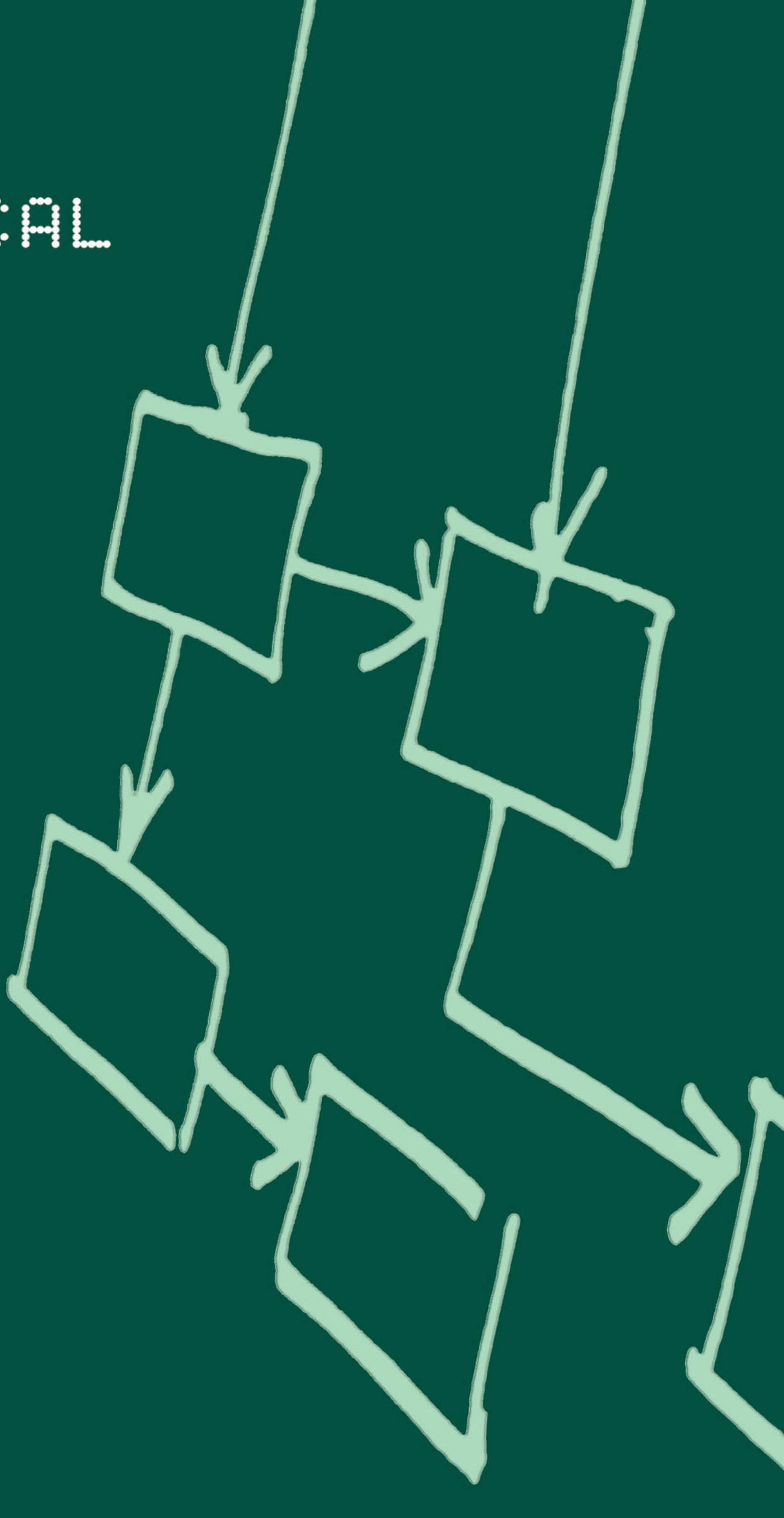
HIERARCHICAL TASK ANALYSIS

Andrew Shepherd



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Preface

Hierarchical Task Analysis (HTA) was initially developed by Keith Duncan and John Annett in the late 1960s. Their approach incorporated several important ideas from other task analysis methods into a practical analytical framework. The approach has been described in a number of useful articles, but these have often lacked sufficient explanation and illustration to enable people to understand its full implications. One consequence is that practitioners often see HTA as just another tool in the tool-box whose main purpose is to present hierarchical diagrams. Producing diagrams never was the purpose of HTA. The original authors' intentions was always to provide a rigorous and realistic method of examining practical tasks. The diagramatic representation was a by-product.

My aim in preparing this book has been to provide a reasonably comprehensive account of HTA and to show how it can be used more widely and more systematically. Task analysis methods should aim to help the analyst engage with a problem in order to identify a solution. The analyst's purpose is essentially practical. Therefore, I have represented HTA as a *framework* for examining tasks in which different considerations and other analytical methods can be applied as the task analysis evolves. A particular aspect of this approach concerns how well the analyst understands the context in which he or she is working.

I have also tried to show the breadth and power of the method by explaining how different aspects of HTA combine to create a rich picture of a task in order to account for complex behaviours. To support this, I have provided illustrations from a wide range of work contexts - manufacturing, maintenance, medical contexts, transportation and commercial activities. All of the examples included are reasonably straightforward. Where I have felt that some readers may be unfamiliar with certain aspects of particular domains, I have included a simple explanation. I believe there is benefit in exploring tasks across domains - even substantially different domains - since lessons learned in one domain often apply to others.

Finally, I have included several chapters concerned with applying HTA to support different aspects of human factors design - job and team design, interface design training, job-aids and human resource management issues. These are not comprehensive accounts of these topics and only deal with them in outline to show how HTA can be applied. Ultimately, task analysis methods can only be judged with respect to the use that can be made of results.

To avoid cluttering the main text with excessive dates and names I have included a final chapter which contains a number of notes that clarify certain numbered points throughout the text. Readers may pursue or avoid these as they choose. References are confined to these notes.

In view of focus and limitations of space, I have limited my discussion of other task analysis methods and only provide a cursory account of the different areas of applications. To compensate for this, I have referred heavily to texts which provide the reader with extensive supplementary material. These are Kirwan and Ainsworth (1992), Salvendy (1997) and Wilson and Corlett (1995).

References

Kirwan, B. and Ainsworth, L. K. (1992)*The Task Analysis Guide*. London: Taylor and Francis.

Salvendy, G. (1997) *Handbook of Human Factors and Ergonomics*, (2nd ed). New York: John Wiley & Sons.

Wilson, J. R., and Corlett, E. N. (1995) *Evaluation of Human Work*. London: Taylor and Francis.

Acknowledgements

I would like to acknowledge the contribution made by both John Annett and Keith Duncan to the theoretical development and the practical conduct of task analysis over the past few years. I have been fortunate to work with both Keith and John on various occasions. Despite offering some variation from how they presented their original ideas, I feel that the account I have provided in this book is entirely consistent with their intentions. I prepared a list of many other friends and colleagues in the human factors community with whom I have worked over the years, but the list got too large. I trust they will see their influence in various parts of the book and I thank them for their support and for providing me with the opportunity to work on some very interesting projects. Finally, I should like to thank the numerous operators, supervisors, managers, nurses, doctors and so on, who have patiently described their responsibilities and given me the opportunity to observe them at work.

Introduction

Hierarchical Task Analysis (HTA) was first proposed in the late 1960s as a general approach to examining tasks. Since then, it has become widely adopted although the method is often applied unsystematically or in ways which fail to ensure its full benefit. The aim of this book is to present the ideas of HTA more fully than previously with a view to demonstrating the method, to show how it can be applied to a number of different work contexts and to show how it can be applied in a number of useful ways. HTA cannot deal with every human factors decision without reference to other methods and ideas, but it can be used to guide an examination of tasks so that other methods and ideas can be used to greater benefit.

Any effort to improve human performance in a work or recreational setting must start by some understanding of what people are required to do and how they achieve their goals. Methods for achieving this understanding are often referred to as *task analysis*. Thus task analysis methods are an important prerequisite to the organisation of work, the design of workplaces, work practices and equipment, and in helping people to master their tasks. Task analysis methods, therefore, should be of direct interest to managers and engineers concerned with setting up and organising systems, to designers concerned with making sure people can use equipment properly, to managers and supervisors concerned with making sure that systems work according to design, to human factors and other management support staff concerned with prescribing conditions to enable people to work effectively, to human resources staff concerned with personnel and training issues, and to safety staff concerned to ensure that safe practices are followed.

In HTA, tasks are represented in terms of hierarchies of *goals* and *subgoals*, using the idea of *plans* to show when subgoals need to be carried out. Figure 0.1 shows these elements representing the simple task of using a toaster. Using HTA to examine something as straightforward as this is not something we would normally bother to do - although using a toaster could be seen as more complex than this - but it provides a good example.

In task analysis, it is always important to think of the reason why the task is carried out. A toaster is used to obtain toast, by cooking ordinary bread to the satisfaction of the person who is to eat it. Thus, the task has a *purpose* or *goal* and *criteria* against which the toast can be judged to be satisfactory or otherwise. Setting the criteria for industrial, commercial and service goals includes specification of the product and constraints on how it is achieved. These constraints can include cost and safety criteria.

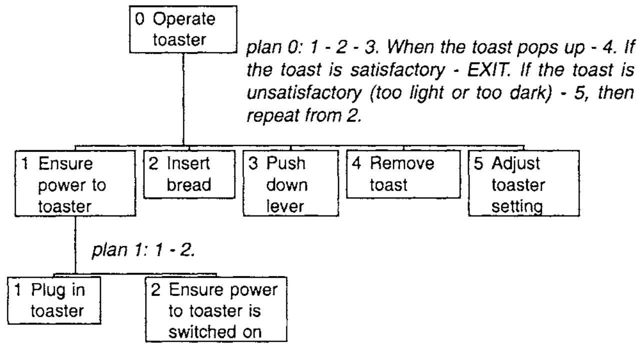

Figure 0.1 *A simple illustration of Hierarchical Task Analysis.*

Thus, motor cars are manufactured to be capable of transporting passengers according to a criterion of speed and acceleration, but this cannot be achieved at the expense of comfort and safety.

Detailed criteria can rarely be specified at the outset of a design process, even in product design. As designs are developed and intermediate design problems are solved, so new aspects of the product and its manufacture are discovered. To achieve a suitable level of power for a new vehicle, for example, a larger engine than had been initially envisaged may need to be included. This immediately places greater constraints on the size and layout of other components, so detailed design criteria are modified.

This process of refining criteria also arises when tasks are examined. As aspects of the task are uncovered, so we realise increasingly what needs to be valued in terms of performance. For example, a task analysis might commence with the aim of improving human performance to gain greater productivity. Notions of safety may be uppermost, but only when task detail is understood are the implications of safety properly appreciated.

Just as a task has a purpose, so too does the task analyst's intervention in doing task analysis. The analyst might be involved in training, or developing a better control panel, or determining how people can work together most effectively, or several of these things. Task analysis should not be done for the sake of it; knowing why we are carrying out the analysis affects how the analysis progresses.

Plans are crucial to HTA. A plan only makes sense in conjunction with the subgoals it is governing. Thus, to operate the toaster, we can use a plan (plan 0 in Figure 0.1) which states that first we must ensure power to the toaster, then we must insert the bread, then we push down the lever, then when the toast pops up, we remove the toast. If the toast is satisfactory we can terminate the toaster operation. If the toast is unsatisfactory we can adjust the toaster then repeat part of the previous activity.

Carrying out HTA on any task entails similar processes to those described for using the toaster. HTA works towards understanding what is necessary to achieve the stated goal. The analyst keeps in mind the performance criteria involved. As the analysis proceeds, the criteria for performance and why these different things are important start to make more sense.

Organisation of the book

Following this introductory chapter, the book is organised into two main sections. Chapters 2 to 6 deal with the issues of how to analyse tasks, while Chapters 7 to 12 deal with issues of applying the analysis. Since this book aims to provide a practical account of HTA, academic references and discussion of a number of issues have been kept to a minimum to allow the reader to follow arguments and examples more easily. To balance this, Chapter 14 has been included to deal with various numbered annotations throughout the book.

Chapter 1 introduces several of the main concepts used in task analysis to show how the basic methods of HTA are justified. Emphasis is placed on the importance of *systems thinking,* because task analysis is always undertaken to help understand human performance in a context such as an office, hospital ward or industrial unit. Carrying out task analysis in a practical way that serves the needs of people responsible for systems working effectively, requires a broad perspective. Chapter 1 also introduces most of the terminology that will be used throughout the book.

Task analysis methods have both *products* by which the task is represented and *processes* by which the analyst gathers information about the task in order to develop this representation. HTA is strongly characterised by hierarchical diagrams, such as that shown in Figure 0.1. This has led people to assume that HTA is, primarily, a method for task representation. However, ***Chapter 2*** will argue that this hierarchical representation is merely the product of a systematic process of examining tasks. Indeed, it will suggest that HTA is most usefully regarded as a framework for guiding task analysis. This framework enables tasks to be explored in accordance with their degree of complexity.

Chapter 3 focuses on the issue of *plans* in HTA. Plans are crucial in redescribing goals, because they specify the conditions when subgoals must be carried out to meet their common goal. It will be shown that much of the flexibility and variety between different tasks can be accounted for by different plans and that plans can combine to account for complex behaviours. Strategies for examining complex plans will also be set out.

Trying to be a clear as possible when describing tasks risks plans appearing too inflexible. As a consequence, task analysis may fail to represent the flexibility that experienced workers have to bring to their work. Real skills often reflects considerable planning and decision-making which causes observable performance to vary in accordance with the context in which the task is carried out. ***Chapter 4*** will deal with this issue. HTA is not a method of *cognitive task analysis* but serves the cause of cognitive task analysis by setting out the context in which such considerations apply. Moreover, attempts at representing how people reason and plan are often unnecessary in practical projects. The manner in which HTA relates to the analysis of cognitive tasks will be discussed.

Chapter 5 discusses issues of recording and representing HTA. Maintaining good records of work in progress and work completed is good practice and essential to task analysis where different aspects of how the task is carried out need to be negotiated with different people in authority and with the necessary expertise. Maintaining good records is essential to record how decisions are made. Good recording systems are also important because task descriptions can become complex; methods of locating parts of the task must be easy to follow without losing essential task detail.

Chapter 6 provides the reader with several examples of task analysis carried out in different work contexts. The aims of Chapter 6 are to demonstrate breadth of application of HTA and to show how similar analyses can be developed elsewhere. Examples are taken from clerical, industrial, health, transportation and service contexts. Operational, maintenance, management and supervisory tasks are included.

The second main section considers application of HTA. Often accounts of task analysis are given simply in terms of gathering and representing information about the task with no guidance provided to show how this information can then be used. This is generally unsatisfactory, because the methods adopted and the decisions taken during a task analysis are closely interrelated with the purpose for which the analysis is being carried out. Moreover, task analysis is a practical activity for which utility is of prime concern. If task analysis methods cannot be used to help identify performance problems or improve the design of tasks, then their value is questionable, no matter how valid the task analysis appears to be. Therefore, Chapters 7 to 12 will deal with various aspects of application of HTA.

Chapter 7 will consider the issue of *human factors design* and how design choices are influenced by various design factors. Design decisions are usually taken as HTA progresses; the HTA framework set out in Chapter 2 shows that making design choices is an integral part of the decision-making in which all analysts must engage. Chapter 7, will develop further how these choices are made, by reference to a range of contextual factors that influence both how tasks are performed and the costs and benefits of the design solutions themselves. Examples are given to illustrate how these factors interact.

Chapter 8 considers the issue of *team and job design*. Task analysis traditionally focuses on the role of the individual operator. However, by using a *functional* approach such as HTA, it is possible to appreciate the demands placed on an individual working within wider team whose role is to service a common function within an organisation. Examples are given of how team functions may be devolved into individual functions. It will also be shown how the various means by which colleagues are able to work effectively with one another can be represented as 'team tasks' in order that they are understood and can be trained. By understanding individual jobs in this way, their contribution to the wider team is clarified.

Chapter 9 considers issues associated with *work design*, including the issue of interface design. As with other design decisions, these aspects of human factors design are considered as an HTA progresses. Of particular importance is the fact that human skill depends upon the information and resources available to the operator carrying out a task. Indeed, many workplace design issues relate to task analysis in terms of the extent to which they support or constrain the operator's use of *information and controls*. HTA can make a useful contribution to this aspect of design by helping to identify the information upon which the operator must rely.

Chapter 10 considers issues of *training*. Training has always been a central focus for HTA. This chapter will illustrate how HTA can be used to identify training needs, identify task knowledge, specify conditions for practice, including helping to prescribe simulation, and assist with assessment.

Chapter 11 considers the development of *job-aids* and other user documents. By providing a clear statement of the task, HTA can be used to identify where job-aids will assist performance. Moreover, the structure of HTA offers substantial benefit in helping set out a job-aid consistent with task requirements and with training.

Chapter 12 deals with the issue of *personnel* or *human resource management*. HTA provides a representation of the task that can aid decisions concerned with aspects of recruiting and managing people to ensure they are consistent with the real requirements of tasks.

Chapter 13 reviews the main arguments in the book to show contribution that HTA can make to human factors and human resource interventions.

Chapter 14 contains notes relating to various issues that have arisen throughout the book.

While each of Chapters 7 to 12 introduces human factors and human resource management concepts, these topics are not dealt with exhaustively. They are explained only to the extent that it is necessary to demonstrate the contribution that HTA can make. The reader must look elsewhere for a comprehensive review of these issues.

Chapter 1

Task analysis, concepts and terminology

Tasks are concerned with what people do when they work to achieve objectives. Although the word 'task' is used frequently by people in normal discourse, it is not a rigorously defined scientific term and it is certainly not used consistently with respect to task analysis. The aim of this chapter is to explore the concept of 'task' with respect to HTA.

It will review issues of systems thinking and systems ideas that underlie skills. Tasks are considered in system terms. Tasks relate to the system's goals, the resources made available to people and the constraints that must be observed in meeting goals. Task analysis is seen as a process of investigating system factors which influence human performance.

Introduction

HTA was developed by two industrial psychologists, John Annett and Keith Duncan, in the 1960s[1]. Their intention was to prescribe a method of examining work which combined describing *human activity* with understanding the *purpose* of work in terms of the organisations and systems in which it was undertaken. Their method of analysis was also intended to provide a practical way of identifying problems which could then be addressed by human factors solutions. These ideas stemmed from two principal considerations - how systems theory was used to understand complex systems and how the ideas of systems theory were used to understand human performance. In developing HTA, they combined a number of basic ideas from existing task analysis methods.

Systems thinking[2]

A system is a *complex grouping of interrelated parts*, and can include human beings and machines. These parts interact to serve a *purpose*. For example, 'transportation' can be treated as a system to move people or objects from one place to another. It has a purpose and it has components that interact in a suitable way to realise that purpose.

Systems, subsystems and their interaction

Systems may be broken down into *subsystems*. A transportation system, for example, would include, among other things, subsystems which provide vehicles for transporting and subsystems for obtaining the things to transport. These subsystems also enjoy the properties of systems in their own right, so they too may be broken down in terms of subsystems. Thus, the function of providing vehicles for transportation would have a function of procuring new vehicles and a function of maintaining their availability through maintenance (Figure 1.1).

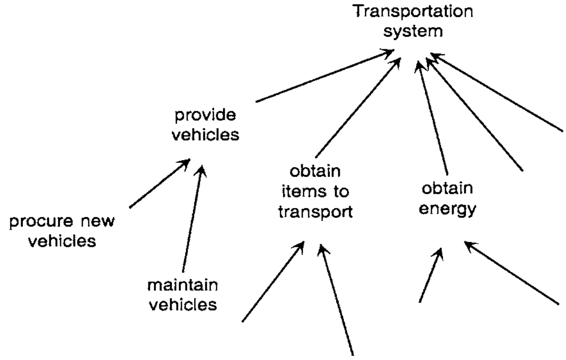

Figure 1.1 Systems and subsystems in a hypothetical transportation system.

[1] This and other notes are dealt with in Chapter 14.

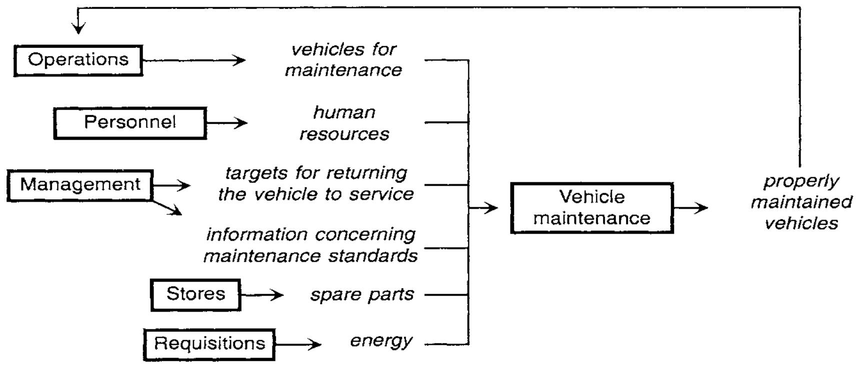

Figure 1.2 *Inputs and outputs to related subsystems.*

To achieve the purpose of the overall system, subsystems need to *interact*. This means that together they produce something that they could not produce separately. This interaction occurs through subsystems having *inputs* and *outputs*. The inputs to a transportation subsystem of maintaining vehicles includes vehicles needing maintenance, spare parts, human resources, information concerning maintenance standards, targets for returning the vehicle to service and energy, such as fuel and electricity, in order to use equipment and test results. With these inputs the maintenance can take place according to requirements and provide the output of a properly maintained vehicle. These inputs arrive at maintenance as outputs from other subsystems, such as operations, personnel, management, stores and requisitions (Figure 1.2). The output, namely properly maintained vehicles, becomes the input to other subsystems such as the operational subsystem for moving cargo from one location to another.

Just as examining a system will reveal subsystems, the main system being investigated is itself part of a wider system. This means that it will be subject to the values of the wider system. It will also receive inputs from and provide outputs to other systems. Thus, if the items being transported were food, inputs would include the food to be transported, its destination and a specification of the conditions for storage, including the permissible times for transportation. Each of these inputs would need to be satisfactory and the transportation system would need to take proper account of the inputs. If food failed to arrive in a satisfactory condition this could be caused by a failure of the storage conditions, failure of the initial production of the food, or inappropriate specifications being given for storage. Inappropriate specification could have been given due to a confusion regarding the food being transported or an incorrect technical judgement being made by food scientists.

System control

An integral part of systems thinking is the *control* and *regulation* of behaviour. This is often done through the mechanism of *feedback*. Feedback is where information from