Chapter 6

Analysis of tasks - some illustrations

This chapter provides several illustrations of HTA to complement those already described. Examples have been selected to demonstrate analysis in a range of different task domains and to illustrate many of the elements of HTA. The tasks included are as follows.

- *Changing a cartridge in a printer or photocopier*
- *Operating a batch process plant*
- *Controlling a continuous process plant*
- *Air-traffic control*
- *Carrying out minimal access surgery*
- *Carrying out a customer service task*
- *Using a wordprocessor*
- *Carrying out mechanical maintenance*
- *Nursing*
- *Management*
- *Supervision*

Although the reader may select topics of interest, the examples are intended to provide a representative account of different applications of HTA. Where domains are not self-explanatory, a simple account of these domains is given. Note also that the examples given are mainly only extracts which have been selected to highlight distinctive features of the task.

Introduction

This chapter shows how HTA can be applied to different types of task. The examples discuss how and why the analysis was done, set out some of the significant aspects of the task analysis and indicate the key lessons to emerge from the analysis. The cases have been selected to demonstrate breadth of application and show how the same few principles of organising task information can be widely used. The detail of the task analyses serves to illustrate points made in the text and also to provide examples for people interested in specific domains. The tasks described are as follows.

Changing a cartridge in a printer or photocopier

This describes a straightforward procedure in which a series of actions and checks are linked together in order to replace toner cartridge in a laser printer. Procedures such as this are extremely common and occur in most task analyses.

Operating a batch process plant

Batch process plants manufacture materials by controlling physical and chemical changes to raw materials. Process control entails the operator making adjustments to process parameters in order to change processing conditions. A short explanation of process control is given.

Control tasks are extremely common and are encountered across a wide range of domains, including commercial and social contexts as well as industrial situations. Control tasks are often seen as associated with automated systems, but the concepts of control relate to any situation where the system under control has its own dynamics and may change even where the operator is not carrying out control actions. The operator's job is to study the system and decide what should be done to influence system behaviour.

Controlling a continuous process plant

Many systems rely on automation, leaving the operator to monitor the system, then intervene when things are not going to plan. Such tasks are seen in the supervision of automated transportation systems and in continuous process manufacturing plant. Skills entail monitoring and solving system problems. This example concerns supervision of a plant, of the type found in the petrochemical, food-processing and power industries.

Air-traffic control

There are several different air-traffic control tasks, those dealing with aircraft movement across air sectors and tasks concerned with takeoff and landing. The task described here deals with the activities involved in ensuring the safe movement of aircraft across an air sector. This example shows how different cognitive elements of a complex task interact.

Minimal access surgery

It is important to appreciate that the surgical skills involved in minimal access surgery are undertaken in the wider context of treating a patient. The surgeon must understand the patient's history and prognosis, since these can influence how the motor tasks are modified to suit the needs of the patient. This example is included to emphasise the importance of context in task analysis and to show how simple task elements become critical when understood in context.

A customer service task

Many tasks require operators to deal with the public over the telephone and use a computer database to order goods, manage accounts or provide other services. The presence of computers is sometimes given too much attention by analysts. The example will show how this type of activity must be understood in the context of the wider task.

Using a wordprocessor

The design and use of applications packages such as wordprocessors or spreadsheets poses some interesting challenges for task analysis. These computer programs are *tools* and their use needs to be understood in the context of the purpose to which they are being put. The example will show a strategy for understanding the use of this sort of computer tool.

Mechanical maintenance

Maintenance is critical to the successful performance of all systems. This example considers mechanical maintenance at a large industrial site. It deals with how individual maintenance *tasks* can be examined in the context of maintenance *jobs*.

Nursing in a hospital ward

Nursing involves a range of technical and interpersonal skills. Some activities are governed by the clock, while others are prompted according by events.

Management

Management is concerned with taking responsibility within an organisation to help meet an organisation's goals. The management task presented here is a general description of management duties, emphasising the importance of monitoring, planning and control in order to enable the system being managed to develop and function effectively.

Supervision

Where management may be concerned with setting up systems, supervision is concerned with making sure an existing system works properly. In many respects, supervisory tasks are like process control tasks. This example deals with a supervisory task relating to nursing on a hospital ward.

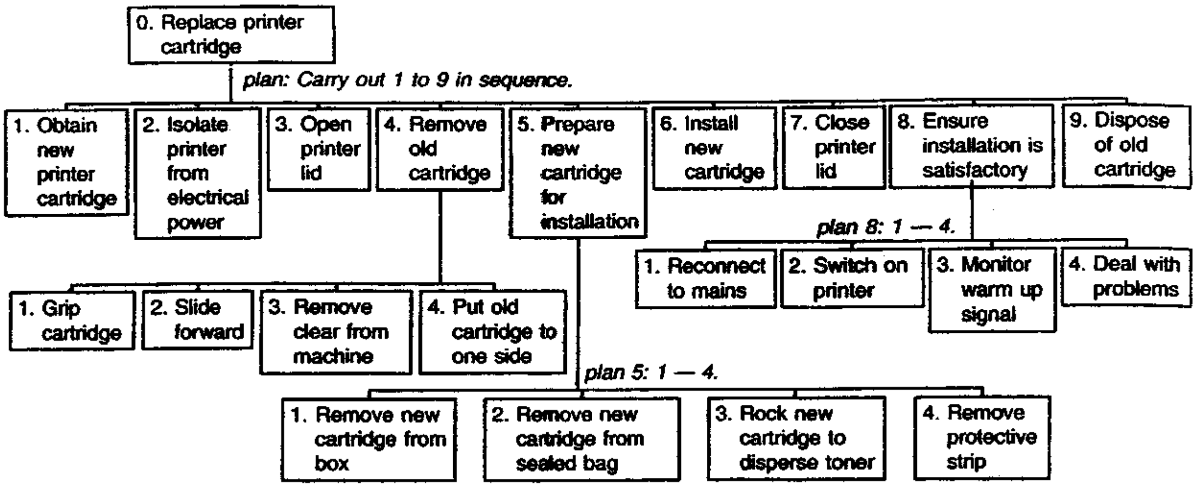

Figure 6.1 *Changing a cartridge in a laser printer.*

Changing a cartridge

Changing a cartridge in a laser printer or a photocopier is a relatively common office routine (see Figure 6.1). It entails doing things in a series of steps, usually in accordance with clearly written instructions, until the printer or photocopier is back into operation. It is similar in structure to many maintenance tasks and many assembly tasks. Sometimes the constituent steps require skill, but often this skill can be minimised by effective equipment design. The design of most printers means that inserting the cartridge the wrong way round is impossible; only when the cartridge is correctly inserted can the lid be closed and the printer switched on.. In this way, the operator gains rapid feedback concerning the success or otherwise of the action.

Process control

In situations such as changing a printer cartridge the operator physically manipulates objects in order to accomplish the task. Left alone, the printer and the cartridge would lie on the desk and do nothing. In contrast, there are many situations where the systems being controlled have their own dynamics, especially where automation is involved. In *process control tasks* it is the operator's job to manipulate controls to achieve a set of conditions in the system such that the system does the things that it is supposed to do.

The term process plant refers to industrial plant where operating conditions are adjusted in order that feedstock can be subjected to controlled physical conditions to enable certain physical processes to occur. For example, in the manufacture of dried milk, fresh milk is sprayed into a tower where it is subjected to heat which causes it to dry. The spray must be adjusted to ensure the particles are of a standard size and the temperature must be carefully controlled to ensure the correct rate of drying - too low would cause the particles to collect into a wet lump; too high would cause burning,

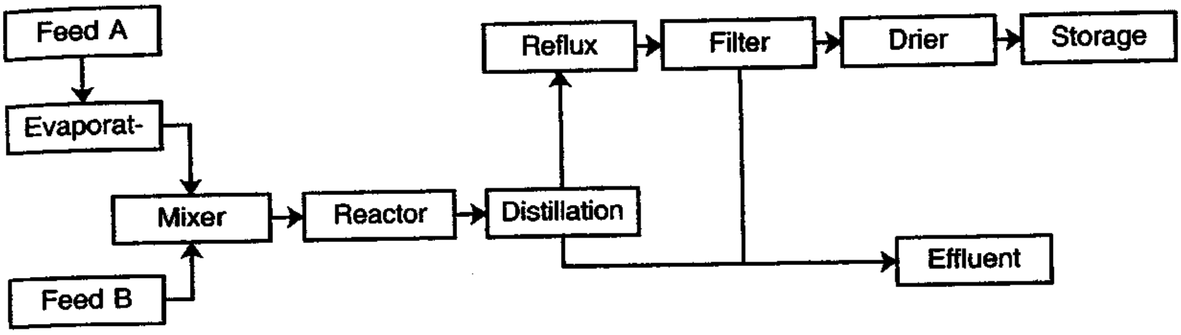

Figure 6.2 *A typical arrangement of processing units in a process plant.*

resulting in ruined batches and the risk of fire. Similarly, in the manufacture of antibiotics, raw materials must be kept at a suitable condition to enable microorganisms to grow. Process control is used in a variety of situations. As well as food-processing and pharmaceuticals, process control is prominent in the chemical, petrochemical, power generation and brewing industries. Principal characteristics are that the operator manipulates controls to change parameters and often depends upon instrumentation to make judgements - for reasons of safety, productivity and hygiene.

Process plants are made up from a number of different stages called *unit operations*. These stages may mix, heat, cool, distil, dry, filter, or store materials. Which of these unit operations are used for a particular process depends upon how the plant designer decides to process raw materials in order to obtain the desired product. Figure 6.2 shows a possible arrangement of unit operations. These are not necessarily separate vessels, but rather, separate stages in transforming raw materials to finished product.

There are two main types of manufacturing in the process industries - *batch* processing and *continuous* processing. *Batch* processing relies on a specified amount of raw materials being introduced as feed, then being moved through the unit operations step-by-step. For several steps the batch operator may not need physically to transfer materials between vessels. For other steps, the operator may be engaged in transfer between vessels - for example in pumping, conveying or even shovelling. An implication for the process operator is that attention moves from handling the introduction of the raw materials, through managing the evaporation, then managing the reaction, and so on. Depending on design, some plants require operators to engage in cycles of manual handling, then monitoring, then diagnosis, then laboratory analysis. Sometimes the operator is also required to start the next batch when the previous batch is clear from a vessel. Therefore, the operator is continually engaged with a number of contrasting tasks and must often learn how to time-share to maximise productivity. A further characteristic is that batch processing often requires the operators to work close to vessels and to product, even opening vessels to make inspection. These activities are often hazardous, so careful attention to safety and to correct procedures is crucial.

In *continuous* processes, raw materials are introduced into plant in a continuous stream with a view to maintaining a continuous output of product. Petroleum refineries are continuous processes because there is a continuous consumption of petroleum products throughout the world. Continued sales are virtually guaranteed, so continuous production is essential to maintain stocks. The same applies to power generation. Gas and electricity are in constant demand, so a continuous feed of raw material is maintained to achieve a continuous output for the national grids. This continuous demand prompts continuous processing. A continuous plant is arranged so that all unit operations are being maintained at the same time. This means that during full production, temperatures, pressures, levels and flows, as well as other critical parameters, are maintained so that the materials flowing through are always subject to the correct conditions to enable processing to take place.

The plant represented in Figure 6.2 could be a batch plant where each batch of new raw material is subjected to each unit in turn. Alternatively, it could be a continuous process where all units are operating simultaneously, with product flowing through continually. The continuous process plant operator is subject to different pressures to the batch plant operator. To maintain conditions in a continuous process plant, most aspects of the control system are automated. Moreover, to maximise profit, plants are large. It means that the operator's job is mainly to supervise a large, often hazardous, automated system. While the batch plant operator is often busy, the continuous plant operator may be subject to periods when little of concern is happening - because the automatic control system is doing its job. Nonetheless, the continuous process plant operator must continually monitor plant conditions to ensure that they are within acceptable tolerances to ensure safety and productivity. Then, if something does happen to cause a disturbance, the operator must respond quickly to work out what to do to make the system safe, then manage its recovery to full production again. Despite the fact that these plants can be distinguished according to their production patterns, there are many overlaps in skills. Continuous process plant operators are often engaged in managing procedures, especially when plants are starting up and shutting down. Equally, batch plant operators are often engaged in periods when they must maintain the batch at a steady state, to enable a reaction to take place.[28] The case of the batch plant operator will be dealt with first.

Task analysis of a batch operation

While the analysis of a batch process control task is guided to some extent by the steps that are followed in the process, this is not where analysis should start. Figure 6.3 shows the top level of the analysis of a typical batch process control task. This reflects the overall cycle of the job that people have to do. Operations 1 and 8 are handover operations concerned with the need to maintain continuity from shift to shift. Operation 3 is concerned with making sure opportunities are taken to get the next batch underway without delay. Operations 6 and 7 are concerned with unscheduled events that occur during production. Operation 4 (maintain production) focus specifically on the unit operations to be dealt with to process the batch. It is important to capture this overall level of any analysis, because it identifies skills concerned with managing the job and not simply the manufacturing process.

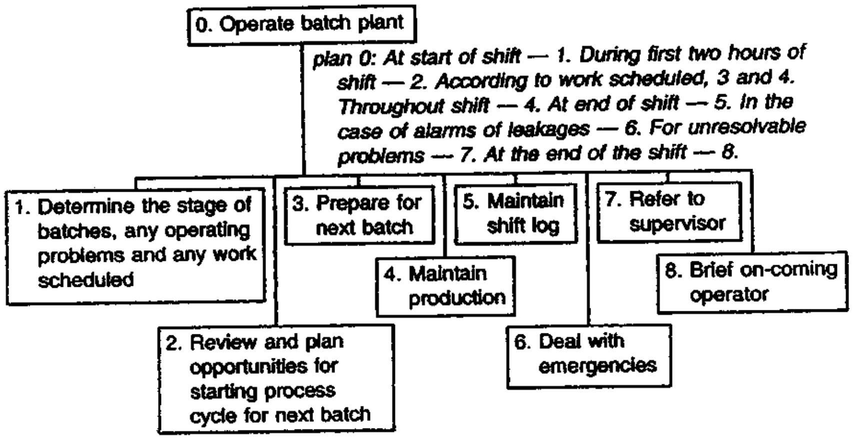

Figure 6.3 The top level of an HTA for a batch plant operation.

Turning to the main processing steps of the batch, these emerge from the analysis of operation 4 and are shown in Figure 6.4. Goals 2 to 11 in Figure 6.4 reflect the stages in chemical processing, but since this is shift-work, and since more than one batch may be involved, it is inappropriate to start at the beginning and work through. Therefore, the plan requires the operator to monitor conditions throughout to see what to do next. The cue to the next action is contained within the plant procedures, often called 'Manufacturing Instructions' - which we will return to in Chapter 11. Thus, the operator must, through monitoring, be aware of what steps are required next and be alert to the conditions - time and batch progress - when these steps should be carried out. Each of these steps in batch production are developed further. Operation 6 in Figure 6.4 illustrates

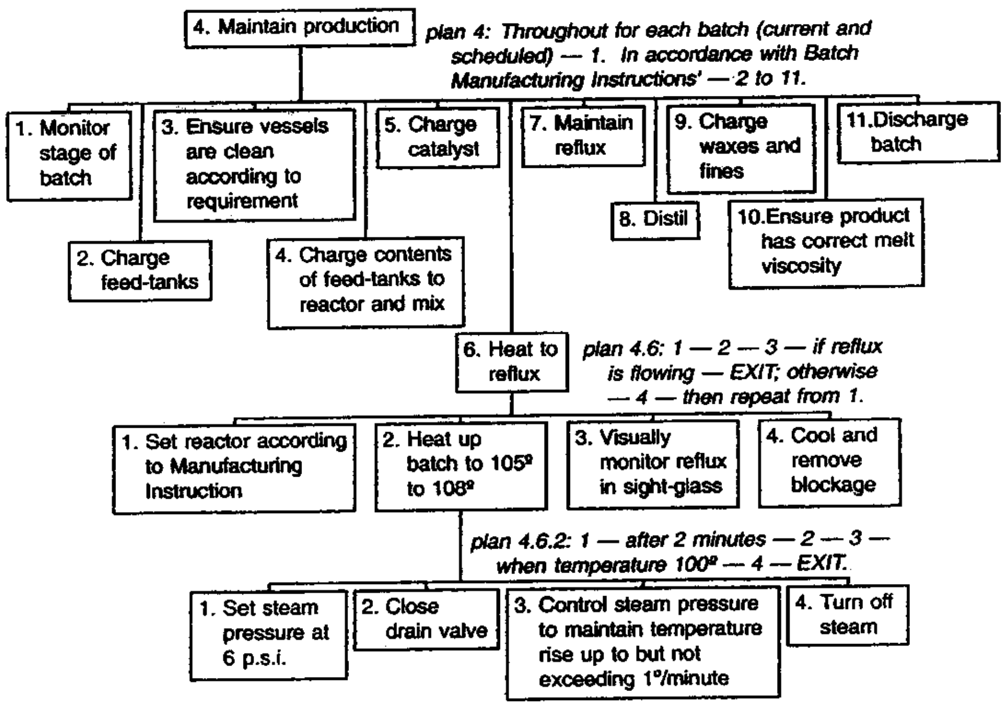

Figure 6.4 The manufacturing phase of the batch plant task analysis.

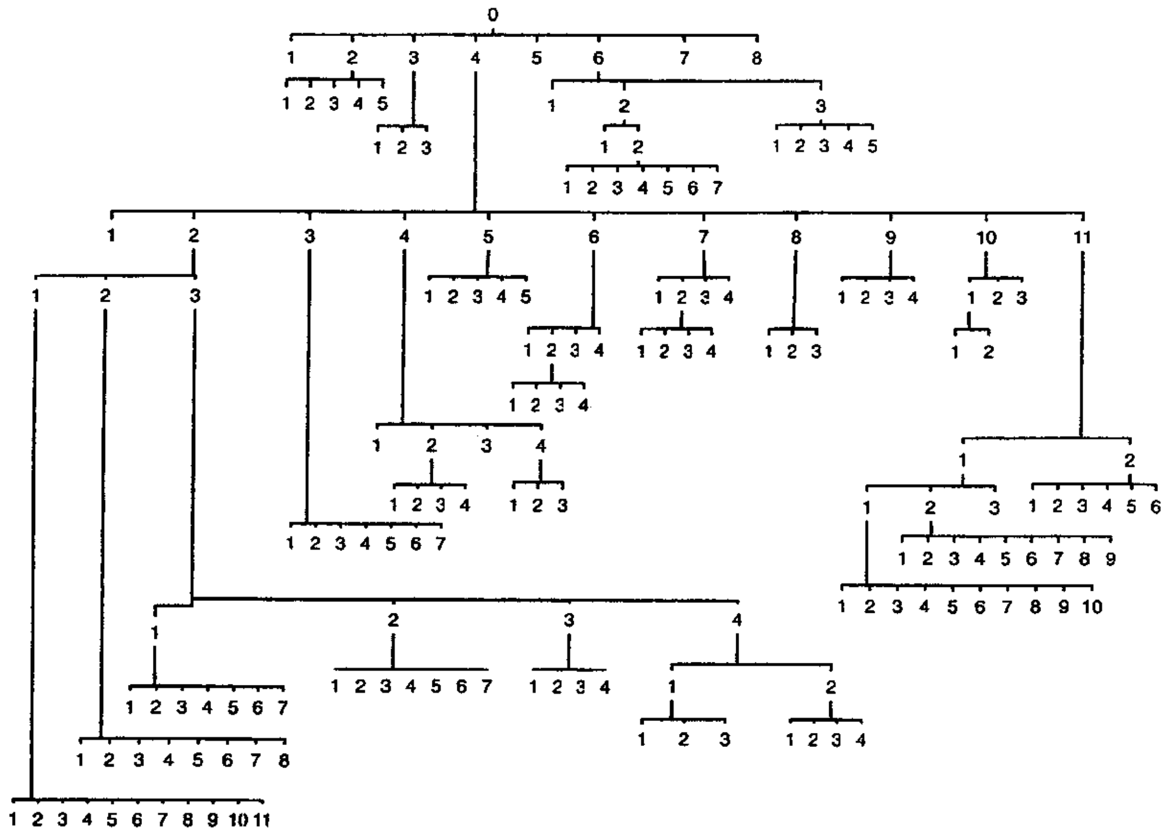

Figure 6.5 *This extent of the HTA developed for the batch processing task.*

how one of these steps - heat to reflux - is carried out. Typically, this involves monitoring information, making judgements and carrying out actions. The plans contain contingent sequences and cycles, typical of this type of work.

It is impossible to present the whole of this task analysis here. However, Figure 6.5 shows the extent of the full HTA that was developed for this project. It represents the hierarchy of goals but not the plans. This is by no means a large analysis, although it may look complicated and daunting. Conducting an analysis of this magnitude requires care and attention, but it is not necessarily difficult. The extracts from this analysis (in Figures 6.3 and 6.4) show that each redescription is reasonably straightforward. The complexity emerges by combining many of these straightforward plans. The *size* of the analysis is dictated by the requirements of the task. The rules and methods of HTA mean that this kind of complexity can be handled with relative ease, provided an appropriate method of recording task analysis is used (see Chapter 5).

By making reference to 'manufacturing instructions (MIs)' in plans, the task can more easily be adapted to enable the operator to deal with other products by using different MIs. Thus, a common set of skills and procedures are adapted in order to produce different products.

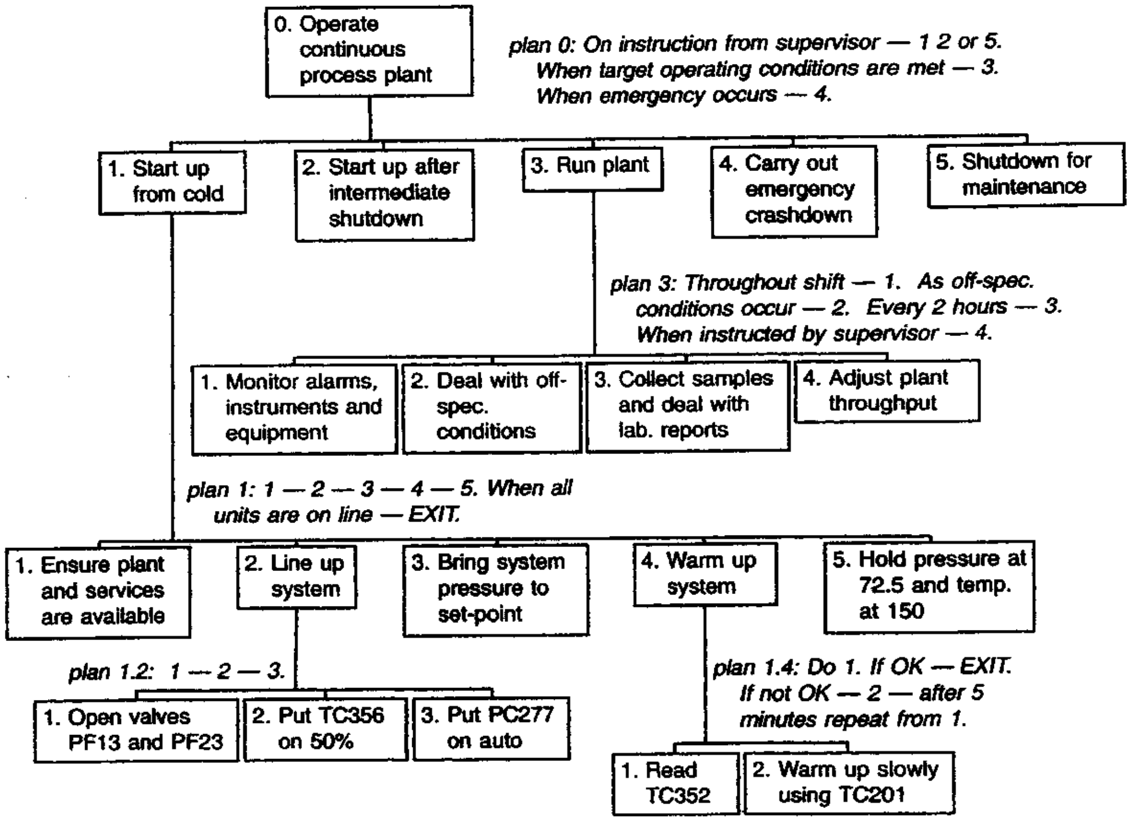

Figure 6.6 *Extracts from an HTA of a typical continuous process control task.*

Task analysis of a continuous process control task

Whereas batch processing requires operators to engage in changing conditions throughout production, continuous processes need far less intervention if they are working properly. Industries such as oil refining or power generation rely on large complex automated plants. As described above, the plant represented in the block diagram in Figure 6.2 could be a continuous process plant in which the operator would try to maintain appropriate operating conditions in each of the vessels at the same time.

Figure 6.6 shows extracts from the HTA of a continuous process control task. The first redescription contains subgoals concerned with starting up the plant, running the plant and shutting the plant down. Note, this analysis represents the control task and not the job the operator is employed to do. To look at a continuous process plant operator's job would entail a top level such as that in Figure 6.3, because, as in all process industries, staff hand over responsibilities to other staff when a shift has finished in order to maintain the ongoing process.

Depending on the system, there could be 'start-up from cold and empty' and 'start-up from an intermediate state'. Following a problem, the plant might be held in an intermediate state while maintenance is carried out. When target operating conditions are to be recovered, the vessels may be still warm and partially full. Therefore, the strategy for recovering from different intermediate states may vary. 'Start-up from cold' may entail a long, invariant, contingent procedure, whereas starting up from an intermediate state may entail more ingenuity and planning on the part of the operator. Often, 'start-up' is best seen in terms of the operator attaining intermediate states, rather than simply treating the procedure as a set of actions. So, plan 1 may be treated as an invariant procedure because it shows that important intermediate states of the system must be achieved in order. However, problems may occur during each of these stages that the operator must deal with before moving on - recall the analysis of the distillation training in Figure 3.8. In this way, the operator might be engaged in a diagnostic and recovery procedure that we would normally anticipate during plant running (operation 3.2 in Figure 6.6 and further expanded in Figure 6.7).

Equally shutdown could be an emergency shutdown or it could be controlled. If a problem arose which needed dealing with instantly in order to avert a crisis, then most systems have an automatic procedure, which quickly moves the system to a safe state. However, starting again from these safe states may be time consuming. If the operator was able to control the shutdown, it may be possible to restart the plant in a more efficient way. Emergency shutdowns need to be as prescribed as possible in order quickly to achieve a safe state. Controlled shutdowns may need the operator to carry out more planning. Thus, emergency shutdowns may warrant frequent routine drills and possibly the use of job-aids, whereas, to ensure that controlled shutdowns are conducted safely and efficiently will require planning skills that may need to be practised in a simulator. Through the task analysis process, the client can indicate which modes of shutdown are required. These will have different requirements for supporting performance, so it is important that they are understood by the analyst.

When target operating conditions have been achieved following start-up, the operator can be said to be in the plant running phase - operation 3 in Figure 6.6. Running a plant entails a number of routine operations, such as collecting samples. There can be operations concerned with changing operating conditions to make product to a different specification. These may be achieved by following standard procedures or they may entail planning and decision-making. Monitoring behaviour, as in operation 3.1 in Figure 6.6, entails paying proper attention, especially to those things currently of concern. Many of these systems will be alarmed - flashing lights or auditory alarms will signal that the plant has gone off specification. In many cases, however, there is still reliance on the conscientious operator keeping an eye on progress to detect when conditions are

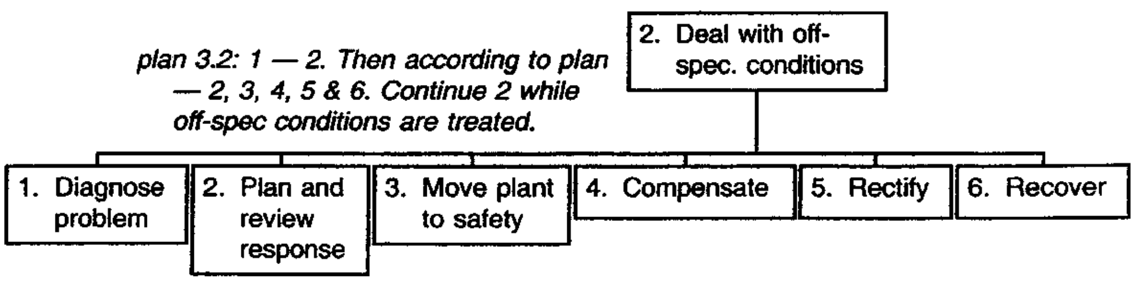

Figure 6.7 Redescription of dealing with off-specification conditions in a continuous process control task.

not as they should be. If a parameter is outside of specification, the operator should first decide whether this is of real concern or whether it could be a temporary situation that will correct itself. If, following this examination, there is cause for concern, the operator must deal with off-specification conditions.

Figure 6.7 shows how dealing with off-specification conditions might be analysed. Depending on the technology and the risk, the operator might be given more or less discretion. In some situations the operator would be required to diagnose and plan a response by reading an operating instruction. In other situations, the operator might be expected to reason and devise the optimal way of dealing with the problem. Elsewhere, the operator might be required to refer the problem to a more qualified colleague. Some situations enable the operator to compensate for the problem to optimise production while the main problem is resolved. In other situations, the operator must move to a safe state before doing anything else. The operator will be required, at some stage, to rectify the situation, either directly or by recruiting the support of maintenance staff. When the plant is fully operational again, the operator must manage the recovery of the process.

It is important to note, with respect to Figure 6.7, that the HTA has set out what people should do and not described how people actually do these things - that is, it is their responsibility to diagnose and plan responses, move the plant to safety, compensate for disturbances, etc. Some of these operations can be examined further using HTA, but if the operator is required to use expertise to devise novel solutions to unforeseen problems then the analyst might use other approaches to explore this behaviour further. As discussed in Chapter 4, this might entail undertaking a *cognitive task analysis*, although often such detail is unnecessary. For example, people can master skills such as diagnosis and planning, by being provided with scenarios in which they must diagnose and plan. To provide such training, simple scenarios can be initially chosen for practise using an appropriate form of simulation to enable the trainee to apply the skills and knowledge which they have been taught. Then the scenarios chosen for practise can be made more difficult. Training can continue until the trainee is performing satisfactorily.

Air-traffic control

The term *process control* is usually applied to manufacturing systems, but many of the same considerations apply in other contexts where the operator is employed to ensure that a system with its own dynamics performs according to expectation or requirement. The *Air-traffic controller's task* is to ensure that aircraft proceed through airspace in a safe manner. For most flights, flight plans are prepared which then generate information that can be used by the air-traffic controller to anticipate when aircraft are due into the air sector they are controlling, from where they are coming and where they are planning to go. This information will also indicate destination and preferred flight path. The air-traffic controller's task is to judge whether conflicts may occur between the flight paths of individual aircraft and then take steps to resolve these conflicts by requiring aircraft to climb or descend to different levels. (This is an oversimplification, because there are

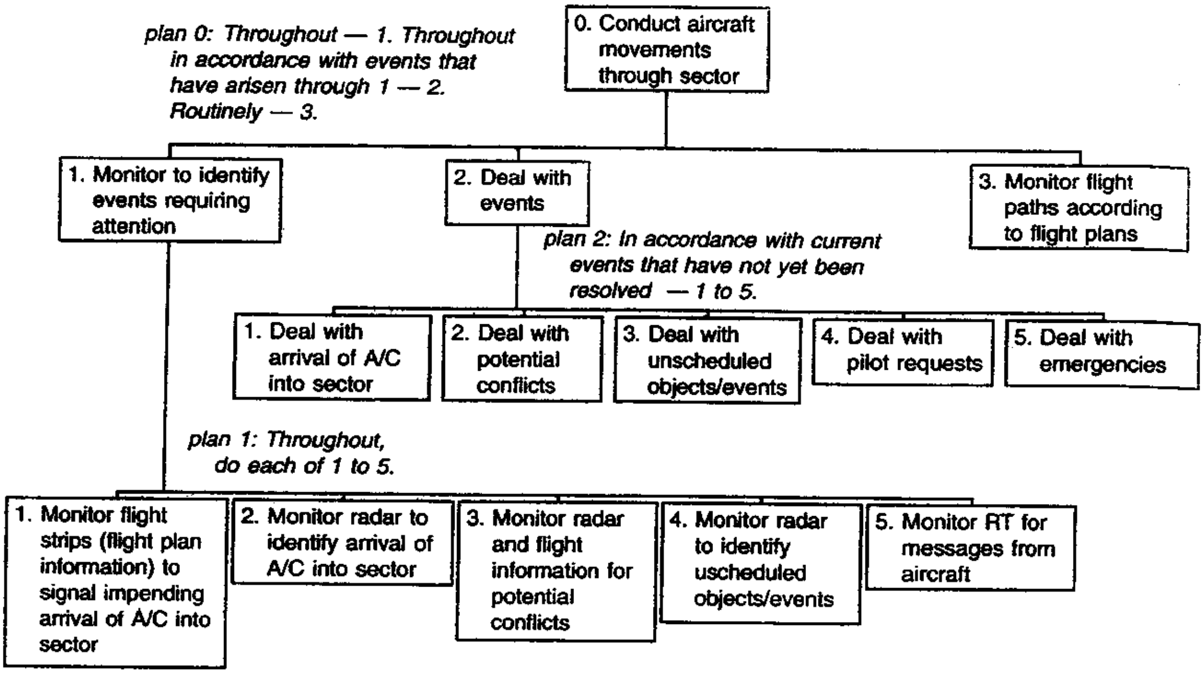

Figure 6.8 *The air-traffic control task.*

many factors that need to be considered and there are many variants on this basic task - but the features described here are characteristic.)[29]

A full analysis of these tasks reveals a range of procedures that must be followed, terminology that must be used, knowledge that controllers need in order to make decisions and skills they need to plan and make adjustments to flight plans. The extract shown in Figure 6.8 is only part of the overall job cycle. Air-traffic controllers work in short sessions of about one hour to an hour and a half. These periods are limited to prevent controllers becoming fatigued as a result of the intense monitoring required. Each time they assume responsibility for the task they must adapt to the previous controller's strategy. Then they must hand over to a colleague when their session is complete. Figure 6.8 shows general goals of 'monitoring to identify events requiring attention', 'dealing with these events' and 'monitoring flight paths according to flight plans'. Even with this small part of the task analysis, a number of implications can be drawn. First of all, there are two sorts of monitoring. One sort (operation 1) is concerned with detection - the controller must identify, as quickly as possible, when certain events arise. The other sort (operation 3) is concerned with maintaining conditions - the controller must keep an eye on each aircraft to determine whether it is operating as expected and deal with any variations. A second main implication is that, according to the plan, the operator must do 1 continually (which really means, as frequently as possible), whereas operation 2 is only required as events arise that need to be dealt with. Operation 3, concerned with maintaining the aircraft on its route, is done intermittently, but reasonably frequently to ensure that the aircraft is where it is supposed to be. When we consider the manner in which events can arise, it is clear that the operator is subject to substantial workload whenever several events occur together.

Moreover, while attention is directed towards dealing with these events, the controller still needs to monitor the system to detect other events that may require attention and to ensure that each aircraft in the sector is making satisfactory progress. The separate decisions and procedures of the Air-traffic controller's task each require considerable skill in their own right, but perhaps the most significant aspect of this sort of work is that the controller may need to deal with many such events at the same time according to what happens during a session.

This task is clearly heavily cognitive. It is concerned primarily with perception, monitoring detection, planning and other sorts of decision-making. But it does not immediately follow that we need to go to great lengths in understanding this cognition. Operation 1 is concerned with different sorts of monitoring. While these things are all done 'throughout' according to the plan, the experienced controller will do each as necessary in accordance with patterns of expectation. For example, operation 1.1 (Monitor radar to identify arrival of A/C into sector) will start to be done when the controller has already seen, from operation 1.1, that a new aircraft is expected arrive shortly. Equally, the experienced controller will focus on potential conflicts (operation 1.3) more closely on some routes and at certain times of the day than other.

Minimal Access Surgery (MAS)

While changing a cartridge is a relatively straightforward task which most people, given written instructions could undertake, minimal access or keyhole surgery is clearly something carried out by people with special expertise. It embodies many of the properties of a procedure - a distinct start and end point, with intervening goals that are carried out in sequence, even though there is great flexibility with regard to how these goals themselves are carried out. Minimal access surgery entails a set of techniques that are applied to a wide range of operations. If we simply think in terms of how minimal access surgery is different to other forms of surgery and focus on the manipulation of instruments during the operation, we may miss some key factors.

In a task analysis like this, it is important to step back to appreciate the wider task context, because keyhole surgery is just part of a wider pattern of treatment that a patient will receive. The patient first presents symptoms to the medical system. Before keyhole surgery is undertaken, a doctor will assess the patient in order to consider which treatments, if any, are to follow. Considerations at this stage entail clinical judgements and also judgements about prognosis and the consequences of different outcomes for the patient. These considerations can affect which courses of treatment will be followed and will also affect how different stages in the treatment will be executed. In the case of dealing with ectopic pregnancies, for example, knowledge of the history and circumstances of the pregnant woman is important. For example, if it is known that the patient has no children, then different decisions might be made during surgery where a pregnancy had not been planned and where the mother had already expressed anxiety about a further birth. These issues are concerned with surgeons identifying and weighing risks. Equally, knowledge of prior operations on a knee and

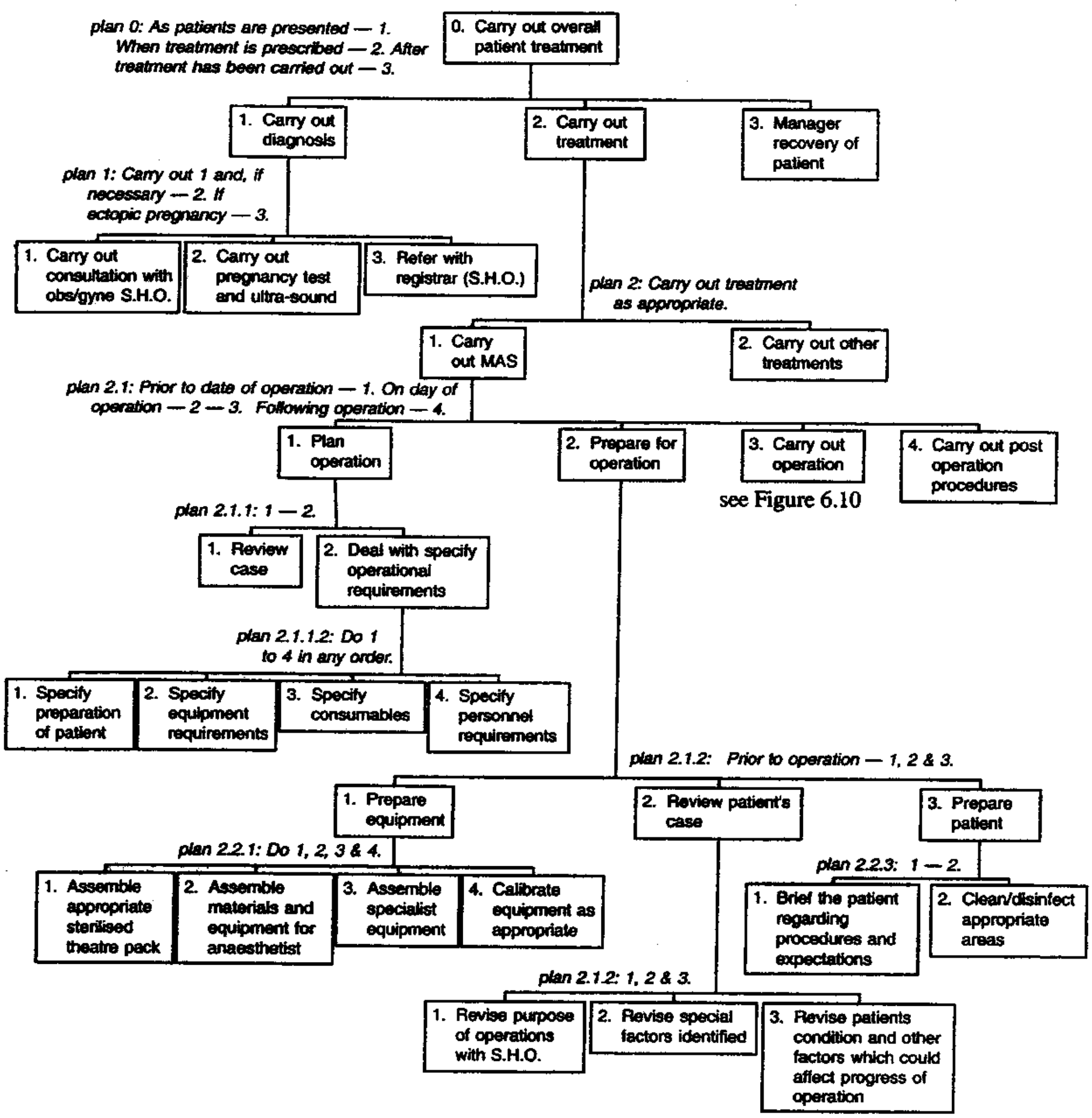

Figure 6.9 *The minimal access surgery task.*

knowledge of whether the person plays sport requiring certain kinds of movement, can affect decisions taken as an operation progresses. As the operation progresses, the surgeon makes judgements about the state of tissue being observed during the operation and must vary strategy and in some cases modify the purpose of the operation. Damage to a knee might be seen as more drastic than had been anticipated and so the operation may be modified or aborted. In the same way, knowledge of how an operation has progressed can influence the decisions that the consultant will subsequently make in making recommendations for courses of remedial therapy, carried out by a physiotherapist, for example.

from Figure 6.9

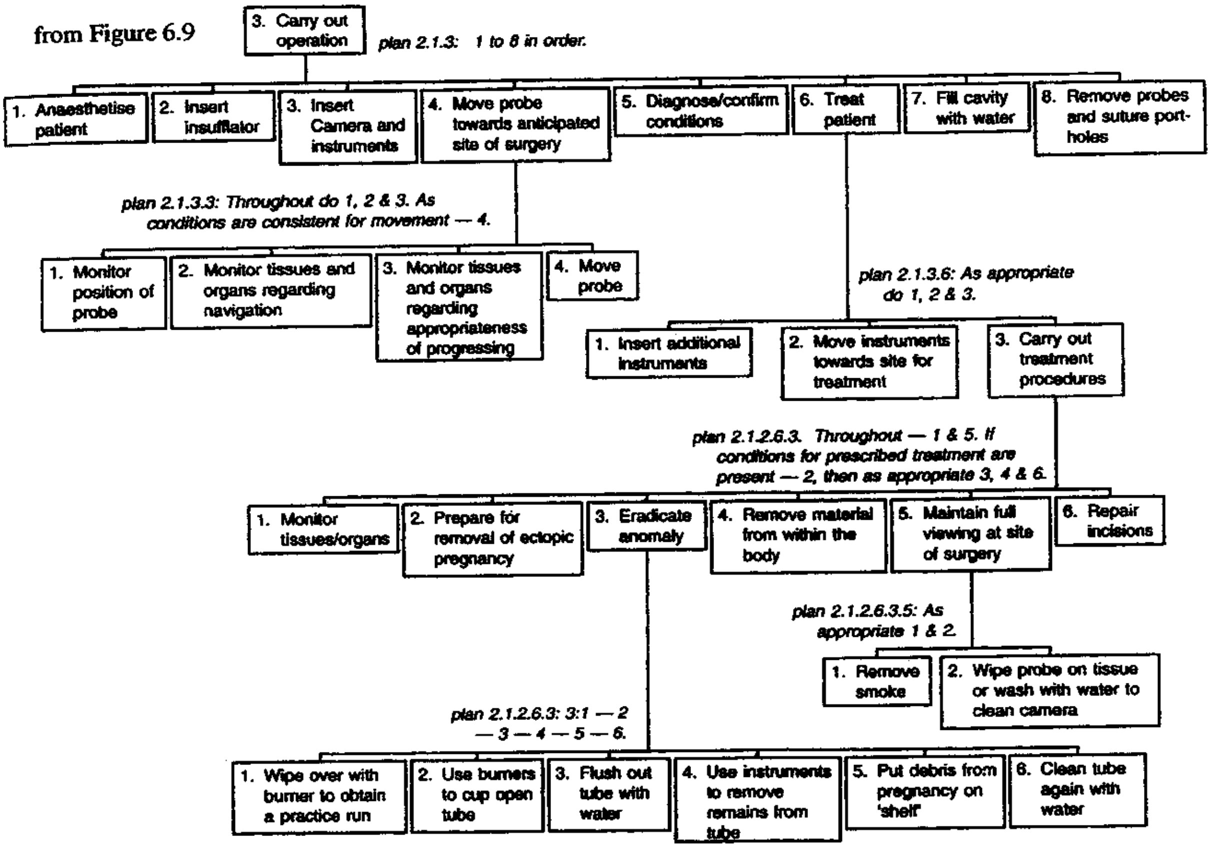

Figure 6.10 Detail from the minimal access surgery task dealing with a number of psychomotor skills.

With these wider considerations, it is clear that the surgeon's skills and decision-making are influenced by what went before and what might follow. If these things are not understood by the analyst, their influence on the decisions taken during surgery cannot be taken into consideration. Thus, the HTA of the keyhole surgery task most usefully begins by considering the full cycle of treatment, as shown in Figure 6.9. This describes a series of stages commencing from where the patient is first presented to the surgeon for examination right through to where the surgeon specifies a pattern of recuperation. Within this description, operation 3 deals with the specific task of keyhole surgery. This part is expanded in Figure 6.10 which describes the surgery involved in dealing with an ectopic pregnancy.

Minimal access surgery can be applied to a number of operations which follow similar patterns using common techniques, but which vary in detail. For example, operations on internal organs require some different procedures to operations on limbs, because the cavities within which the surgeon works have different physical characteristics and require different techniques to enable movement of instruments. If an analyst was required to consider keyhole surgery in general, this is best done by first focusing on a specific type of surgery, then, when that analysis is complete, the next type is considered. The analyst will now find that several parts of the task are common

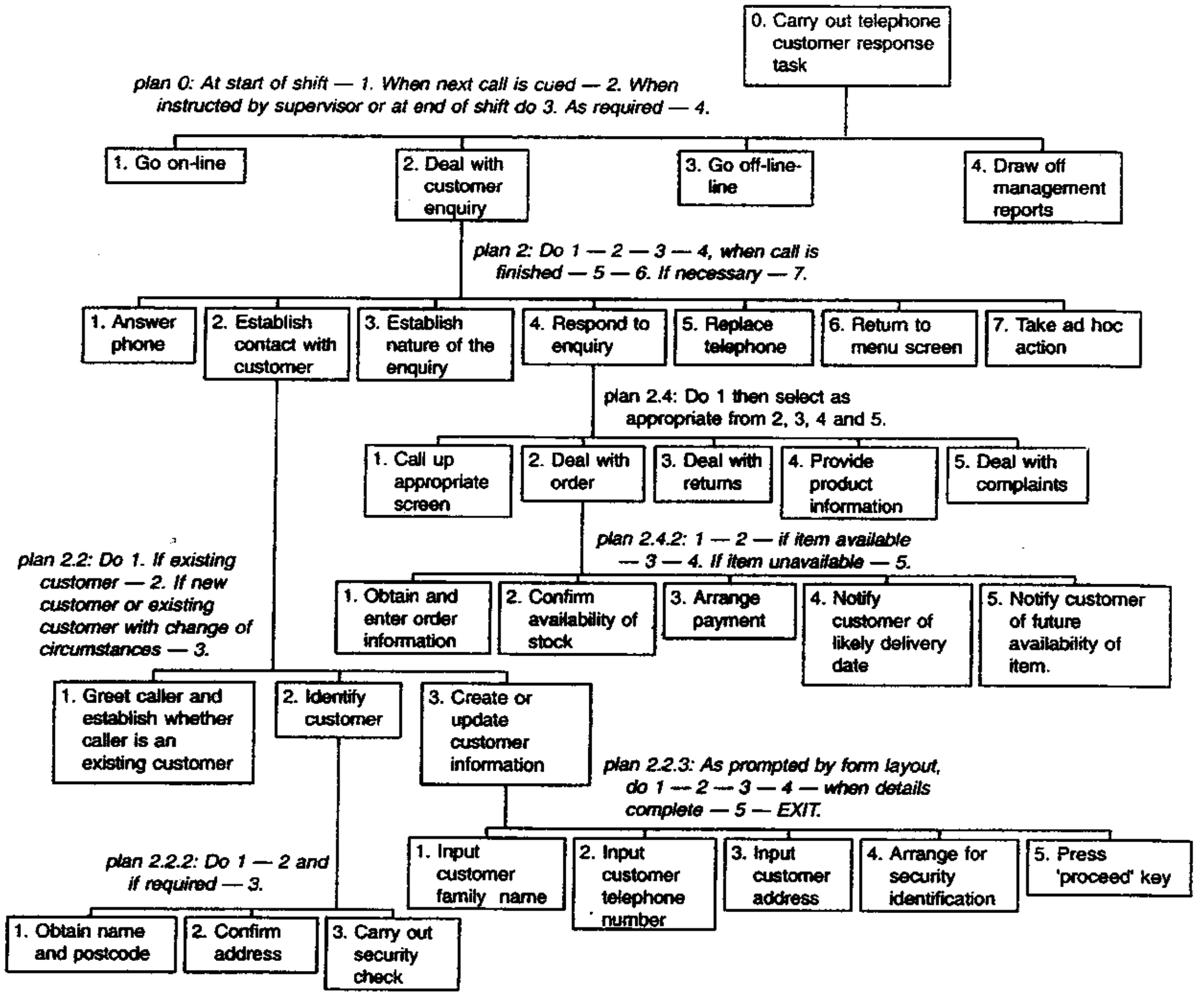

Figure 6.11 A telephone customer service task.

to the earlier example; only those parts that are different need to be considered. Then another type of surgery will yield fewer 'new' aspects. Soon, a number of different sorts of operation will be understood by reference to a common model in which many aspects of the tasks require similar skills.

A customer service task

Appropriate use of computers is critical to the success of many organisations. Increasingly, organisations make contact with their customers over the telephone and use telesales operators to identify customer needs and help fulfil these needs by interacting with the organisation's computer. Similar tasks exist in the services industries, such as providing gas and electricity services to domestic customers. There is nothing particularly special about tasks involving computers, indeed, they are often more straightforward than most because computer interfaces are often reasonably well designed and have been specifically tailored to the user's needs. A good interface will prompt the user concerning actions that will achieve the user's goals. This minimises the need to learn complicated sequences of action, hence, training is minimised. Should the user press the wrong key, an 'undo' function will often return the computer to its previous state, so any error should be easy to detect and rectify. Where technology and the task prevent the designer from developing a good interface, the task will be more difficult and more training will be required to overcome these difficulties.

The telephone customer service task in Figure 6.11 shows a sequence of activity commencing with the procedures of switching on equipment at the start of shift and finishing with the task of drawing off management reports. Operation 2 focuses on dealing with customer enquiries. This is a sequence of activity that is repeated each time the phone rings. A crucial early action is to identify the caller. This may entail obtaining the customer's name and postcode or a customer identification number. Sometimes the telephone system aids this identification process by automatically identifying the caller's location. Generally, as indentifiers are entered into the computer, further details of the customer will appear, prompting the operator to request confirmation. Different calls warrant different responses and these are reflected in goal 2.4.

The significant feature of this task analysis is that it examines the *whole* task, of which the computer interaction is only one part. The operator is the interface between the customer and the organisation; the operator's task is to represent the customer to the organisation and the organisation to the customer. The flexibility that a human operator can bring is often essential because customers may be unclear about what they require. Good interface and task design is especially important, therefore, because operators need to focus on the customer's needs and not allow dealing with the computer interface to interrupt this discourse.

Using a wordprocessor

Wordprocessors, spreadsheets and design program's, for example, are computer applications which present the user with a set of *functions* which enable them to carry out certain tasks. Such programs are *tools*, in the same way that a hammer or an egg-whisk is a tool. Used appropriately, they provide considerable assistance to the user. Unused, they lay dormant. We cannot carry out a task analysis of a wordprocessor, but we can analyse tasks in which wordprocessors are used. This can provide useful insight about the nature of the program itself. An analyst might wish to undertake the task analysis of a wordprocessing package to evaluate the interface, compare how two or more wordprocessors are similar or different, develop a user support document or help prescribe training. A first consideration is that, while there are many generic skills in wordprocessing, different programs work in different ways. Therefore, any task analysis should focus on a specific program, even though the results of several might then be compared to identify core skills in order to provide elements of a wordprocessing course, for example.

The strategy for examining the use of the wordprocessor using HTA is to devise a series of tasks which, taken together, will account for the range of functions of interest.

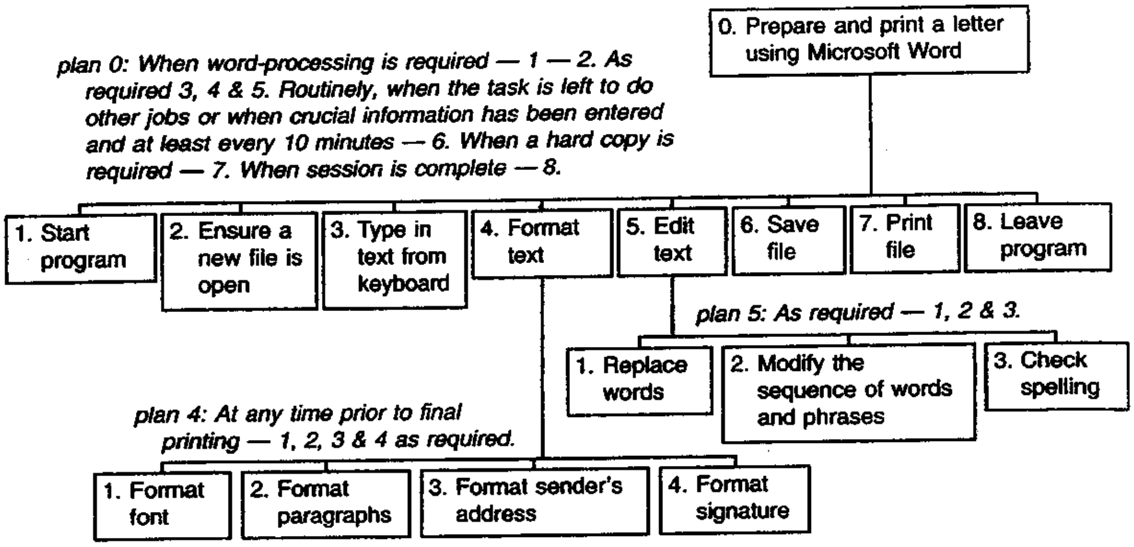

Figure 6.12 Preparing and printing a letter in a wordprocessor.

For example, by choosing something straightforward, such as 'writing a letter', the analyst will encounter the basic processes of starting and quitting the program, entering text, simple formatting and printing. Following this, the analyst can consider something more complex, such as 'writing a short report', which will involve continuing to practise existing skills plus adding new ones, such as, numbering pages and creating contents pages.

Figure 6.12 shows part of the analysis of the task of preparing and printing a letter using Microsoft Word™. This is the higher level of description of the task of writing a letter. It covers the main activities. Many plans refer to the user's choices, because that

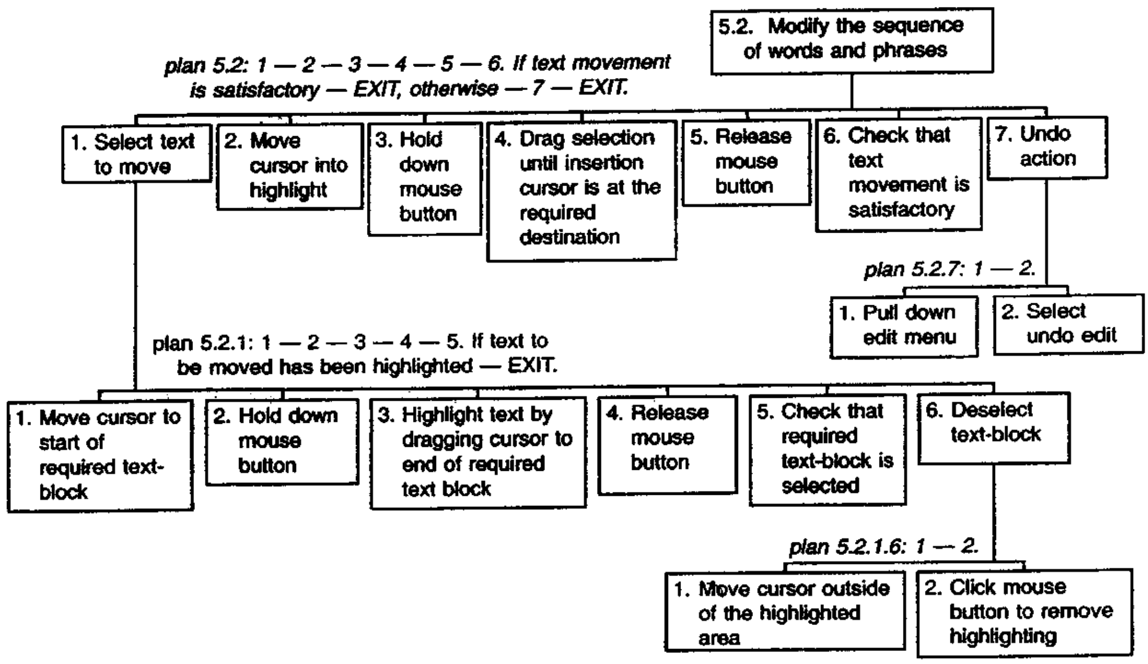

Figure 6.13 Modifying the order of words in the text.

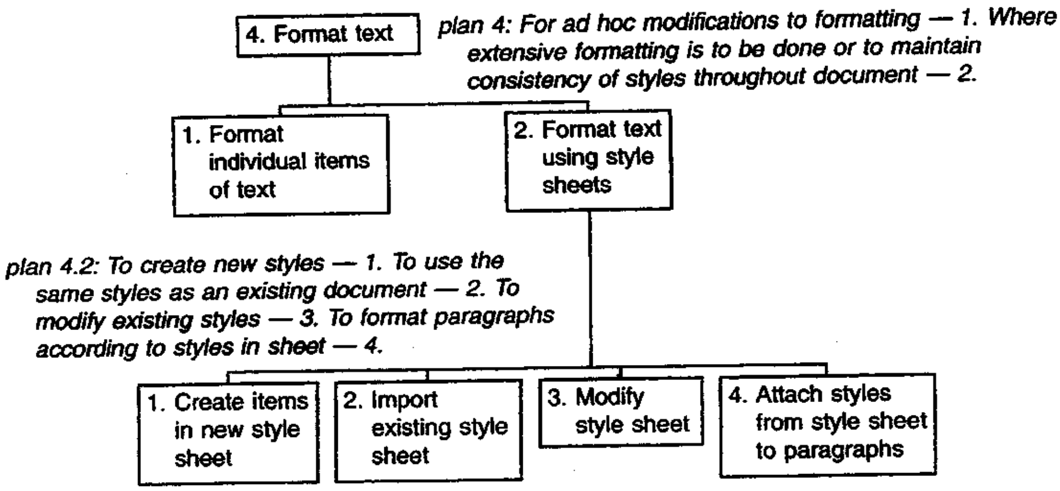

Figure 6.14 Ways of developing text formatting.

is what using a tool requires. Writing a letter relies on the user knowing how to compose a letter and what the content and length of the letter will be.

Figure 6.13 considers one of the subordinate goals that might be developed further. This example is concerned with modifying the order of words and phrases in order to rephrase text and make corrections. Here, the analysis can continue until operations are expressed as actions within the wordprocessor. It is noticeable that this level of detail starts to reveal common routines that are applied throughout the use of the program, for example, how to undo an unwanted action (operation 5.2.7) is revealed. Equally, procedures for highlighting, used here for moving text blocks (operation 5.2.1) are the same as when blocks of text are to be reformatted. These are procedures that can be picked up later on, saving time for the analyst.

Further tasks can be analysed that encompass additional functions of the wordprocessor. These further analyses can be used to modify the earlier versions. Thus, Figure 6.14 shows how more advanced wordprocessing skills can be incorporated. These functions will vary between products, although many such features are shared. An example is the use of style sheets for text formatting. Using a style sheet entails generating standard properties for blocks of text, then applying these as needed. For example, a user might decide that where a quotation is included in a document it will always be presented in italics, inset by 1 cm and with extra space above and below. In this way, a single style called 'quote' is created and can then be applied easily and consistently throughout the document. Moreover, if the user then decides that the format of quotations does not look very good after all and prefers, instead, that they are underlined and indented by 2 cm, then the 'quote' style can be edited. This will result in all blocks of text to which the 'quote' style is attached changing to the new format. To extend the HTA in this way the analyst needs to find out what these advanced variations might be and then look for text editing tasks where they are used. As the process develops, further wordprocessing concepts that the user needs are identified.

The plans that emerge from such analyses of computer applications packages generally conform to procedures or choices. *Procedures* are the steps that the user must follow to achieve a required outcome. So these are things that must be learned, or prompted by effective interface design or followed in a manual. *Choices* are usually reflections of the user's preferences - what material to enter, how to present it, etc.

Depending on the analyst's purpose, the HTA can progress in different ways to reveal different things. The analyst might choose to examine all procedures in detail to determine whether the design of methods are consistent or economical throughout the program. If the purpose of the analysis is to support training or the development of a user guide, then examination of plans will reveal where choices are made. This will point to the concepts the user will need in order to make these choices.

Mechanical maintenance

The principal purpose of *maintenance* is to ensure that systems are kept in a suitable state to ensure that they can be operated to fulfil the purpose for which they were

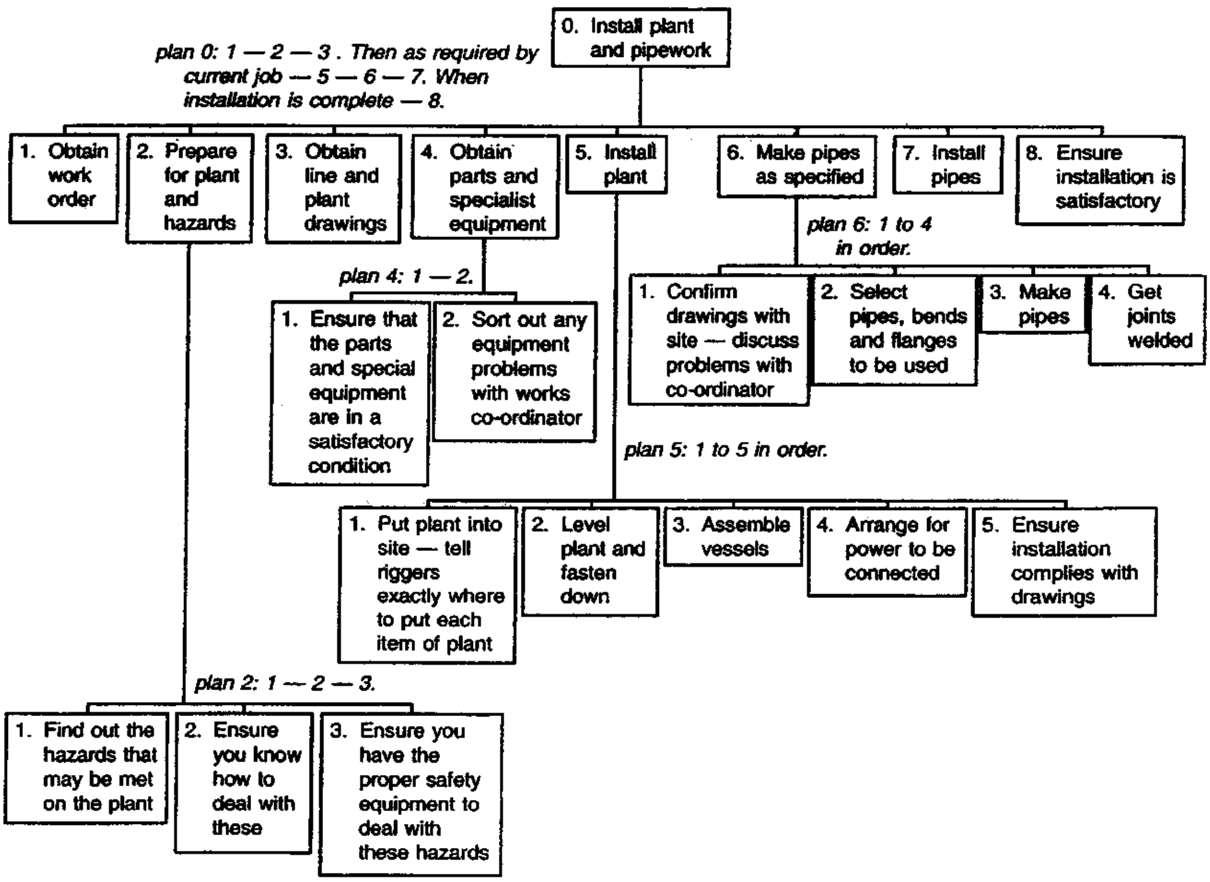

Figure 6.15 Installing plant and pipework — illustration of a typical mechanical maintenance task.

designed. Thus maintenance might be concerned with *preventing* problems or quickly *dealing* with them when they arise. When we encounter maintenance tasks in industry we see a mixture of activities which can involve the installation of new or replacement equipment, diagnosis and repair of equipment *in situ* due to some failure of the overall system, or removal of equipment and subsequent maintenance and repair in a workshop. Changing the cartridge in a printer or photocopier is a maintenance task, because it is designed to ensure that a piece of equipment again performs to the required standard. Equally, the ultrasonic testing task and the systems engineering tasks, described in Chapter 4 were types of maintenance task.

Mechanical maintenance tasks, such as repairing items of equipment, are parts of maintenance jobs and operate within maintenance systems. One difficulty in analysing maintenance tasks is capturing the way in which the same sorts of procedures must be applied to many different pieces of equipment. The analyst's problem is to work out how these variations can be accommodated sensibly within the single analysis. We have already seen two instances of how this can be done using HTA. In the case of minimal access surgery, the analyst first focused on a single surgical operation, then considered a second surgical operation to establish how the second differed. This process lead to recognising where tasks are similar and different - the general engagement with the patient was similar across surgical operations, but the detail of certain tasks varied between operations. Similarly, in the case of the wordprocessor analysis, focus upon the simple task of writing a letter revealed a general task structure that could be applied to more complex tasks. The same strategy is applied when considering the analysis of a multi-batch process plant used to manufacture products to different specifications using the same equipment.

To examine tasks such as maintenance it is helpful to focus first on a single task activity. Figure 6.15 shows the task analysis that emerged from considering one common maintenance activity, namely, installing plant and pipework[30]. The task analysis shows how the maintenance fitter must first obtain the relevant paperwork, must become familiar with safety issues, must obtain tools and equipment and must then carry out various craft tasks to install the equipment - indeed, mechanical maintenance is not simply confined to exercising mechanical craft skills.

There are two ways in which this HTA needs to be extended. First, the technician must do more than *instal* new equipment. Other types of activity include *dealing with faults, carrying out scheduled maintenance* and *maintaining in the workshop.* Second, the HTA must be extended to cope with the other items of equipment and plant subsystems that need to be maintained. For example, the technician needs to cope with *pumps, valves, centrifuges, refrigeration units* and many other items.

To achieve the first of these a general analysis of the mechanical maintenance technician's task was sought. When the HTA of *install plant and pipework* is examined, it is apparent that some activities are concerned with general steps in engaging with a maintenance problem, while other activities focus on a particular context. It is possible to represent the overall task of the maintenance technician's task as something like that shown in Figure 6.16. This summarises the range of things that are in the technician's job-description.

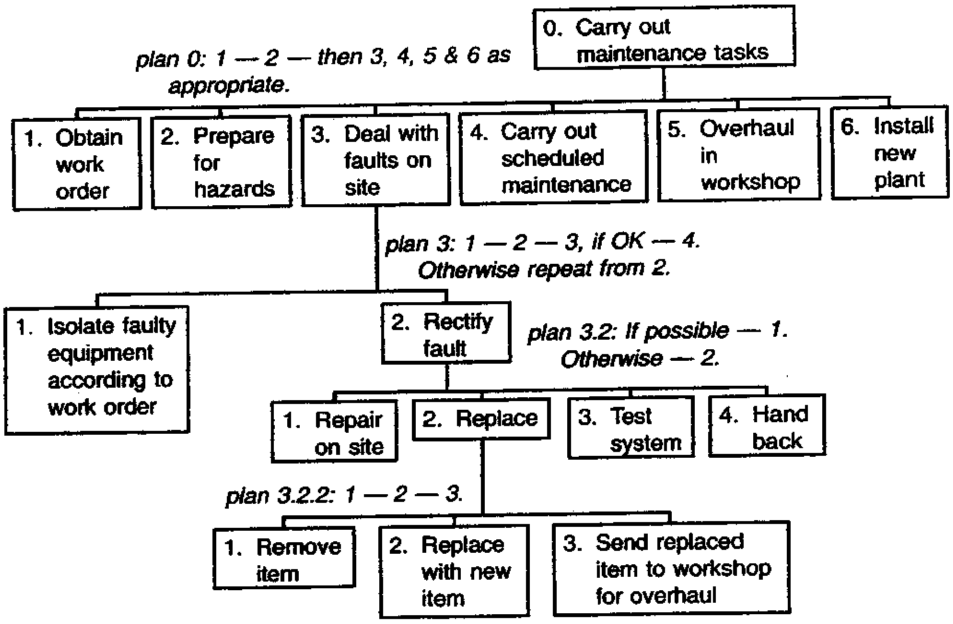

Figure 6.16 Representation of the general maintenance job

With regard to the second problem - the range of plant and equipment to be dealt with by maintenance technicians - an inventory was taken of all the equipment on the site. Table 6.1 shows how this inventory was recorded. Different items of equipment were listed to define *rows* in a matrix (in the real application, different types of pump and valve were also distinguished). Then the different sorts of maintenance activity were set out to define the *columns* in the matrix. Then each cell was considered, in turn to decide whether analysis was warranted. The shaded cells indicated where the task did not exist, for example refrigeration systems were never removed to the workshop for repair and dealing with faults did not apply to pipework. The remaining cells represented sub-tasks that required attention. This did not mean that every combination needed detailed analysis, because as the analysis of later sub-tasks was undertaken, it became apparent that much detail had already been completed already when considering earlier tasks. It was also possible simply to focus on the specific task undertaken in context. For example, in the analysis in Figure 6.17 it was possible to focus on just the

Table 6.1 Table of sub-tasks to be analysed for the mechanical maintenance project.

		A	B	C	D
		Install plant	Deal with faults	Scheduled maintenance	Workshop repair
1	Valves				
2	Pumps				
3	Pipework				
4	Weigh scales				
5	Refrigeration system				
	etc.				

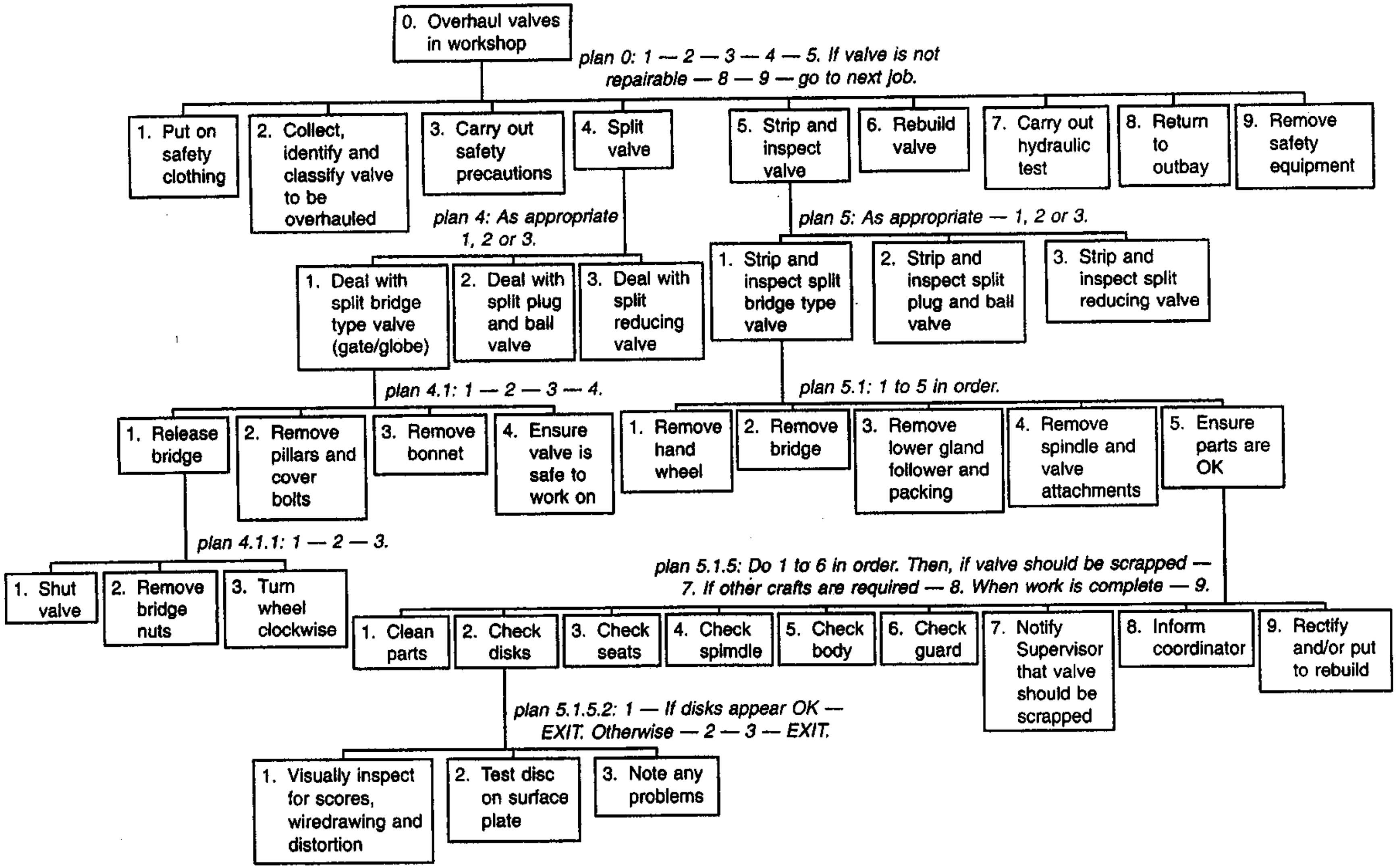

Figure 6.17 Analysis of 'overhaul valves in workshop which focuses on maintenance of a specific type of equipment in a particular domain.

activities that were concerned with *overhauling the valve in the workshop.* Some of the skills relevant to this were also encountered in other workshop tasks and some skills were also relevant to carrying out repairs in the workshop on other items of equipment.

Despite these methods of economising on analysis, this project required a substantial effort for the analyst and the company. Such projects are only worth undertaking if the outcome is important. Even then, it is advisable to seek as many benefits from this sort of exercise as possible. This work could provide an audit to check that tasks were safe, it could provide the basis for developing procedural guides and for developing and administering apprentice training.

Nursing

Many of the tasks discussed so far have been concerned with industrial or commercial applications. This next example deals with the duties of a nurse working in a hospital ward. Nursing duties are extremely varied and entail mixing rigid procedures with discretion. They also entail diagnostic skills, where they must make judgements about the patient's response to treatment, and interpersonal skills, where they need to judge the patient's well being and reassure patients concerning the progress they are making.

Figure 6.18 sets out the range of activities involved in ward-nursing and shows how they relate to each other. A full HTA would make clear the extent of discretion the nurse has. Nurses must make clinical judgements but the responsibility for acting on these judgements does not always rest with them - as with the neonatal intensive care nurse in Figure 4.7.

The task entails monitoring the wellbeing of patients and judging whether their treatment remains appropriate. It also involves counselling patients and preparing them psychologically for when they return home. Thus, many social skills are involved. It may be possible to model social skills using HTA, using ideas such as monitoring facial expressions and responses, but this is unlikely to be very satisfactory. While this might not be felt to be worthwhile, it is worthwhile setting out what this range of skills might be, what purpose these skills serve and how they must be carried out in the context of other parts of the task. HTA is effective for placing social skills in context just as it places cognitive skills in context.

Management

Management and supervision are important in any organisation since they are concerned with supporting operational tasks. Management is concerned with setting goals, providing and managing resources and ensuring that systems work effectively. Supervision focuses on the issues of ensuring that systems are working effectively, especially that staff are fulfilling their functions. Management and supervisory tasks have not traditionally been dealt with using HTA.

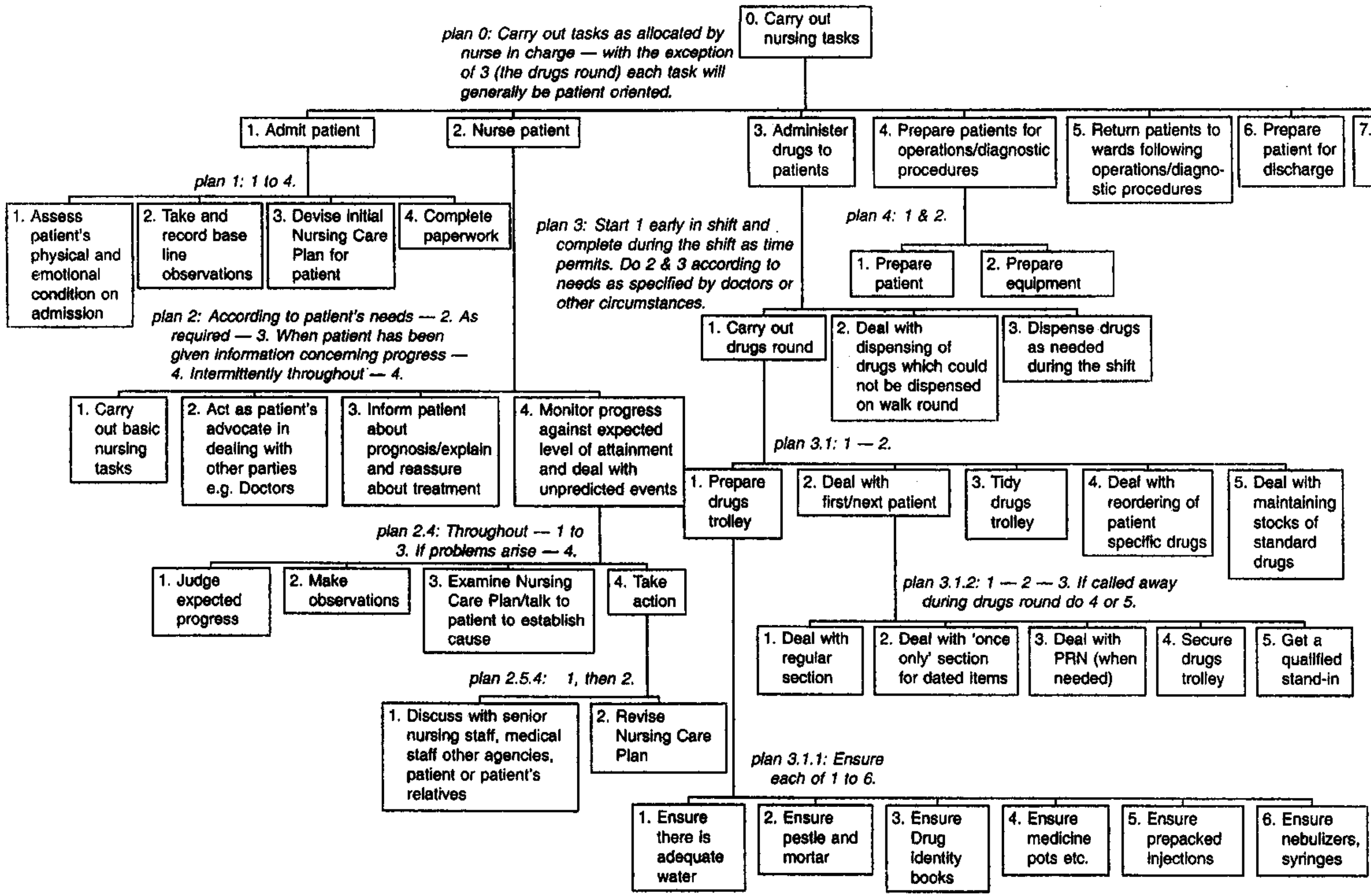

Figure 6.18 Carrying out nursing duties in a hospital ward.

People who are called managers or supervisors in organisations are often given these titles because of historical precedent or the requirement to emphasise status. Often it is arbitrary whether people are called supervisors or managers. We would expect supervisors to report to managers, and managers to senior managers. We would not normally expect managers to report to supervisors, although some managers themselves have supervisors. Management and supervision can only be discussed sensibly by defining their functions.

The management function is to take responsibility for achieving a set of goals in accordance with certain constraints. These goals or targets could be to provide a service to a particular standard or to obtain a profit. Constraints will be concerned with the amount of investment available, a set of resources, including human resources, that are available to use, and various constraints on how things should be done. Constraints include meeting health and safety requirements, complying with local or industry custom and practice and various company standards. Management functions include the following:

- Set up or modify an organisation to meet given targets and goals
- Monitor and maintain the adequacy of that organisation
- Develop the organisation

Depending on the organisation, some of these functions may be required and others not. In a mature company a manager may be required to manage a department by monitoring and maintaining its continued adequacy without looking for changes or without the requirement of having to set up the organisation in the first place. In a new organisation managers may be required to engage more in the processes of developing how things should be done. In a mature organisation under conditions of change a manager may be looking both within the organisation and outside of the organisation for opportunities to improve productivity.

In addition to these central management functions, managers would also be expected to carry out the following:

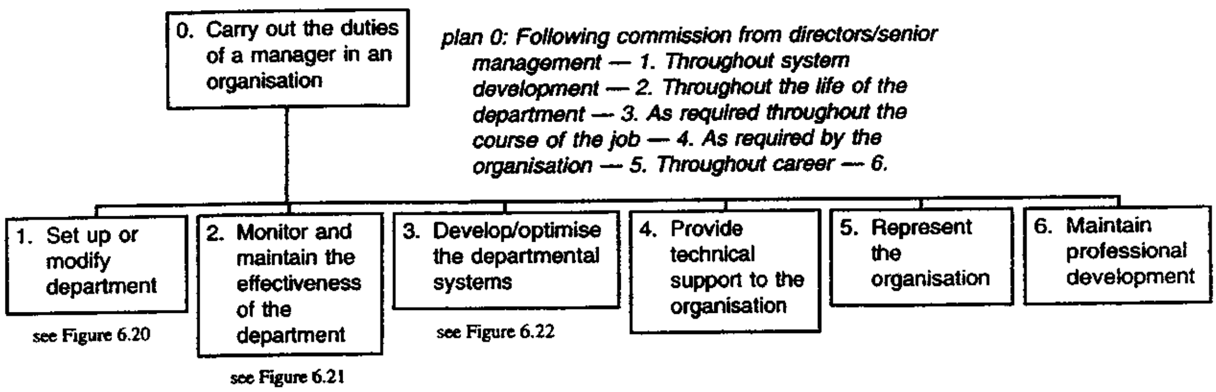

Figure 6.19 The overall functions of the management task.

- Provide technical support to the organisation
- Represent the organisation to outside agencies
- Maintain professional development

These three aspects are not strictly management functions but they are the things that managers often have to do. A manager may have technical expertise that could be used elsewhere in the organisation. Thus managers often join working parties within the organisation to facilitate other developments. Organisations exist within communities and so managers often undertake duties outside. These could be representing organisations at trade associations, industry working parties, representing the organisation to outside inspectors and also supporting public relations. A final function is that managers are also regarded as senior professionals within an organisation and it is their responsibility to maintain their own professional development. One would expect managers to keep abreast with what is happening in their field in order that their own work can be improved.

To represent the management task as an HTA, it is useful first to consider the ways in which the general functions of management can be set out. An example is given in Figure 6.19. This contains the various management functions described earlier together with a plan which sets out the conditions when they are required. Of course, the details of Figure 6.19 will vary between organisations in accordance with how the term 'management' is actually used.

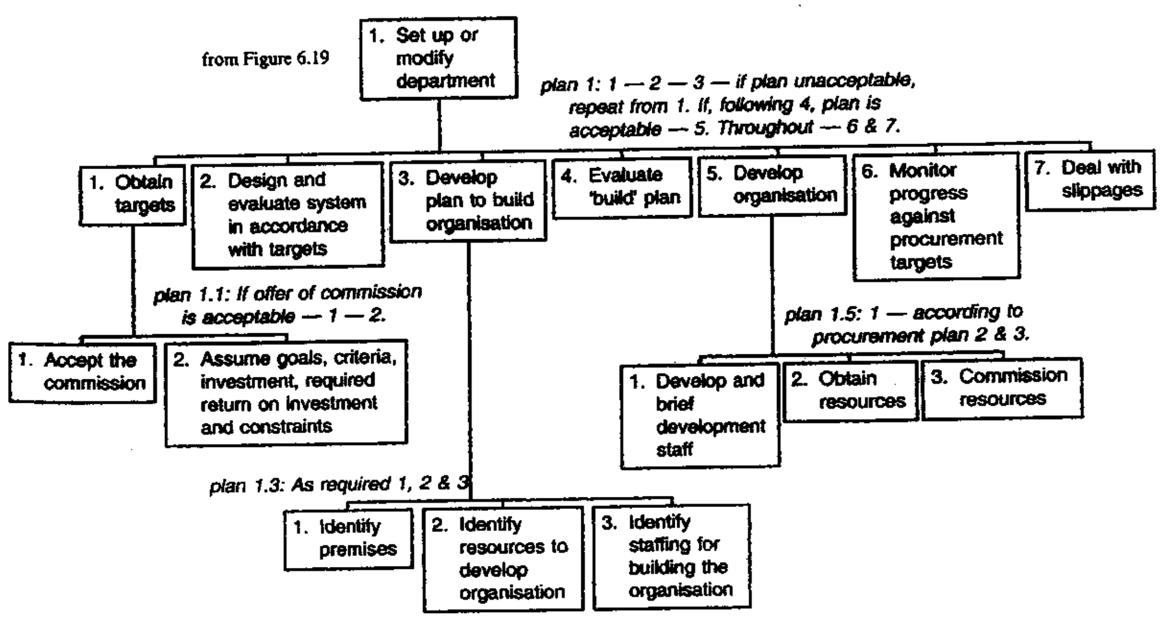

Figure 6.20 Setting up and modifying a department.

Set up or modify department

The subtask of 'setting up or modify a department' is set out in Figure 6.20. When a new organisation, department or project is set up within an organisation the manager charged with this responsibility will first obtain the targets that have to be met or that are expected to be met by the director (or senior manager), who decides on investment priorities. The decision to set up a new project may have been made following some kind of analysis of markets or needs. Therefore, the manager will be given targets to achieve, criteria of performance to be met, will be told of the investment that will be available, and should be told the required return on investment. The manager should also be told, or already know, the constraints. Constraints can include the requirement to use existing plant, the requirement to use existing staff or recruit from the locality, the requirement to use certain raw materials or suppliers and various time constraints for achieving goals and intermediate goals.

A second activity concerning design in evaluating the system in accordance with targets requires the manager and colleagues to create an appropriate system to meet these targets which is consistent with these constraints. This entails analysing the functions of the system, identifying the components that need to be in place to achieve the system and ensuring that these components relate to one another. In effect, this is *systems analysis*. It is something that can be done very well using HTA.

Having generated a prototype system, the manager and colleagues need to develop the plan to build the organisation that will be capable of sustaining this system. This could include identifying premises, identifying resources to develop the organisation and identifying staffing for building the organisation.

The manager and colleagues should now evaluate the plan's likely success. This entails projecting expenditure against the procurement plan; as various stages within the plan are reached, various expenditure must be made. Done properly, this step should enable the manager either to report that the project is or is not feasible, or that it needs modification.

Given the go-ahead, the organisation is developed. This includes developing and briefing staff to assist with the development, obtaining resources according to the development plan, and then commissioning resources as they are obtained. As more resources are obtained then more parts of the system can be tested in conjunction with each other, until the whole system is built. At this stage the infrastructure for normal operations can be put into place and normal operations can commence, thereby obtaining a return on the investment. Throughout the procurement plan, progress should be monitored against targets and slippages dealt with.

Many aspects of this phase of management can be shared between colleagues with different expertise, including financial, technical and human resources staff. Organisations vary substantially with regard to who is employed and who is available for consultation and collaboration. Small companies have different opportunities to large companies. Companies with adequate resources may be able to contract out certain aspects of these processes, whereas less well-off companies cannot. Despite these

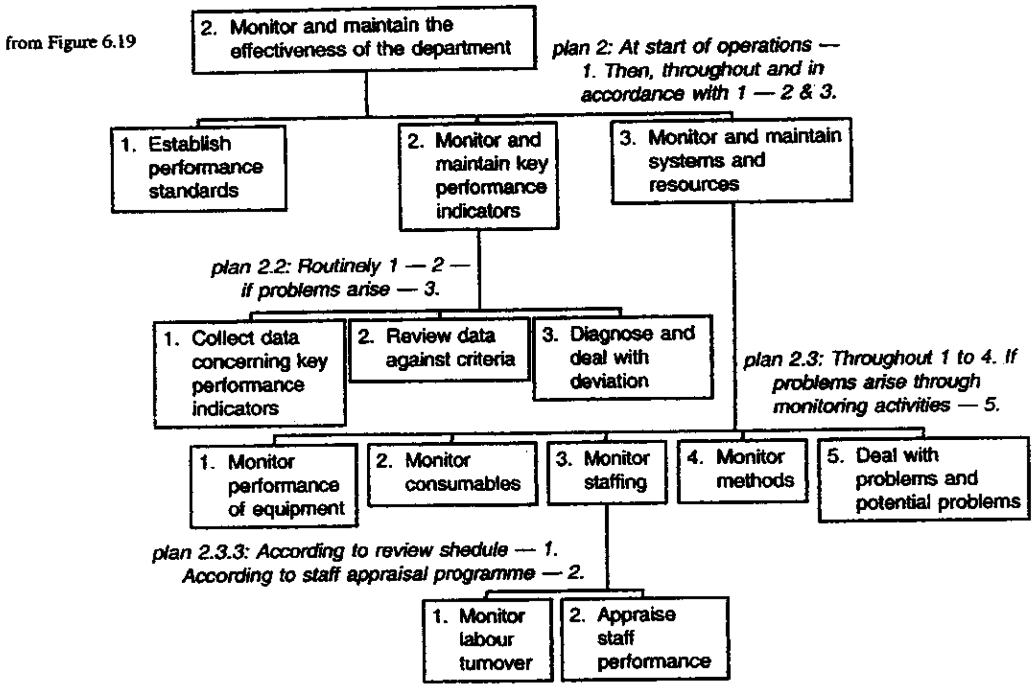

Figure 6.21 Activities in monitoring and maintaining the effectiveness of the department.

variations, the same functions must be met, whatever the size of the project and whatever size the organisation.[31]

Monitoring and maintaining the effectiveness of the department

The manager must ensure that a system continues to perform according to required standards. These standards might be given by directors initiating the project, or they might be given by an outside agency, for example, central government. Performance targets will vary in accordance with the nature of the work involved. In any case, the manager's job is to devise ways in which these standards can be measured and set up systems to collect suitable data.

In addition to targets formally set, the manager should also identify factors that will signal whether or not the department is working effectively. For example, a company may be concerned with output, but it may also be the case that labour turnover or morale in certain departments is a factor which is known to affect output. Collecting appropriate data in this way can help in any subsequent investigation of weakness and help to avert problems that might arise. Thus, it is usually worthwhile to have systems which monitor and maintain key performance indicators concerned with the *product* of companies or departments, and systems which monitor and maintain systems and resources concerned with the *processes* of securing these key performance indicators. Figure 6.21 sets out a range of product and process system measures which may be used to give warning of problems to enable remedial action to be taken. These may be measured and acted on formally or they may be used intuitively by supervisory staff in ensuring the department performs most effectively.

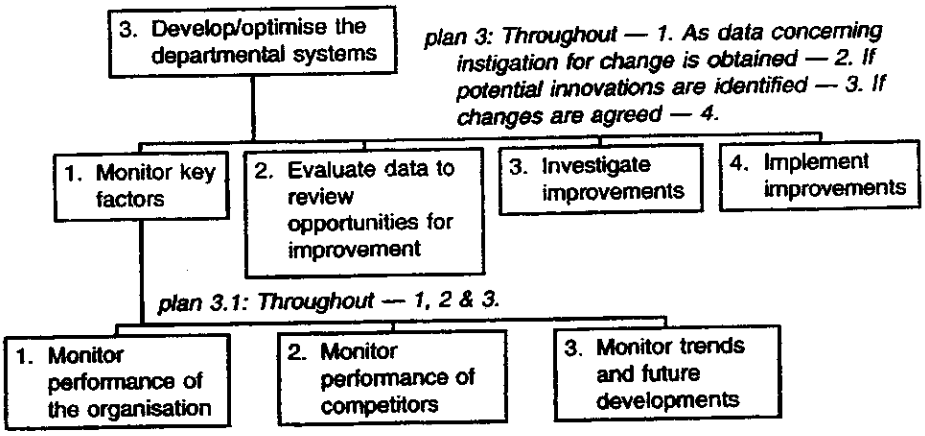

Figure 6.22 Developing the department's systems.

Developing the organisation - managing change

In any system, symptoms which highlight deviation either show that various characteristics need adjustment - this has just been discussed with respect to 'monitoring and maintaining the adequacy of the department' - or they suggest that the system itself needs modification. Where a manager is charged with the responsibility of looking for opportunities to optimise an organisation, he or she must monitor the performance of the organisation, and must also monitor those aspects which could give clues to beneficial change. Monitoring performance of the organisation will show the extent to which the targets expected of a department or system are failing, or the extent to which there is a downward trend in productivity.

As well as comparing how the department is doing it is also important to monitor the performance of competitors, to see how successful they are, to look for new services they are offering and to appreciate the new methods and technologies they are using. It is also important to keep an eye on trends and future developments. In a manufacturing organisation new materials or production methods will substantially affect productivity. In a local authority social services organisation, knowledge of an impending closure of a large factory could prompt an increase in demand for services caused by unemployment. Equally knowledge of developments on the use of the Internet by a sales organisation should prompt an investigation into alternative ways of selling. Activities involved in development of a department are shown in Figure 6.22.

If an organisation is to be responsive to these changes, it is important for a manager to set aside time to review improvement opportunities. Such an activity will signal potential new projects which themselves need to be investigated and, if appropriate, implemented. These decisions would prompt the activities concerned with setting up or modifying the organisation discussed previously, as indicated in plan 0 in Figure 6.20.

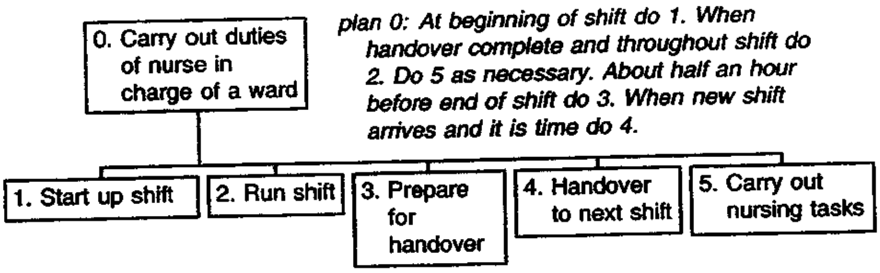

Figure 6.23 HTA of nurse in charge of a ward — an example of staff supervision.

Staff supervision - nurse in charge of a ward

Figures 6.19 to 6.22 represent management *functions*. Whether people who do these things are called managers, supervisors or team leaders, the same functions apply. Some functions are concerned with change, while other functions are concerned with ensuring that a department operates the way it is designed to. Jobs which are mainly concerned with ensuring that a department functions as it is supposed to are often called *supervision*.

To provide an example of supervision, we turn to the role of a nurse in charge of a ward. The nurse-in-charge will be carrying out duties as set out in the HTA in Figure 6.23 to oversee the work of nursing staff whose tasks are set out in Figure 6.18. To supervise staff a supervisor must be clear about what the department is expected to achieve and must be familiar with the capabilities of staffing and other resources.

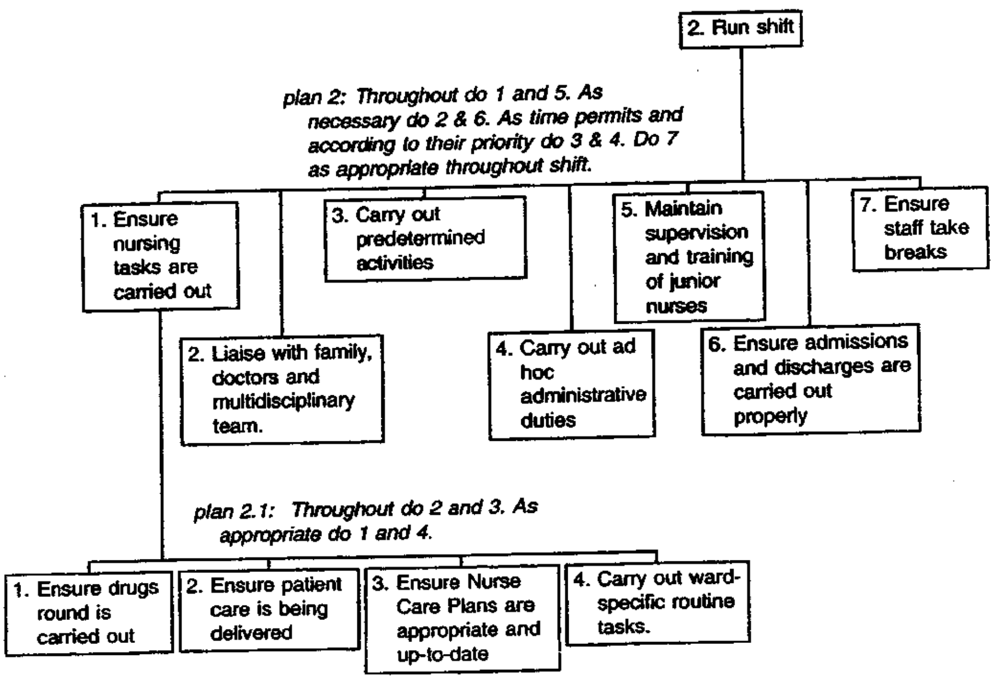

Figure 6.24 Running the shift.

The nurse supervisor's job is carried out over a shift commencing with a set of shift 'start-up' activities which are followed by ensuring that nursing tasks are properly carried out by the shift team. Towards the end of the shift, steps are taken to prepare for handover. While the shift is being run, the supervisor may also need to supplement the effort of staff by undertaking nursing tasks in their own right. This is typical of the demand placed on supervisors - while their main job is to ensure that a shift is run successfully, this can require supervisors to step into the breach themselves. Sometimes a supervisor must contribute in this way to cope with events that have overstretched members of the team, and sometimes the supervisor has specialist skills that no other team member currently possesses. The danger is that a supervisor is too eager to engage in the tasks of team members at the expense of attending to supervisory duties.

Running the shift

Running the shift, set out in Figure 6.24, entails overseeing that staff are conducting their duties appropriately (operations 2.1 & 2.6), ensure that staff have the opportunity to relax (operation 2.7), carrying out various senior tasks (operations 2.2, 2.3, 2.4 & 2.5). One of these is 'maintaining supervision and training of junior nurses'. This is typical of the responsibilities of supervisors. To do this, the supervisor needs instructional skills, one of which is appraising the needs of new staff and the current opportunities available on the ward to meet these needs.

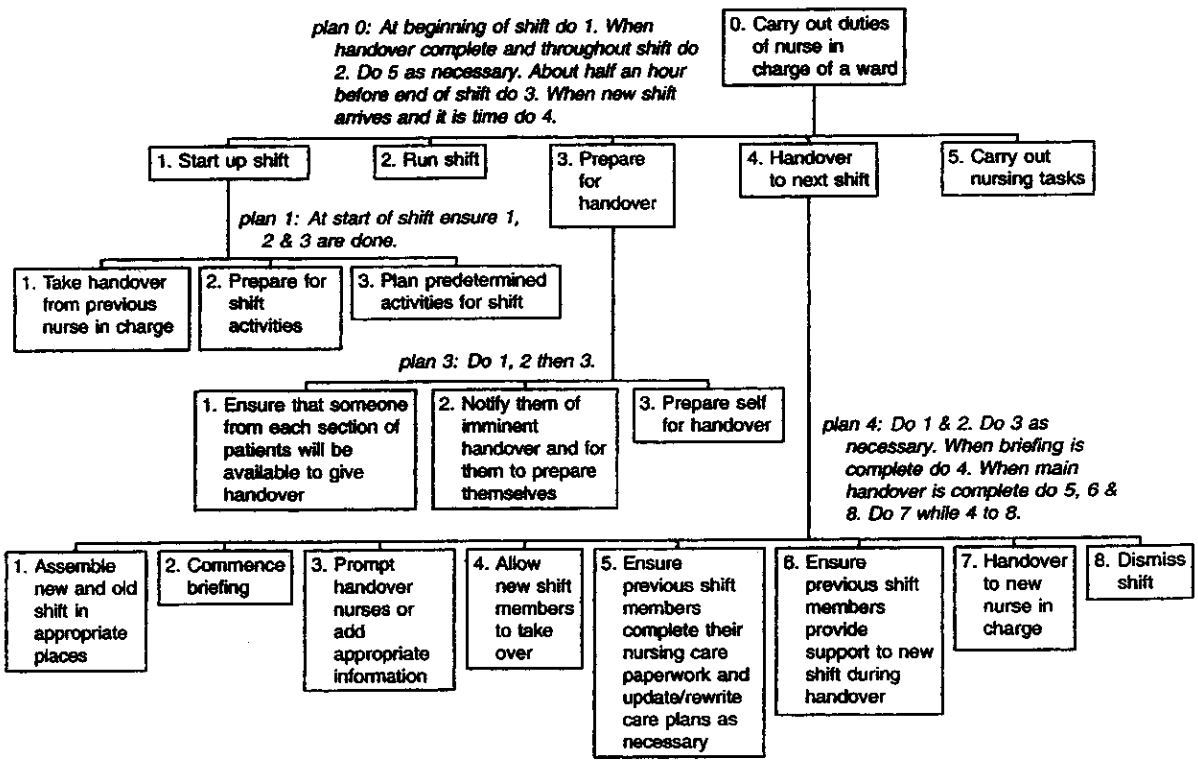

Figure 6.25 Liaising with other shifts.

Liaising with other shifts

Since patients need 24 hour a day nursing care, an essential part of providing nursing care is maintaining continuity between shifts. This means ensuring the team is effectively engaged at the start of the shift and assists the next shift in engaging with the task.

Figure 6.25 illustrates the activities engaged in maintaining continuity of care. In starting up the shift, the nurse in charge must listen carefully to what the previous nurse in charge has to say, and then make plans for the shift to come. As the shift progresses, all staff need to keep notes on progress and significant events; as the shift nears its end, the nurse in charge ensures that the nursing team is preparing itself for briefing the next shift. Handover in a ward is a team effort. The nurse in charge must coordinate this activity but relies on individual nurses with direct experience of past events to brief the new shift. There are also activities to ensure that no loose ends are left as one shift hands over to another, so paper work and other tasks need to have been completed. It may also be necessary in some circumstances to stay with the new shift to ensure that the newcomers are clear about what they are doing. Finally, a formal assignment of the responsibility for the ward must be given to the new nurse in charge such that lines of authority are entirely clear.

Many of these supervisory activities are common in other contexts. They will, of course, vary in detail with regard to local requirements. There is a danger that supervisors are merely seen as 'super' operators, but clearly their job is to ensure that departments work effectively, rather than being engaged in tasks directly. The supervisor is involved in a number of activities, including monitoring persuading, criticising, training and record keeping. These entail a wide range of operational skills, administrative skills and interpersonal skills.

Concluding remarks

This chapter has illustrated the application of HTA to a wide range of tasks, choosing examples from industry, commerce and the caring professions. This has been done to illustrate the breadth of application of HTA. Reviewing these examples, it is clear how tasks from different domains are similar in many respects to one another. A common feature is the extent to which some tasks are concerned with maintaining a system's status. Thus, continuous process control, air-traffic control, nursing, many aspects of management and most supervision is concerned with monitoring a system to determine whether it is performing according to target and whether intervention is necessary. This work paradigm is common in industry and it is also common in management. Managers and supervisors are often concerned with making sure that a system is operating according to intention. Thus, the system must be monitored against targets - if system performance is unsatisfactory then remedial operations must be implemented.

It is important to observe the distinction between *tasks* and *jobs*. Tasks relate to meeting a system's goals, while jobs may entail several tasks that an operator is employed to carry out. To understand jobs it is important to identify all the things that are done when a person gets to work and then leaves work, as well as what goes on in between. This is especially important in jobs concerned with continuity of system supervision or care. Equally, some jobs may only be understood by analysing several different tasks that the job-holder carries out.

Chapters so far have concentrated on how HTA is carried out. In the next few chapters we shall consider how HTA can be applied.