3	10:31	McFn	R Barrant	UE	v + 10s
56	Wed 3	10:43	Westbr	ADickinson		--wanted to give instructions to
						phleb for cross match sample, missed Note btn
33	Wed 3	10:45	Westbr	H Foster	INR	v

18.5	Wed 3	11:01	McFn	GTurner	FBC UE LFT RBS	+ 51 secs v
39	Wed 3	15:39	Westbr	K Smith	FBC UE LFT TSH	
20	Wed 3	15:39	Westbr	N Carr	CEP[1]	
20	Thu 4	15:40	Westbr	N Carr	CEP[2]	
26	Fri 5	15:40	Westbr	NCarr	CEP[3]	
130	Wed 3	15:42	Westbr	J SMITH	FBC ESR UE	
19	Wed 3	15:43	Westbr	P Oakley	UE	
24	Wed 3	16:44	McFn	P Oakley	UE KCCT v	
48	Thu 4	16:45	McFn	P Oakley	UE KCCT v	
30	Thu 4	16:46	McFn	B McNul	INR KCCT v	Macfarln doesn't sign his forms
19	Thu 4	09:27	Westbr	A Dickin	FBC UE v + 30s	
28	Thu 4	15:13	Hough	F Green	FBC ESR	
17	Thu 4	15:14	Hough	A Dickinson		--fasting blood glucose added by hand
29	Thu 4	15:19	Hough	B McNul	KCCT added INR by hand. Added on heparin and warfarin & tomorrow by hand.	
36	Thu 4	15:20	Hough	P Oakley	FBC ESR UE LFT	--tomorrow by hand on haem forms only
10	Thu 4	15:21	Hough	P Oakley		--asked for clotting screen. Put tomorrow's date by hand
117	Thu 4	16:34	Westbr	F Emes	FBC UE RBS LFT	-- Note problems with Current therapy v
85	Fri 5	15:50	Westbr	O Smith	INR KCCT DVT/	-- Clicked INR by mistake, crossed out by hand. Tomorrow& therapy by hand .V tired. v + 25
<p>All Hough tests up to 9.59 8/11 lost in crash.  Transactions 33 to 41 are only recorded on the tape, not in this file.  Monday  Lost Anew Dickinson reqs: Note that 1) a clin det was added to the immuno and haem elect forms, and that the abbrev_HAEM was filled out to HAEMOLYSIS screen by hand</p>						
134	Mon 8	09:59	Hough	j smith	AMY TSH Hypothermia Hypoglycaemia,/ v	
61	Mon 8	10:02	Forr	P Oakley	KCCT meningitis,/ v	
17	Mon 8	10:03	Forr	O Smith	KCCT DVT ,/ v + 18s these 2	
22	Mon 8	10:07	Forr	j smith	ESR Hypothermia Hypoglycaemia ,/ v	
152	Mon 8	10:13	McFn	E WHIT	FBC UE TSH RBS #NOF,/ v	
42	Mon 8	10:23	McFn	B McNul	FBC ESR LFT TSH DVT/ v	
90	Tue 9	10:35	Forr	O Smith	INR KCCT DVT ,/ v	
27	Wed 10	10:36	Forr	O Smith	KCCT INR DVT ,/ v	
35	Thu 11	10:36	Forr	O Smith	INR KCCT DVT ,/ v	
16	Mon 8	11:03	Forr	R Barrand	TSH ccf secondary to myocardial infarction/ v	

124 Mon 8 11:06 Forr R Barrant DIGOX UE ccf secondary to myocardial infarction/  
v

81 Mon 8 11:16 McFn F Emes UE CA LFT TSH COAD ,,,/ v

Crashed Mon Forr D Bray v

19 Mon 8 11:51 McFn H Foster INR ON WARFARIN,/ ALL V until 13.59

186 Mon 8 12:01 Walk N Priestl UE ,,/

18 Tue 9 12:03 Walk N Priestl UE , ,/

93 Wed 10 12:04 Walk N Priestl UE , ,/

24 Fri 12 12:05 Walk N Priestl UE , ,/

360 Sat 13 12:11 Walk N Priestl UE , ,/

140 Tue 9 12:17 Walk G Lawson INR KCCT DVT,/

41 Wed 10 12:18 Walk G Lawson INR KCCT DVT ,/

106 Thu 11 12:21 Walk G Lawson INR KCCT DVT ,/On Heparin ,On Warfarin ,

32 Fri 12 12:22 Walk G Lawson KCCT INR DVT ,/On Heparin ,On Warfarin ,

215 Mon 8 12:25 Walk D Clay FBC UE CVA/

---TIMES TAKEN FROM HERE ONWARDS

33 Thu 11 12:26 Walk D Clay UE CVA ,/

175 Tue 9 13:40 Walk E Lawr INR PE/On Warfarin,

52 Wed 10 13:41 Walk E Lawr INR PE ,/On Warfarin ,

35 Thu 11 13:42 Walk E Lawr INR PE ,/On Warfarin ,

38 Fri 12 13:43 Walk E Lawr INR PE ,/On Warfarin ,

225 Wed 10 13:46 Walk I BEECH UE CA BRONCHUS/

30 Fri 12 13:47 Walk I BEECH UE CA BRONCHUS ,/

139 Wed 10 13:49 Walk M MASO INR WARFARIN/

20 Fri 12 13:49 Walk M MASO INR WARFARIN ,/

23 Tue 9 13:50 Walk M MASO INR WARFARIN ,/

23 Thu 11 13:50 Walk M MASO INR WARFARIN ,/

127 Tue 9 13:52 Walk H HUNT UE RENAL IMP,/

28 Wed 10 13:53 Walk H HUNT UE RENAL IMP ,/

41 Fri 12 13:54 Walk H HUNT UE RENAL IMP ,/

332 Wed 10 13:59 Walk F FLUDE FBC AN/

22 Fri 12 13:59 Walk F FLUDE FBC AN ,/

23 Mon 8 16:12 McFn B McNul INR DVT/On Warfarin ,

28 Mon 8 16:12 McFn P Oakley UE KCCT meningitis,/

12 Mon 8 16:13 McFn H Foster INR ON WARFARIN,/

TUESDAY

26 Tue 9 10:30 Hough j smith FBC UE LFT RBS Hypothermia Hypoglycaemia ,/  
NOT V

18 Tue 9 11:07 Forr F Emes FBC UE COAD ,,,/ v

77 Tue 9 11:08 Forr F Emes LFT BICARB CA INR KCCT COAD ,,,/ v

139 Tue 9 11:24 Forr S chapm FBC UE TSH arrythmia,/ v

28 Tue 9 11:25 Forr B McNul LFT DVT/ v

31	Tue 9 11:25	Forr j smith	FBC CEP[2] UE LFT DIGOX Hypothermia Hypoglycaemia ,/ v
30	Tue 9 11:26	Forr E WHIT	FBC B12 FOLATE #NOF ,/ v
16	Tue 9 11:30	Hough D Bray	ESR FBC mi ,/ --NOT V added a clin det by hand
134	Tue 9 11:36	McFn fletcher l	KCCT DVT,MEDICAL OUTLIER,/ v
301	Tue 9 11:39	McFn M RILEY	UE CA LFT TSH HYONEPHROSIS,?DISSEMINATED CARCINOMATOSIS,MEDICAL OUTLIER/ v knackered by bug on greyoutbuttons/redtests
232	Thu 11 14:03	Walew CREDLA	FBC UE NIDD DKA/
43	Thu 11 14:04	Walew CREDLA	UE NIDD DKA ,/
406	Tue 9 14:15	Walew SINYARD	INR KCCT DVT,/On Warfarin,On Heparin,
33	Wed 10 14:32	Walew SINYARD	INR KCCT DVT ,/
28	Thu 11 14:32	Walew SINYARD	INR KCCT DVT ,/
38	Wed 10 14:34	Walew Strach D	UE CCF ,/
31	Wed 10 14:35	Walew Strach D	INR CCF ,/
37	Thu 11 14:36	Walew CREDLA	UE NIDD DKA ,/
21	Wed 10 14:36	Walew CREDLA	UE NIDD DKA ,/
33	Wed 10 14:38	Walew CARNA S	INR KCCT dvt ,/
60	Thu 11 14:40	Walew CARNA S	INR KCCT dvt ,/
30	Wed 10 14:41	Walew EVANS M	FBC UE uti,/
28	Wed 10 14:41	Walew TOWS A	FBC UE anaemia ,dementia ,/
105	Tue 9 14:58	McFn l white	UE CEP[2] COAD,HEART FAILURE,/
286	Wed 10 15:01	McFn C CRO	CEP[3] ISCHAEMIC HEART DISEASE,/
96	Wed 10 15:04	McFn H Foster	INR ON WARFARIN,/? NOW POSSIBLE DVT ON Rx,
21	Tue 9 15:26	Forr H Foster	INR ON WARFARIN,/
19	Tue 9 15:27	Forr B McNult	INR DVT/ --NOTE MESS CAUSED BY CLICKING TOO
50	Wed 10 15:28	Forr B McNult	INR DVT/ QUICKLY FOR SYSTEM
128	Tue 9 16:18	McFn M SPOO	RBS BENIGN INTRACRANIAL HBP,/
70	Tue 9 16:19	McFn M SPOO	RBS PROT BENIGN INTRACRANIAL HBP ,/
43	Wed 10 16:57	Walk PICKE E	UE ccf ,/
35	Thu 11 16:58	Walk PICKE E	UE INR ccf ,/
74	Fri 12 16:59	Walk PICKE E	UE INR ccf ,/
9	Wed 10 17:00	Walk PICKE E	INR ccf ,/
10	Tue 9 17:04	Forr O Smith	INR DVT ,/

58	Wed 10 09:02	McFn	M RILEY	UE HYONEPHROSIS,?DISSEMINATED CARCINOMATOSIS,MEDICAL OUTLIER,/
24	Wed 10 09:02	McFn	fletcher l	KCCT INR DVT ,MEDICAL OUTLIER
19	Thu 11 09:03	McFn	fletcher l	INR KCCT DVT ,MEDICAL OUTLIER ,/
30	Wed 10 09:06	McFn	l white	CEP[3] UE COAD ,HEART FAILURE
156	Wed 10 09:22	McFn	COOPER M	UE CEP[3] LVF,/
37	Fri 12 13:33	Forr	fletcher l	INR KCCT DVT ,MEDICAL OUTLIER ,/
24	Fri 12 13:34	Forr	B McNulty	INR DVT/
27	Fri 12 13:35	Forr	j smith	UE Hypothermia Hypoglycaemia ,/
18	Thu 11 13:36	Forr	j smith	UE Hypothermia Hypoglycaemia ,/
11	Wed 10 13:37	Forr	B McNulty	FBC DVT/
19	Wed 10 13:47	Forr	F Emes	FBC UE LFT COAD ,,,/
22	Fri 12 13:50	Forr	F Emes	FBC UE LFT COAD ,,,/
82	Thu 11 08:32	McFn	M RILEY	UE HYONEPHROSIS,?DISSEMINATED CARCINOMATOSIS,MEDICAL OUTLIER, RENAL IMPAIRMENT KNOWN AND BEING MONITORED,/
13	Thu 11 09:07	Forr	O Smith	INR KCCT DVT ,/
22	Fri 12 09:08	Forr	O Smith	INR KCCT DVT ,/
16	Thu 11 09:14	Forr	P Oakley	KCCT meningitis,/
THURSDAY from 10.15am				
177	Fri 12 12:28	McFn	leslie white	GLY COAD ,HEART FAILURE ,/? newly diagnosed diabetic,
32	Thu 11 12:29	McFn	leslie white	GLY COAD ,HEART FAILURE ,/? newly diagnosed niddm,
217	Fri 12 15:34	Walk	RMarsh	FBC ESR UE LFT TSH CA COR Hyponatraemia,/
33	Sat13 15:35	Walk	RMarsh	UE Hyponatraemia ,/
73	Sun 14 15:37	Walk	R Marsh	UE Hyponatraemia ,/
134	Mon15 15:40	Walk	R Marsh	UE Hyponatraemia ,/
467	Fri 12 15:46	Walk	P Ward	UE CEP[2] Collapse,/
27	Sat 13 15:46	Walk	Ps Ward	UE CEP[3] Collapse ,/
200	Fri 12 15:49	Walk	M Kopec	FBC ESR UE RBS LFT TSH CEP[2] CA Status Epilepticus,/
122	Fri 12 15:51	Walk	M Kopec	B12 RedCellFolate Status Epilepticus ,/
309	Fri 12 15:54	Walk	S Pegg	INR KCCT ?PE,/On Heparin,
49	Sat 13 15:55	Walk	S Pegg	INR KCCT ?PE ,/On Heparin ,
42	Sun 14 15:56	Walk	S Pegg	KCCT INR ?PE ,/
23	Mon15 15:57	Walk	S Pegg	INR KCCT ?PE ,/On Heparin ,
23	Mon15 15:59	Walk	P Ward	UE Collapse ,/
57	Sat 13 16:01	Walk	N Priestley	UE Imp renal func,/
18	Sun14 16:01	Walk	N Priestley	UE Imp renal func,/
19	Mon15 16:02	Walk	N Priestley	UE Imp renal func,/

42	Sat13	17:26	Forr	O Smith	INR KCCT DVT ,/
39	Sun14	17:26	Forr	O Smith	INR KCCT DVT ,/
25	Mon15	17:27	Forr	O Smith	INR KCCT DVT ,/
44	Sat 13	17:28	Forr	fletcher l	INR KCCT DVT ,MEDICAL OUTLIER ,/
43	Sun 14	17:29	Forr	fletcher l	INR KCCT DVT ,MEDICAL OUTLIER ,/
27	Mon15	17:29	Forr	fletcher l	INR KCCT DVT ,MEDICAL OUTLIER ,/
41	Sat 13	17:31	Forr	B McNulty	INR DVT/
25	Mon15	17:31	Forr	B McNulty	INR DVT/
25	Sat13	17:32	Forr	H Foster	INR ON WARFARIN,/
18	Sun 14	17:33	Forr	H Foster	INR ON WARFARIN,/
19	Mon15	17:33	Forr	H Foster	INR ON WARFARIN,/

FRIDAY from 10.33am

190	Mon15	15:38	Walk	L Prime	FBC UE ClottingScreen CA/
356	Mon15	15:41	Walk	ASmith	FBC UE RBS Infective COAD,/
486	Mon15	15:43	Walk	D Carlton	FBC UE UTI,/
97	Mon15	15:45	Walk	F FLUDE	FBC UE AN ,/
85	Mon15	15:48	Walk	PICKERING E	UE INR ccf ,Low K,/
258	Mon15	15:51	Walk	F Chapman	UE CCF,CHB AF,/
110	Sat13	15:58	Walk	M Kopec	PHENYT Status Epilepticus ,UTI,/
36	Mon15	15:59	Walk	M Kopec	FBC UE Status Epilepticus ,UTI,/
87	Mon15	16:01	Walk	TOWNSEND A	FBC UE anaemia ,dementia ,/
70	Sa 13	16:05	Walk	CARNALL S	INR KCCT dvt ,/On Heparin,On
26	Sun 14	16:06	Walk	CARNALL S	INR KCCT dvt ,/On Heparin,On
25	Mon15	16:06	Walk	CARNALL S	INR KCCT dvt ,/On Heparin,On

SATURDAY 13th from 7.10 pm

34	Tue 16	13:45	Walew	CARNALL S	INR KCCT dvt ,/
47	Wed 17	13:46	Walew	CARNALL S	INR KCCT dvt ,/
28	Thu 18	13:47	Walew	CARNALL S	INR KCCT dvt ,/
26	Tue 16	13:48	Walew	PICKERING E	UE ccf ,Low K,/
20	Tue 16	13:49	Walew	N Priestley	FBC UE Imp renal func,/
21	Tue 16	13:49	Walew	F FLUDE	FBC UE AN ,/
31	Mon15	13:50	Walew	STEINSB B	UE ccf,/
28	Tue 16	13:51	Walew	L Prime	FBC KCCT CA ,/
29	Wed 17	13:52	Walew	L Prime	FBC KCCT CA ,/
26	Thu 18	13:53	Walew	L Prime	FBC KCCT CA ,/
22	Tue 16	13:53	Walew	RMarsh	FBC UE Hyponatraemia ,/

21	Wed 17	13:54	Walew	R Marsh	UE Hyponatraemia ,/
23	Thu 18	13:54	Walew	R Marsh	UE Hyponatraemia ,/
182	Tue 16	13:57	Walew	Baxter	INR KCCT pe,/
54	Wed 17	13:58	Walew	Baxter	INR KCCT pe ,/
38	Thu 18	13:59	Walew	Baxter	INR KCCT pe ,/
118	Tue 16	14:00	Walew	Walk	INR KCCT pe/
24	Wed 17	14:00	Walew	Walk	INR KCCT pe ,/
27	Thu 18	14:01	Walew	Walk	INR KCCTpe ,/
<u>MONDAY 15th from 2.55pm</u>					
32	Thu 18	18:03	Forr	B McNulty	INR KCCT DVT/On Heparin ,
<u>WEDNESDAY from 4.40 pm</u>					
36	Fri 19	15:20	Walk	PICKERING E	UE INR ccf ,Low K,/
35	Mon22	15:21	Walk	PICKERING E	UE INR ccf ,Low K,/
53	Fri 19	15:22	Walk	N Priestley	UE Imp renal func,/
27	Sat 20	15:22	Walk	N Priestley	UE Imp renal func,/
19	Mon22	15:23	Walk	N Priestley	UE Imp renal func,/
24	Mon22	15:23	Walk	FFLUDE	FBC AN ,/
22	Fri 19	15:24	Walk	RMarsh	UE Hyponatraemia ,/
17	Mon22	15:24	Walk	RMarsh	UE Hyponatraemia ,/
24	Fri 19	15:25	Walk	F Chapman	UE CCF ,CHB AF ,/
19	Mo 22	15:25	Walk	F Chapman	UE CCF ,CHB AF ,/
23	Fri 19	15:26	Walk	A Smith	FBC Infective COAD ,/
34	Mon22	15:26	Walk	A Smith	FBC UE Infective COAD ,/
269	Fri 19	15:30	Walk	L Wright	FBC UE An (gi H'ge)/
21	Mon22	15:31	Walk	L Wright	FBC An (gi H'ge) ,/

FROM VIDEO, not in log.

Hough P Oakley FBC UE LFT  
Hough P Oakley FBC UE LFT

Hough P Oakley FBC UE

Hough A Dickinson FBC Film  
Hough A Dickinson ESR  
Hough A Dickinson Haem  
Hough A Dickinson Immunos

Walker V Siny INR KCCT

Walew L prime FBC ClottingScreen

## C2 Transaction log

Note that transactions numbered in italics were not included in the construction of the activity list for the application of TAKD.

Transaction #	Start	Finish	Doctor	Patient	Event	Remarks
<i>i</i>	00.00	01.02	AM	NCarr	Request	No sound
<i>ii</i>	02.25	04.08	AM	RSmallwood		No sound
<i>iii</i>	04.23	04.40	AM	ATunnard	Add patient	
1	04.49	07.27	AM	SRamsden	Add patient	
2	07.53	08.45	LW	ADickinson	Request	
3	08.45	09.36	LW	AJPotter	Request	
4	10.17	10.46	LW	BMcNulty	Request	
5	16.06	16.46	RH		Add patient	by mistake
6	18.31	18.56	RH	POakley	Request	
7	20.14	20.53	AM	RBarrand	Request	
8	22.22	22.52	RH	POakley	Request	handwritten
9	24.08	24.53	RH	POakley	Request	handwritten
10	25.30	26.14	AM	BMcNulty	Request	
11	26.25	26.40	AM	EBrowse	Remove pat	No sound
12	26.45	26.57	AM	DCaddick	Remove pat	No sound
13	26.58	27.03	AM	MFlint	Remove pat	No sound
14	28.17	30.33	LW	AHawcroft	Add pat + Req	No sound
15	30.34	31.14	LW	AHawcroft	Request	No sound
16	31.44	32.20	AM	RBarrand	Request	
17	32.37	32.52	AM	Temp	Remove pat	
18	35.38	36.24	LW	HFoster	Add pat + Req	
19	36.54	37.55	AM	GTurner	Request	
20	39.23	40.15	LW	KSmith	Request	
21	40.17	40.39	LW	NCarr	Request	
22	40.39	41.00	LW	NCarr	Request	
23	41.03	41.31	LW	NCarr	Request	
24	44.12	44.43	LW	POakley	Request	
25	44.54	45.37	LW	AHawcroft	Request	
26	45.38	45.46	LW	JSmith		
27	46.37	47.31	AM	POakley	Request	
28	47.38	47.46	AM	SRamsden	Remove pat	
29	48.17	48.51	AM	BMcNulty	Request	
30	50.13	51.07	LW	ADickinson	Request	
31	51.22	53.19	LW	FEmes	Add patient	
32	53.32	55.20	LW	OSmith	Add pat + Req	
33	55.37	57.31	RH	POakley	Request	
34	57.32	58.28	RH	POakley	Request	
35	58.46	58.45	RH	POakley	Request	
36	1.01.30	1.02.38	RH	ADickinson	Request	- date bug!
37	1.02.28	1.03.30	RH	ADickinson	Request	
38	1.02.44	1.03.30	RH	ADickinson	Request	
39	1.03.31	1.04.11	RH	ADickinson	Request	
40	1.06.00	1.08.55	SW	VSinyard	Add pat + Req	
41	1.11.56	1.20.40	RW	LPrime	Add pat + Req	- crash!
42	1.25.46	1.27.54	RH	JSmith	Add pat + Req	
43	1.29.25	1.30.44	AF	POakley	Request	
44	1.30.45	1.31.25	AF	OSmith	Request	
45	1.32.38	1.35.16	AM	EWhittaker	Add pat + Req	
46	1.36.15	1.37.22	AF	POakley	Request	- prob with pat identification
47	1.37.26	1.38.30	AM	BMcNulty	Request	
48	1.39.36	1.41.06	AF	OSmith	Add pat + Req	
49	1.41.09	1.41.39	AF	OSmith	Request	
50	1.41.40	1.42.40	AF	OSmith	Request	
51	1.42.51	1.43.29	AF	JSmith	Request	
52	1.43.50	1.46.10	AF	RBarrand	Add pat + Req	UE problem
53	1.46.33	1.48.02	AM	FEmes	Request	
54	1.48.40	1.53.02	AF	SChapman	Add patient	-crash!
55	1.55.40	1.56.00	AM	HFoster	Request	Talk re. list order
56	1.57.34	2.00.47	SW	NPriestley	Add pat + Req	
57	2.00.48	2.02.08	SW	NPriestley	Request	Talk re. batch order
58	2.02.11	2.03.47	SW	NPriestley	Request	
59	2.03.49	2.04.17	SW	NPriestley	Request	
60	2.04.18	2.04.40	SW	NPriestley	Request	
61	2.06.22	2.08.46	SW	GLawson	Add pat + Req	
62	2.08.58	2.09.43	SW	GLawson	Request	
63	2.11.23	2.13.13	SW	GLawson	Request	Include therapy prob
64	2.13.15	2.13.51	SW	GLawson	Request	
65	2.14.55	2.16.58	SW	DClay	Request	
66	2.17.00	2.20.04	SW	DClay	Req + change	Remove prob

67	2.20.46	2.23.38	SW	ELawrence	Add pat + Req	
68	2.23.39	2.24.39	SW	ELawrence	Request	
69	2.24.40	2.25.26	SW	ELawrence	Request	
70	2.25.27	2.26.08	SW	ELawrence	Request	
71	2.26.25	2.27.17	SW	IBeech	Request	
72	2.27.18	2.27.53	SW	IBeech	Request	
73	2.28.02	2.29.44	SW	MMason	Add pat + Req	Warfarin as working diag!
74	2.29.45	2.30.09	SW	MMason	Request	
75	2.30.26	2.31.02	SW	MMason	Request	
76	2.31.06	2.31.31	SW	MMason	Request	
77	2.31.40	2.33.17	SW	HHunt	Add pat + Req	
78	2.33.18	2.33.53	SW	HHunt	Request	
79	2.33.54	2.34.51	SW	HHunt	Request	
80	2.35.13	2.37.30	SW	FFlude	Add pat + Req	
81	2.37.31	2.37.54	SW	FFlude	Request	
82	2.38.41	2.39.01	AM	BMcNulty	Request	
83	2.39.02	2.39.34	AM	POakley	Request	
84	2.39.35	2.39.55	AM	HFoster	Request	
85	2.40.56	2.41.01	AM		Remove pat	
86	2.41.02	2.42.09	AM	RSiddows	Remove pat	Search for pat
87	2.42.42	2.44.24	AF	FEmes	Request	
88	2.45.36	2.47.58	AF	SChapman	Add pat + Req	
89	2.47.50	2.48.32	AF	BMcNulty	Request	
90	2.48.33	2.49.08	AF	JSmith	Request	
91	2.48.21	2.40.12	AF	EWhittaker	Request	
92	2.50.52	2.53.13	AM	LFLetcher	Add pat + Req	
93	2.53.24	2.56.03	AM	MRiley	Add pat + Req	Talk re queries
94	2.58.14	3.00.50	RW	MCook	Add patient	
95	3.00.52	3.05.04	RW	Sinyard	Add pat + Req	Therapy prob
96	3.05.17	3.05.27	RW	MCook	Remove pat	
97	3.06.24	3.08.05	RW	Ibbotson	Add patient	
98	3.08.06	3.10.23	RW	Stracher	Add patient	
99	3.10.24	3.12.06	RW	Steinsbury	Add patient	
100	3.12.07	3.13.27	RW	Warburton	Add patient	
101	3.13.28	3.14.45	RW	Evans	Add patient	
102	3.14.46	3.15.55	RW	Townsend	Add patient	
103	3.15.58	3.17.11	RW	Carnall	Add patient	
104	3.17.16	3.18.34	RW	Pickering	Add patient	
105	3.1838	3.20.02	RW	Kenny	Add patient	
106	3.20.03	3.20.49	RW	Sinyard	Request	
107	3.20.50	3.21.21	RW	Sinyard	Request	
108	3.22.19	3.23.02	RW	Douglas	Request	
109	3.23.16	3.23.52	RW	Douglas	Request	
110	3.23.53	3.24.41	RW	Credland	Request	
111	3.24.42	3.25.13	RW	Credland	Request	
112	3.26.40	3.27.14	RW	Carnall	Request	
113	3.27.16	3.28.25	RW	Carnall	Request	
114	3.29.05	3.29.36	RW	Evans	Request	
115	3.29.45	3.00.14	RW	Townsend	Request	
116	3.31.05	3.31.34	RW	Townsend	Change details	
117	3.31.33	3.32.33	RW	Prime	Remove pat	
118	3.32.33	3.32.40	RW	Sinyard	Remove pat	
119	3.33.34	3.35.25	AM	White	Add pat + Req	
120	3.36.03	3.38.26	AM	Crookes	Add pat + Req	
121	3.38.37	3.40.36	AM	Foster	Request	Probs with clin dets
122	3.41.32	3.42.04	AF	Foster	Request	
123	3.42.30	3.42.53	AF	McNulty	Request	
124	3.42.54	3.43.48	AF	McNulty	Request	System too slow for user
125	3.45.11	3.47.23	AM	Spencer	Add pat + Req	
126	3.47.27	3.48.42	AM	Spencer	Request	Sample was CSF
127	3.49.22	3.50.45	SW	Pickering	Add patient	Pre-existing pat
128	3.50.47	3.51.33	SW	Pickering	Request	
129	3.51.35	3.52.11	SW	Pickering	Request	
130	3.52.26	3.53.45	SW	Pickering	Request	
131	3.53.54	3.54.29	SW	Pickering	Request	
132	3.55.14	3.55.33	AF	OSmith	Request	

### C3 Raw data for statistical analysis

Task #	Transaction #	Task Type #	Transaction Type #	Position in sequence	Doctor occasion	Doctor #	Time (seconds)
1	1	2	2	0	1	1	3.2
2	1	2	2	0	1	1	22.9
3	1	2	2	0	1	1	10.3
4	1	2	2	0	1	1	2.6
5	1	2	2	0	1	1	23.2
6	1	2	2	0	1	1	10.1
7	1	2	2	0	1	1	2.4
8	1	2	2	0	1	1	14.4
9	1	2	2	0	1	1	5.2
10	1	2	2	0	1	1	30
11	1	2	2	0	1	1	1.8
12	1	2	2	0	1	1	2.4
13	2	13	3	0	1	2	6.7
14	2	7	3	0	1	2	2.9
15	2	14	3	0	1	2	0.8
16	2	9	3	0	1	2	21.7
17	2	14	3	0	1	2	5.1
18	3	13	3	0	2	2	12.0
19	3	7	3	0	2	2	10.6
20	3	4	3	0	2	2	2.0
21	3	14	3	0	2	2	1.7
22	3	9	3	0	2	2	14.2
23	3	14	3	0	2	2	1.4
24	4	13	3	0	3	2	2.1
25	4	4	3	0	3	2	3.0
26	4	11	3	0	3	2	2.8
27	4	14	3	0	3	2	2.1
28	4	9	3	0	3	2	9.6
29	4	14	3	0	3	2	1.3
30	5	2	2	0	1	3	2.1
31	5	2	2	0	1	3	15.4
32	5	2	2	0	1	3	23.1
33	5	8	2	0	1	3	1.4
34	6	13	1	0	2	3	3.5
35	6	4	1	0	2	3	8.5
36	6	4	1	0	2	3	1.8
37	6	14	1	0	2	3	2.8
38	6	14	1	0	2	3	0.9
39	7	13	3	0	2	1	2.1
40	7	6	3	0	2	1	0.8
41	7	6	3	0	2	1	2.6
42	7	5	3	0	2	1	
43	7	14	3	0	2	1	3.6
44	7	9	3	0	2	1	21.3
45	7	14	3	0	2	1	2.9
46	7	8	3	0	2	1	0.5
47	8	13	1	0	3	3	4.1
48	8	14	1	0	3	3	3.6
49	8	14	1	0	3	3	4.1
50	8	14	1	0	3	3	2.7
51	9	2	1	0	4	3	1.9
52	9	2	1	0	4	3	52.4
53	9	13	1	0	4	3	1.7
54	9	14	1	0	4	3	1.5
55	9	14	1	0	4	3	1.8
56	9	14	1	0	4	3	1.6
57	9	8	1	0	4	3	3.0
58	10	13	1	0	3	1	5.1
59	10	4	1	0	3	1	6.0
60	10	4	1	0	3	1	0.1
61	10	12	1	0	3	1	0.7
62	10	12	1	0	3	1	1.9
63	10	12	1	0	3	1	1.8
64	10	10	1	0	3	1	4.4
65	10	14	1	0	3	1	1.5
66	10	14	1	0	3	1	2.1
67	11	1	4	0	4	1	4.6
68	11	1	4	0	4	1	3.1
69	11	1	4	0	4	1	0.9
70	11	1	4	0	4	1	5.6
71	11	1	4	0	4	1	1.1
72	12	1	4	0	5	1	4.5
73	12	1	4	0	5	1	1.9
74	12	1	4	0	5	1	0.5
75	12	1	4	0	5	1	3.5
76	12	1	4	0	5	1	1.4
77	13	1	4	0	5	1	1.0
78	13	1	4	0	5	1	3.1
79	13	1	4	0	5	1	0.8
80	14	2	2	1	4	2	8.1

81	14	2	2	1	4	2	1.1
82	14	2	2	1	4	2	17.8
83	14	2	2	1	4	2	26.5
84	14	2	2	1	4	2	6.5
85	14	2	2	1	4	2	10.4
85	14	2	2	1	4	2	26.8
87	14	2	2	1	4	2	13.5
88	14	2	2	1	4	2	1.7
89	14	11	2	1	4	2	5.2
90	14	12	2	1	4	2	9.1
91	14	4	2	1	4	2	2.9
92	14	14	2	1	4	2	4.2
93	14	14	2	1	4	2	3.5
94	15	13	1	2	5	2	1.9
95	15	12	1	2	5	2	1.6
96	15	12	1	2	5	2	1.0
97	15	12	1	2	5	2	4.2
98	15	4	1	2	5	2	2.0
99	15	14	1	2	5	2	2.2
100	15	14	1	2	5	2	1.5
101	16	13	1	0	6	1	11.1
102	16	7	1	0	6	1	2.8
103	16	11	1	0	6	1	5.2
104	16	14	1	0	6	1	1.6
105	16	14	1	0	6	1	1.7
106	17	1	4	0	7	1	1.3
107	17	1	4	0	7	1	2.0
108	17	1	4	0	7	1	1.1
109	17	1	4	0	7	1	1.5
110	17	1	4	0	7	1	1.9
111	18	13	3	0	6	2	2.4
112	18	4	3	0	6	2	2.4
113	18	12	3	0	6	2	1.0
114	18	12	3	0	6	2	0.2
115	18	12	3	0	6	2	0.6
116	18	14	3	0	6	2	1.8
117	18	9	3	0	6	2	16.7
118	18	14	3	0	6	2	1.8
119	19	13	3	0	8	1	5.3
120	19	11	3	0	8	1	4.1
121	19	5	3	0	8	1	2.2
122	19	11	3	0	8	1	4.0
123	19	4	3	0	8	1	1.5
124	19	11	3	0	8	1	1.0
125	19	4	3	0	8	1	0.5
126	19	11	3	0	8	1	5.8
127	19	14	3	0	8	1	1.8
128	19	9	3	0	8	1	20.2
129	19	14	3	0	8	1	2.3
130	20	13	3	0	7	2	5.6
131	20	6	3	0	7	2	2.6
132	20	5	3	0	7	2	2.6
133	20	4	3	0	7	2	2.7
134	20	4	3	0	7	2	1.4
135	20	14	3	0	7	2	5.3
136	20	9	3	0	7	2	10.6
137	20	14	3	0	7	2	2.1
138	21	13	1	1	8	2	2.5
139	21	4	1	1	8	2	2.0
140	21	14	1	1	8	2	3.1
141	21	14	1	1	8	2	2.1
142	22	13	1	2	9	2	1.2
143	22	4	1	2	9	2	1.8
144	22	12	1	2	9	2	1.4
145	22	12	1	2	9	2	2.4
146	22	12	1	2	9	2	2.4
147	22	14	1	2	9	2	1.3
148	22	14	1	2	9	2	2.1
149	23	13	1	3	10	2	1.8
150	23	4	1	3	10	2	1.4
151	23	12	1	3	10	2	1.4
152	23	12	1	3	10	2	1.9
153	23	12	1	3	10	2	5.0
154	23	12	1	3	10	2	2.5
155	23	14	1	3	10	2	0.6
156	23	14	1	3	10	2	1.5
157	24	13	1	0	11	2	3.1
158	24	7	1	0	11	2	3.6
159	24	14	1	0	11	2	1.3
160	24	14	1	0	11	2	2.3
161	24	14	1	0	11	2	1.4
162	25	13	1	0	12	2	4.8
163	25	9	1	0	12	2	2.7
164	25	9	1	0	12	2	14.7
165	25	3	1	0	12	2	12.2
166	25	14	1	0	12	2	2.1
167	25	14	1	0	12	2	1.8
168	26	1	4	0	13	2	2.1
169	26	1	4	0	13	2	1.8

170	26	1	4	0	13	2	4.6
171	27	13	1	0	9	1	1.9
172	27	11	1	0	9	1	2.0
173	27	5	1	0	9	1	1.7
174	27	11	1	0	9	1	1.2
175	27	5	1	0	9	1	0.9
176	27	7	1	0	9	1	0.6
177	27	10	1	0	9	1	2.5
178	27	4	1	0	9	1	3.4
179	27	14	1	0	9	1	1.9
180	27	14	1	0	9	1	4.7
181	27	12	1	0	9	1	1.0
182	27	12	1	0	9	1	1.1
183	27	12	1	0	9	1	4.0
184	27	11	1	0	9	1	1.1
185	27	14	1	0	9	1	1.4
186	27	14	1	0	9	1	2.2
187	28	1	4	0	10	1	1.3
188	28	1	4	0	10	1	3.8
189	28	1	4	0	10	1	1.0
190	28	1	4	0	10	1	1.4
191	28	1	4	0	10	1	19.0
192	29	13	1	0	11	1	2.9
193	29	12	1	0	11	1	3.0
194	29	12	1	0	11	1	1.4
195	29	12	1	0	11	1	2.7
196	29	10	1	0	11	1	6.6
197	29	4	1	0	11	1	2.0
198	29	4	1	0	11	1	0.9
199	29	14	1	0	11	1	2.9
200	29	14	1	0	11	1	2.3
201	30	13	1	0	14	2	2.0
202	30	6	1	0	14	2	1.4
203	30	5	1	0	14	2	1.4
204	30	11	1	0	14	2	1.1
205	30	14	1	0	14	2	1.4
206	30	14	1	0	14	2	3.4
207	30	8	1	0	14	2	2.2
208	31	2	2	0	15	2	2.1
209	31	2	2	0	15	2	9.1
210	31	2	2	0	15	2	10.4
211	31	2	2	0	15	2	4.5
212	31	2	2	0	15	2	5.0
213	31	2	2	0	15	2	7.8
214	31	2	2	0	15	2	10.1
215	31	2	2	0	15	2	1.7
216	31	2	2	0	15	2	14.4
217	31	2	2	0	15	2	5.2
218	31	2	2	0	15	2	10.4
219	31	2	2	0	15	2	2.7
220	31	2	2	0	15	2	6.2
221	31	2	2	0	15	2	2.7
222	31	2	2	0	15	2	1.8
223	31	2	2	0	15	2	0.7
224	31	2	2	0	15	2	3.8
225	31	10	2	0	15	2	2.6
226	31	5	2	0	15	2	2.6
227	31	4	2	0	15	2	4.0
228	31	4	2	0	15	2	1.3
229	31	9	2	0	15	2	3.2
230	31	9	2	0	15	2	6.3
231	31	14	2	0	15	2	4.7
232	31	14	2	0	15	2	3.0
233	31	8	2	0	15	2	2.9
234	32	2	2	0	16	2	1.4
235	32	2	2	0	16	2	13.2
236	32	2	2	0	16	2	8.3
237	32	2	2	0	16	2	2.5
238	32	2	2	0	16	2	7.8
239	32	2	2	0	16	2	10.1
240	32	2	2	0	16	2	2.7
241	32	2	2	0	16	2	5.7
242	32	2	2	0	16	2	5.5
243	32	2	2	0	16	2	1.4
244	32	11	2	0	16	2	1.5
245	32	4	2	0	16	2	3.1
246	32	4	2	0	16	2	3.0
247	32	14	2	0	16	2	5.3
248	32	14	2	0	16	2	3.2
249	32	8	2	0	16	2	1.1
250	33	12	1	1	5	3	1.6
251	33	12	1	1	5	3	5.1
252	33	13	1	1	5	3	1.5
253	33	12	1	1	5	3	1.8
254	33	12	1	1	5	3	0.8
255	33	12	1	1	5	3	1.4
256	33	5	1	1	5	3	13.7
257	33	4	1	1	5	3	1.6
258	33	3	1	1	5	3	22.3

259	33	11	1	1	5	3	0.5
260	33	14	1	1	5	3	1.4
261	33	14	1	1	5	3	2.3
262	34	12	1	2	6	3	0.9
263	34	12	1	2	6	3	0.5
264	34	12	1	2	6	3	14.7
265	34	12	1	2	6	3	9.7
266	34	13	1	2	6	3	2.7
267	34	11	1	2	6	3	8.0
268	34	5	1	2	6	3	0.6
269	34	11	1	2	6	3	2.1
270	34	14	1	2	6	3	1.4
271	34	14	1	2	6	3	1.7
272	35	13	1	3	7	3	2.6
273	35	12	1	3	7	3	1.9
274	35	12	1	3	7	3	0.6
275	35	12	1	3	7	3	3.7
276	35	12	1	3	7	3	1.8
277	35	11	1	3	7	3	3.2
278	35	5	1	3	7	3	1.8
279	35	4	1	3	7	3	1.8
280	35	3	1	3	7	3	32.9
281	35	12	1	3	7	3	3.8
282	35	14	1	3	7	3	1.1
283	35	14	1	3	7	3	1.8
284	36	13	1	1	8	3	6.1
285	36	11	1	1	8	3	2.9
286	36	6	1	1	8	3	2.5
287	36	4	1	1	8	3	2.7
288	36	14	1	1	8	3	3.9
289	36	14	1	1	8	3	2.3
290	37	11	1	2	9	3	5.5
291	37	13	1	2	9	3	1.8
292	37	11	1	2	9	3	1.8
293	37	14	1	2	9	3	5.1
294	37	14	1	2	9	3	1.6
295	38	3	1	3	10	3	21.9
296	38	13	1	3	10	3	3.7
297	38	11	1	3	10	3	5.5
298	38	14	1	3	10	3	2.1
299	38	14	1	3	10	3	1.7
300	39	3	1	4	11	3	10.1
301	39	11	1	4	11	3	6.3
302	39	13	1	4	11	3	5.7
303	39	14	1	4	11	3	2.0
304	39	14	1	4	11	3	5.5
305	40	2	2	0	1	5	1.3
306	40	2	2	0	1	5	28.6
307	40	2	2	0	1	5	1.1
308	40	2	2	0	1	5	8.6
309	40	2	2	0	1	5	5.2
310	40	2	2	0	1	5	20.0
311	40	2	2	0	1	5	9.8
312	40	2	2	0	1	5	2.7
313	40	12	2	0	1	5	2.6
314	40	12	2	0	1	5	2.9
315	40	12	2	0	1	5	2.7
316	40	11	2	0	1	5	1.1
317	40	4	2	0	1	5	1.1
318	40	4	2	0	1	5	1.3
319	40	14	2	0	1	5	2.9
320	40	14	2	0	1	5	2.0
321	41	2	2	0	1	6	1.9
322	41	2	2	0	1	6	80.3
323	41	2	2	0	1	6	15.0
324	41	2	2	0	1	6	13.1
325	41	2	2	0	1	6	13.4
326	41	2	2	0	1	6	52.2
327	41	2	2	0	1	6	42.6
328	41	2	2	0	1	6	8.0
329	41	2	2	0	1	6	5.6
330	41	2	2	0	1	6	3.2
331	41	2	2	0	1	6	5.5
332	41	2	2	0	1	6	7.1
333	41	2	2	0	1	6	15.0
334	41	2	2	0	1	6	10.0
335	41	2	2	0	1	6	4.3
336	41	2	2	0	1	6	3.0
337	41	12	2	0	1	6	16.2
338	41	12	2	0	1	6	3.4
339	41	12	2	0	1	6	3.3
340	41	6	2	0	1	6	3.3
341	41	3	2	0	1	6	30.7
342	41	14	2	0	1	6	4.2
343	41	14	2	0	1	6	2.8
344	42	2	2	0	11	3	1.0
345	42	2	2	0	11	3	8.5
346	42	2	2	0	11	3	14.3
347	42	2	2	0	11	3	3.1

348	42	2	2	0	11	3	11.9
349	42	2	2	0	11	3	9.5
350	42	2	2	0	11	3	17.9
351	42	2	2	0	11	3	10.4
352	42	11	2	0	11	3	2.4
353	42	4	2	0	11	3	2.3
354	42	4	2	0	11	3	8.3
355	42	14	2	0	11	3	2.9
356	42	14	2	0	11	3	2.0
357	43	13	1	0	1	4	11.1
358	43	4	1	0	1	4	9.0
359	43	14	1	0	1	4	39.3
360	43	14	1	0	1	4	4.4
361	44	13	1	0	2	4	8.3
362	44	4	1	0	2	4	3.2
363	44	14	1	0	2	4	0.6
364	44	14	1	0	2	4	3.4
365	44	8	1	0	2	4	9.6
366	45	2	2	0	12	1	19.9
367	45	2	2	0	12	1	2.1
368	45	2	2	0	12	1	21.1
369	45	2	2	0	12	1	10.3
370	45	2	2	0	12	1	17.5
371	45	2	2	0	12	1	8.7
372	45	2	2	0	12	1	6.8
373	45	2	2	0	12	1	17.6
374	45	2	2	0	12	1	2.7
375	45	5	2	0	12	1	5.8
376	45	4	2	0	12	1	2.0
377	45	12	2	0	12	1	4.7
378	45	4	2	0	12	1	2.7
379	45	14	2	0	12	1	3.5
380	45	14	2	0	12	1	2.4
381	46	13	1	0	3	4	10.5
382	46	12	1	0	3	4	11.8
383	46	12	1	0	3	4	2.1
384	46	12	1	0	3	4	2.8
385	46	4	1	0	3	4	4.6
386	46	13	1	0	3	4	23.3
387	46	8	1	0	3	4	4.6
388	47	13	1	0	13	1	7.4
389	47	11	1	0	13	1	2.5
390	47	6	1	0	13	1	0.5
391	47	4	1	0	13	1	1.8
392	47	4	1	0	13	1	10.5
393	47	4	1	0	13	1	0.7
394	47	11	1	0	13	1	4.0
395	47	14	1	0	13	1	2.8
396	47	14	1	0	13	1	3.0
397	48	13	1	1	4	4	5.5
398	48	11	1	1	4	4	2.0
399	48	12	1	1	4	4	1.3
400	48	12	1	1	4	4	1.1
401	48	12	1	1	4	4	2.6
402	48	4	1	1	4	4	4.0
403	48	4	1	1	4	4	0.9
404	48	12	1	1	4	4	5.0
405	48	12	1	1	4	4	1.0
406	48	12	1	1	4	4	20.0
407	48	12	1	1	4	4	2.7
408	48	14	1	1	4	4	0.7
409	48	14	1	1	4	4	15.0
410	48	12	1	1	4	4	3.6
411	48	12	1	1	4	4	4.7
412	48	12	1	1	4	4	1.6
413	48	14	1	1	4	4	0.3
414	48	14	1	1	4	4	2.9
415	49	13	1	2	5	4	1.9
416	49	12	1	2	5	4	1.7
417	49	12	1	2	5	4	0.9
418	49	12	1	2	5	4	6.2
419	49	12	1	2	5	4	0.8
420	49	4	1	2	5	4	3.4
421	49	4	1	2	5	4	1.0
422	49	14	1	2	5	4	2.4
423	49	14	1	2	5	4	2.4
424	50	13	1	3	6	4	1.3
425	50	12	1	3	6	4	1.5
426	50	12	1	3	6	4	1.5
427	50	12	1	3	6	4	3.5
428	50	12	1	3	6	4	3.4
429	50	4	1	3	6	4	0.9
430	50	4	1	3	6	4	0.7
431	50	14	1	3	6	4	1.7
432	50	14	1	3	6	4	1.6
433	50	8	1	3	6	4	1.4
434	51	13	1	1	7	4	10.9
435	51	4	1	1	7	4	3.5
436	51	14	1	1	7	4	3.8

437	51	14	1	1	7	4	1.6
438	51	8	1	1	7	4	1.2
439	52	13	1	2	8	4	1.6
440	52	4	1	2	8	4	5.2
441	52	7	1	2	8	4	103.0
442	52	14	1	2	8	4	4.0
443	52	14	1	2	8	4	2.0
444	52	8	1	2	8	4	0.5
445	53	13	1	0	14	1	1.1
446	53	10	1	0	14	1	1.7
447	53	10	1	0	14	1	2.2
448	53	11	1	0	14	1	2.3
449	53	7	1	0	14	1	1.6
450	53	11	1	0	14	1	6.1
451	53	4	1	0	14	1	2.7
452	53	4	1	0	14	1	5.2
453	53	11	1	0	14	1	39.5
454	53	4	1	0	14	1	2.0
455	53	10	1	0	14	1	5.2
456	53	14	1	0	14	1	3.8
457	53	14	1	0	14	1	1.7
458	54	2	2	0	9	4	23.0
459	54	2	2	0	9	4	3.9
460	54	2	2	0	9	4	31.0
461	54	2	2	0	9	4	10.1
462	54	2	2	0	9	4	2.1
463	54	2	2	0	9	4	14.0
464	54	2	2	0	9	4	68.4
465	54	2	2	0	9	4	8.5
466	54	2	2	0	9	4	2.7
467	54	2	2	0	9	4	3.9
468	54	2	2	0	9	4	1.4
469	54	7	2	0	9	4	9.1
470	54	4	2	0	9	4	8.7
471	54	4	2	0	9	4	10.4
472	54	11	2	0	9	4	7.0
473	54	4	2	0	9	4	1.9
474	54	11	2	0	9	4	3.1
475	54	14	2	0	9	4	1.5
476	54	14	2	0	9	4	4.0
477	55	13	1	0	15	1	1.6
478	55	11	1	0	15	1	4.5
479	55	4	1	0	15	1	2.0
480	55	14	1	0	15	1	3.3
481	55	14	1	0	15	1	1.9
482	56	2	2	1	2	5	3.7
483	56	2	2	1	2	5	10.2
484	56	2	2	1	2	5	24.6
485	56	2	2	1	2	5	4.8
486	56	2	2	1	2	5	21.7
487	56	2	2	1	2	5	8.2
488	56	2	2	1	2	5	4.3
489	56	2	2	1	2	5	30.1
490	56	2	2	1	2	5	21.1
491	56	11	2	1	2	5	4.7
492	56	2	2	1	2	5	5.6
493	56	13	2	1	2	5	4.1
494	56	7	2	1	2	5	4.1
495	56	14	2	1	2	5	9.0
496	56	14	2	1	2	5	1.6
497	57	12	1	2	3	5	0.6
498	57	12	1	2	3	5	3.1
499	57	12	1	2	3	5	0.9
500	57	11	1	2	3	5	3.8
501	57	7	1	2	3	5	1.5
502	57	14	1	2	3	5	11.7
503	57	8	1	2	3	5	7.5
504	57	13	1	2	3	5	18.9
505	57	7	1	2	3	5	7.4
506	57	14	1	2	3	5	1.9
507	57	14	1	2	3	5	2.2
508	58	13	1	3	4	5	1.7
509	58	12	1	3	4	5	1.7
510	58	12	1	3	4	5	39.2
511	58	12	1	3	4	5	9.8
512	58	12	1	3	4	5	4.8
513	58	12	1	3	4	5	1.6
514	58	12	1	3	4	5	0.4
515	58	12	1	3	4	5	3.0
516	58	12	1	3	4	5	1.6
517	58	14	1	3	4	5	2.7
518	58	14	1	3	4	5	5.8
519	58	7	1	3	4	5	2.8
520	58	14	1	3	4	5	1.9
521	58	14	1	3	4	5	1.8

**Task type**

Task type #	KRG sentences
1	3
2	4
3	25,27,31
4	26,28,32,35
5	29,30,38
6	33,34,39,40
7	36,37
8	2'2
9	3'9
10	4'10
11	4'17
12	5'9
13	5'11, 5'12
14	6'5
15	4'13,4'14,4'15,

**Doctors**

Doctor #	Initial
1	AM
2	LW
3	RH
4	AF
5	SW
6	RW

**Transaction types**

Type #	Transaction type
1	Request only
2	Add patient
3	Pre-admitted patient
4	Remove patient

# C4 Diagnostic graphs for the statistical analysis

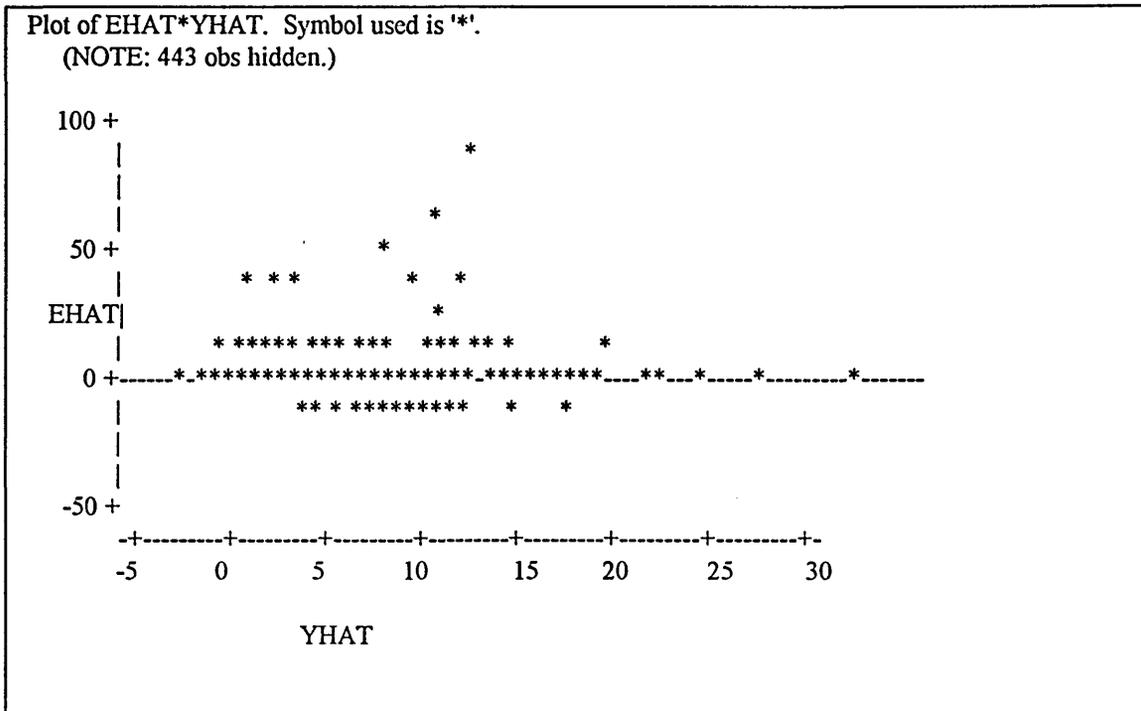


Figure C1 Residuals against fitted values, raw times.

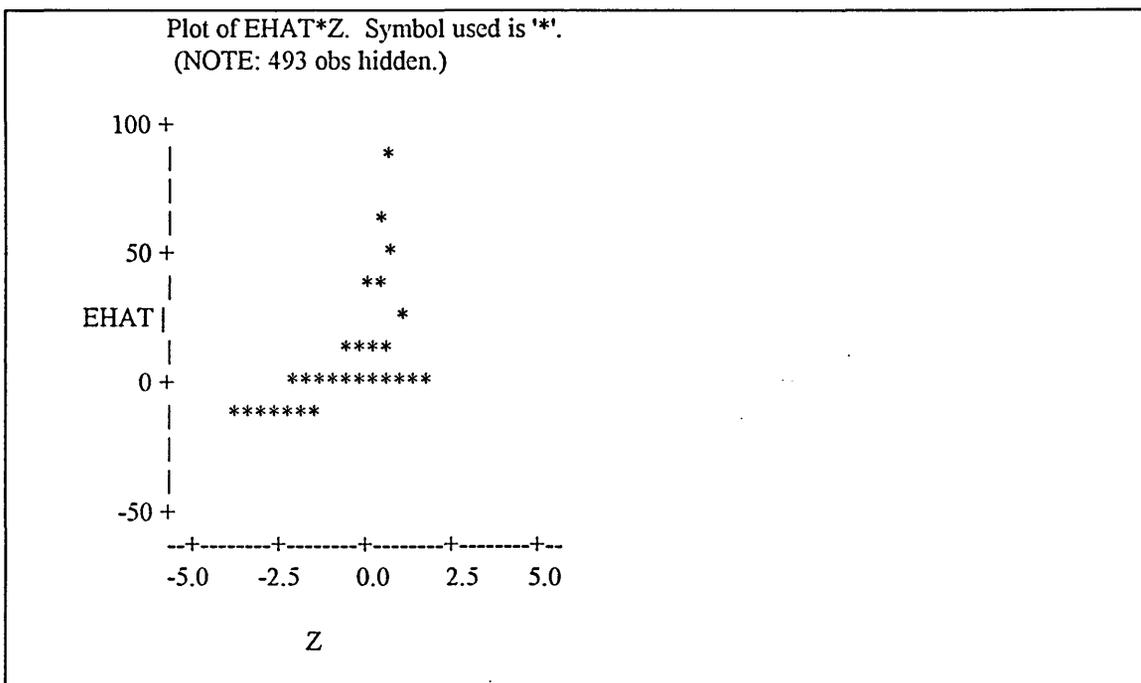


Figure C2 Normal probability plot of residuals, raw times

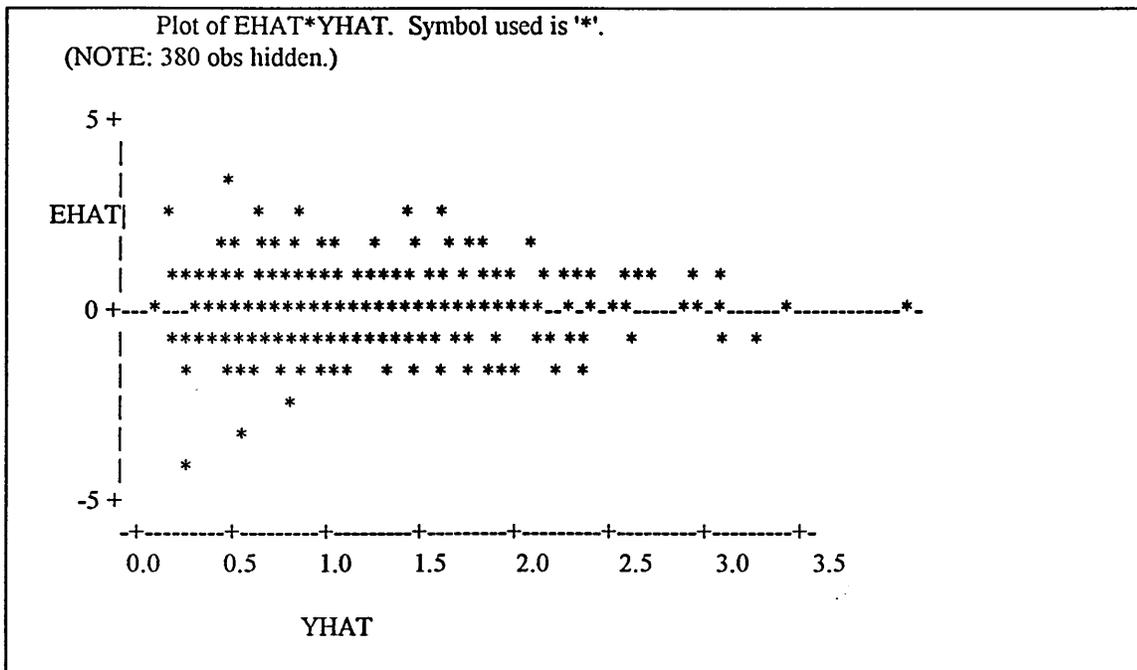


Figure C3 Residuals against fitted values, log times.

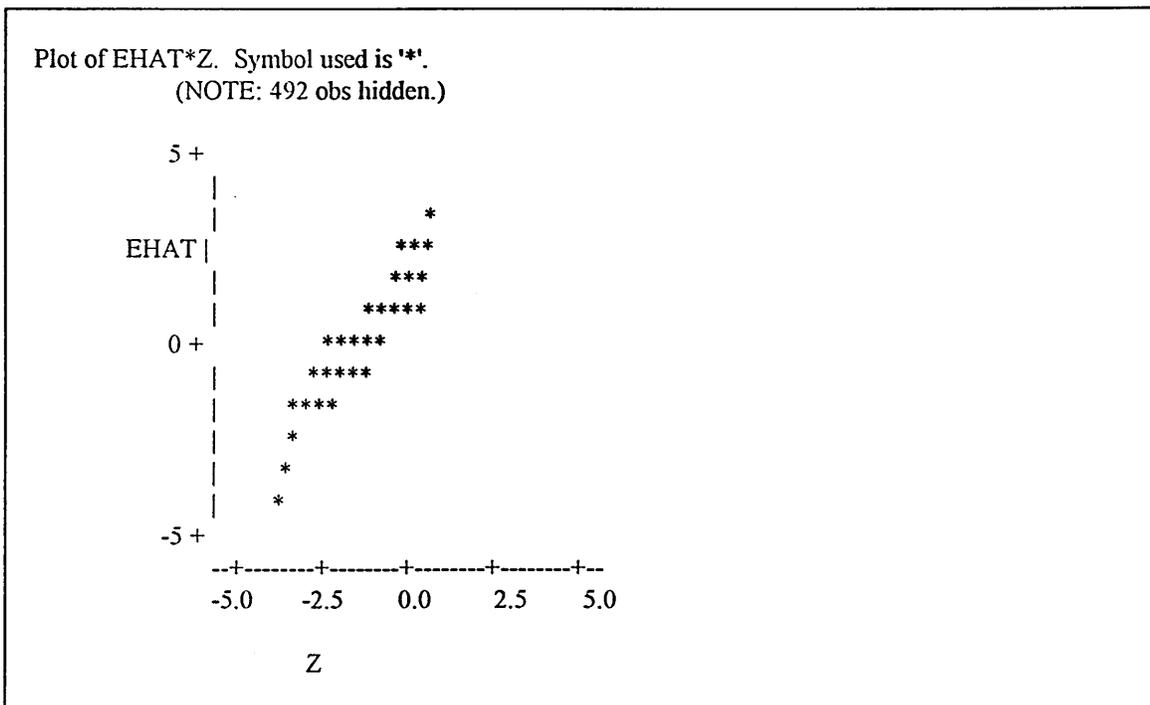


Figure C4 Normal probability plot of residuals, log times

## C5 Comparison of form completion times

Time (s)	No of forms	Time (s)	No of forms	Time (s)	No of forms
21	1	25	1	19	1
34	2	18	1	58	1
23	1	19	1	10	1
24	1	41	1	43	1
19	1	25	1	35	2
22	1	44	1	74	2
17	1	43	1	9	1
24	1	27	1	19	1
53	1	42	1	50	1
27	1	39	1	21	1
19	1	25	1	28	2
36	2	57	1	30	2
35	2	18	1	33	1
32	1	19	1	60	1
21	1	23	1	37	1
23	1	33	1	21	1
22	2	73	1	38	1
28	2	134	1	31	1
29	2	16	1	43	1
26	2	13	1	16	1
31	1	22	1	30	1
21	2	82	1	31	2
20	2	19	2	28	1
26	1	22	2	18	1
34	1	11	1	77	2
47	1	27	1	26	2
28	1	18	1	12	1
87	2	24	1	28	2
85	2	37	1	23	1
97	2	30	1	33	1
190	3	24	1		
Average time per form					27.9 s

Computerised task completion times

Time(s)					
32	32	57	28	35	19
45	54	40	24	26	38
23	32	22	25	18	25
19	19	20	21	29	23
72	28	33	22	16	51
Average time per form					30.9 s

Manual task completion times

T Test:  $t = 0.064$ , Null hypothesis:  $t = 0.06$ ,  $df = 128$ . Accept  $H_0$ .  
The average task completion times are not different

# Appendix D

## Supplementary data collection

Total of 142 forms surveyed in Haematology and Clinical Chemistry files.

Haematology: 60 forms, 17 days' forms from P1

Clinical Chemistry: 82 forms, 13 days' forms from P1

Number of incomplete forms = 96 or 68%.

Table 1 Number of forms containing omitted data:

Item	Haematology	Clinical Chemistry	Total	Percentage of forms
Clinical details	10	9	19	13.4
Date of birth	17	20	37	26.1
Hospital number	0	1	1	0.7
Sex	7	14	21	14.8
Doctor name	30	46	76	53.5
Bleep number	7	7	14	9.9
Signature	2	1	3	2.1
Sample type	23	6	29	20.4

Tables 2 Frequencies of different tests requested

Haematology tests	Percentage (n= 690)
FBC	56
ESR	23
B12/Folate	9
Film	6
Red cell folate	3
Ferritin	2
Haemolysis screen	<1
Intrinsic factor Ab	<1
Reticulocyte count	<1
Electrophoresis	<1
Plasma viscosity	<1
Thalassaemia screen	<1
Clinical chemistry	Percentage (n=113)
U&E	55
CEP	10
RBS	9
Digoxin	4
LFT	4
TFT	4
Calcium	4
Protein	4
Theophylline	2
Creatinine	2
Serum iron	<1
HbA	<1
Urine electrolytes	<1
Glycosylated Hb	<1
Plasma osmolality	<1



		Strongly disagree	Disagree	Undecided	Agree	Strongly agree
1	I have difficulty finding the most common investigations.	<input type="checkbox"/>				
2	There are too many patient details displayed.	<input type="checkbox"/>				
3	The general layout bears little relation to how I request tests.	<input type="checkbox"/>				
4	The row of buttons below the working diagnosis is not useful.	<input type="checkbox"/>				
5	The computer makes form filling less repetitive .	<input type="checkbox"/>				
6	It is good that all the desired tests can be requested at one go.	<input type="checkbox"/>				
7	Little effort is required once the patient has been selected.	<input type="checkbox"/>				
8	I have no problem going from one part of the task to another.	<input type="checkbox"/>				
9	I would prefer all the tests to be in straight alphabetical order	<input type="checkbox"/>				
10	The system should allow me to enter more than a working diagnosis	<input type="checkbox"/>				
11	I think the labs would be satisfied with the patient data this gives.	<input type="checkbox"/>				
12	It is good that the system allows ordering for only one date at a time	<input type="checkbox"/>				
13	It is confusing that I am allowed to select the tests before the patient	<input type="checkbox"/>				
14	I know where to look to find particular information.	<input type="checkbox"/>				
15	The general layout of the screens could be more logical	<input type="checkbox"/>				
16	I agree with the order in which the tests have been placed.	<input type="checkbox"/>				
17	I would like more control in the printing of each individual form	<input type="checkbox"/>				
18	This system allows me the flexibility to do things in the order I want.	<input type="checkbox"/>				
19	The more common the test, the easier it is to select.	<input type="checkbox"/>				
20	I have to move the mouse around too much to make a request.	<input type="checkbox"/>				
21	There is no need for a facility for setting the time as well as the date.	<input type="checkbox"/>				
22	Related types of information are clearly grouped together.	<input type="checkbox"/>				
23	It is convenient to print the working diagnosis with each request.	<input type="checkbox"/>				
24	I prefer to write my request forms on the day the sample is to be taken	<input type="checkbox"/>				
25	I often order the same batch of tests for several days ahead.	<input type="checkbox"/>				
26	My priority with clinical details is that they should be easy to enter.	<input type="checkbox"/>				
27	A patient's clinical details change frequently.	<input type="checkbox"/>				
28	It is important to be able to order tests in advance of the date required.	<input type="checkbox"/>				
29	I want to be able to report different clinical details to different labs.	<input type="checkbox"/>				
30	Sometimes it is required that the sample collection time be stipulated.	<input type="checkbox"/>				