AIR TRAFFIC CONTROLLER REACTIONS TO COMPUTER ASSISTANCE

RICHARD CHARLES CRAWLEY Ph.D.

THE UNIVERSITY OF ASTON IN BIRMINGHAM

MAY 1981

THE UNIVERSITY OF ASTON IN BIRMINGHAM

Ph.D. 1981 RICHARD CHARLES CRAWLEY

AIR TRAFFIC CONTROLLER REACTIONS TO COMPUTER ASSISTANCE

SUMMARY

The research was instigated by the Civil Aviation Authority (CAA) to examine the implications for air traffic controllers' (ATCO) job satisfaction of the possible introduction of systems incorporating computer-assisted decision making. Additional research objectives were to assess the possible costs of reductions in ATCO job satisfaction, and to recommend appropriate task allocation between ATCOs and computer for future systems design (Chapter 1).

Following a review of the literature (Chapter 2) it is argued that existing approaches to systems and job design do not allow for a sufficiently early consideration of employee needs and satisfactions in the design of complex systems. The present research develops a methodology for assessing affective reactions to an existing system as a basis for making recommendations for future systems design (Chapter 3).

The method required analysis of job content using two techniques: (a) task analysis (Chapter 4.1) and (b) the Job Diagnostic Survey (JDS). ATCOs' affective reactions to the several operational positions on which they work were investigated at three levels of detail: (a) Reactions to positions, obtained by ranking techniques (Chapter 4.2); (b) Reactions to job characteristics, obtained by use of JDS (Chapter 4.3); and (c) Reactions to tasks, obtained by use of Repertory Grid technique (Chapter 4.4).

The conclusion is drawn that ATCOs' motivation and satisfaction is greatly dependent on the presence of challenge, often through tasks requiring the use of decision making and other cognitive skills. Results suggest that the introduction of systems incorporating computer-assisted decision making might result in financial penalties for the CAA and significant reductions in job satisfaction for ATCOs. General recommendations are made for allocation of tasks in future systems design (Chapter 5).

KEY WORDS: System Design
Satisfactions
Air Traffic

ACKNOWLEDGEMENTS

Sincere thanks are extended to the many Air Traffic Controllers without whose wholehearted cooperation this research would not have been possible, in particular those at Heathrow Airport, LATCC and Birmingham Airport;

to the Supervisors, Management and Training Staff in ATC who gave their support and helped with administrative arrangements;

to Bob Ball at RSRE, Nickie Fonda at Brunel Institute for Organisational and Social Studies, Mildred Shaw at Middlesex Polytechnic, Richard Hackman at Yale University, and Phil Brewin and Ron Easterby at the University of Aston in Birmingham for their professional advice at various times or help with the misty world of computers;

to Peter Spurgeon and David Whitfield at the University of Aston in Birmingham for their constant support, encouragement and advice 1976 - 81;

to Barbara Parker for making such a smashing job of the typing;

and last, but far from least, to Sheila Crawley for enduring my moods, keeping me together and organising our house move whilst I scowled from amidst the packing cases, ever writing.

This research was carried out under Ministry of Defence Research Agreement No. AT/2097/026, funded by the Civil Aviation Authority and the Air Travel and Transport Industry Training Board.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

1.1 BACKGROUND TO AIR TRAFFIC CONTROL RESEARCH AT ASTON UNIVERSITY

The Ergonomics Development Unit (EDU) of the Applied Psychology Department in the University of Aston, first became formally involved with air traffic control (ATC) systems design research through the Royal Signals and Radar Establishment (RSRE) at Malvern. In 1972, RSRE had begun a long term research programme on ATC problems, in particular into the 'architecture' of ATC systems. The question had been raised as to how tasks should be divided between human controllers and computers, given that the latter would have some decision-taking capability. The rationale for introducing computers into problem-solving areas in ATC is explained later in this chapter.

Several issues with respect to this area were causing RSRE concern. Firstly, they were concerned about the acceptability of solutions offered by the computer to the air traffic controller (ATCO). During the course of recent trials involving a computer-assisted decision-making system, they had found that experienced ATCOs were reluctant to accept some of the solutions offered (Fearn, 1975). Secondly, they felt that solutions should correspond closely to those the ATCO would have envisaged so that if the system failed, the ATCO could carry on. However, RSRE had experienced difficulty in defining the way that ATCOs solved problems.

RSRE felt that they did not have the expertise to deal adequately with these issues alone, and therefore they asked the EDU to submit a research proposal to help their ATC systems research. Since 1973 the EDU has been involved in co-operative research with RSRE on behalf of the Civil Aviation Authority (CAA). Initially the EDU was involved solely with standard ergonomics issues relating to, for example, the design of interfaces and procedural aids. However, the initial research proposal had mentioned that human factors research should be concerned also with matters of job satisfaction, since this was of relevance to allocation of function and to system effectiveness. The research that forms the basis of this thesis was a direct result of the broadening of the EDU's work for RSRE into the area of job satisfaction. The events that led up to the commencement of this research in August 1976 will be discussed later in the chapter.

1.2 ATC IN THE UNITED KINGDOM

1.2.1 General Background

The objective of ATC is to ensure the safe, orderly and expeditious flow of air traffic. The ATC service in the U.K. comes within the province of the National Air Traffic Services (NATS) which is a joint Ministry of Defence and Civil Aviation Authority organisation. Airports are manned entirely by civil ATCOs, but some major units including the London Air Traffic Control Centre (LATCC) are staffed by both civil and military ATCOs working, in some cases, side by side.

The first distinction to be made is between 'controlled' and 'uncontrolled' airspace. At one time all airspace was uncontrolled, but with the pressure of increasing traffic movements, in particular around certain key areas, the need to designate controlled airspace arose. All aircraft wishing to enter controlled airspace are required by law to contact the appropriate ATC service to receive permission to do so, and to receive an advisory service as to their flight plan. Aircraft flying in uncontrolled airspace are allowed to do more or less what they like, within the general laws of aviation. Controlled airspace over the U.K. is separated into three categories. First, there are 'Airways', which are corridors of space ten miles wide and 66,000 feet high, usually having a base of between 5 - 7,000 feet. Secondly, there are 'Terminal Areas' at the intersections of busy airways and commonly surrounding major airports; and finally 'Control Zones' which more closely surround the major airports. Heathrow, for example, is enclosed in a Control Zone from ground level to 2,500 feet and the London Terminal Area (TMA) encloses all the major airports in and around London.

The control of air traffic falls into three broad categories also. 'Aerodrome Control', based in Control Towers, includes all departures and landings at airports, and covers both the control of aircraft and helicopters in the air within visual range of the Tower together with the control of all aircraft and vehicles on the ground. 'Approach Control' which also is based in the Control Towers, deals with aircraft and helicopters in the Control Zone either approaching the airfield for landing or crossing the Zone via approved 'corridors', but not usually within visual range of the Tower. The third and most centralised category of control is 'Area' or 'En Route' Control, which handles the control of air traffic in the Airways and Terminal Areas. En Route Control in the U.K. is conducted mainly from two units, LATCC and the Scottish ATCC.

One final distinction to be made is that between strategic and tactical ATC. Strategic control is usually defined as taking place fifteen minutes to three hours before an aircraft enters the airspace or active control of a particular sector or unit. Strategic control is a form of pre-planning and it typically takes the form of allocating times and routes to aircraft so that traffic peaks and congestion are smoothed out as much as possible, thus facilitating the safe and expeditious flow of traffic. A good example of this is the allocation of departure 'slot' times to aircraft before they start their engines at the airport. Tactical control, on the other hand, takes place in the 'live' traffic environment and requires ATCOs to maintain a safe and expeditious service for aircraft actively under their control or about to come under their control by means of allocation of headings, levels and speeds. The existing system in the U.K. is a mixture of strategic and tactical control, the majority of ATCOs being involved in the latter at any one time.

1.2.2 LATCC and Heathrow Airport

This section will describe briefly the organisation of the ATC system at the moment, focussing on LATCC and Heathrow Airport as examples since these were the two units studied for the research.

LATCC is responsible for the bulk of En Route and TMA traffic in an area known as the London Flight Information Region (FIR) that extends from the English Channel in the south to a line (55° North) just below Newcastle in the north of England. Exceptions to this rule are aircraft operating below 13,000 feet in the Manchester TMA, below 13,000 feet on the airways and advisory routes over the Irish Sea, and aircraft flying below 10,000 feet on the airways south to Birmingham, all of which come under the control of the Manchester Sub-Centre.

Airspace in the London FIR is divided up into sectors, each sector being the responsibility of a particular group of ATCOs. At LATCC, the Operations Room comprises a number of sectors which are laid out in a broadly geographical formation, the two main divisions being the North and South Banks. Each Bank has a number of En Route Sectors, London TMA being divided up into TMA North and South.

Each sector is represented physically in the Operations Room by a suite containing necessary radar and television displays, displays of flight progress strips and static map displays, together with equipment for ground - ground and ground - air communications.

A team of ATCOs and ATC Assistants (ATCAs) is allocated to each sector under the management of a Chief Sector Controller or Crew

Chief. In practice, each sector as defined so far is divided up often into smaller volumes of airspace, and a separate frequency and controller allocated to each sub-division. The TMA South suite, for example, has two horizontal radar displays, one either side of the Crew Chief, representing TMA South-west and TMA South-east. At peak traffic levels, these positions may each be manned by two ATCOs, one dealing with inbound traffic and the other with outbounds. Supporting the Radar Controllers is an ATCO acting as Assistant Sector Controller or 'Wing Man', and an ATCA.

At Heathrow Airport, the tasks of the Tower and Approach have been allocated to controllers in a mainly serial way, with four control positions in the Tower involving communication with and control of aircraft, and up to six positions in Approach.

The details of these positions and their relationship to each other will be presented now by means of two examples of aircraft, one departing from Heathrow and the other flying into Heathrow.

1.2.3 Two Examples of Aircraft Controlled by LATCC and Heathrow

The following is not a complete description of the ATC system in operation, but is merely an outline of the involvement of ATCOs in the control of air traffic at the two Units, including the functional relationships between controllers within and between the Units.

The first example is of a scheduled departure from London to a major European airport. A short time before the aircraft is ready for departure, the pilot contacts Heathrow Tower and asks the Ground Movement Planner (GMP) for clearance to start-up his engines. GMP checks his flight data display for the flight progress strip pertaining to the aircraft. Noting the requested route for the aircraft, GMP checks to see whether that route is subject to ATC restrictions. If it is, he may ask his Assistant to contact the Departure Flow

Regulator (DFR) cell at LATCC for a departure 'slot' time, which represents the time the aircraft must be airborne. Once obtained, this 'slot' time is passed on to the pilot together with other details related to the flight. The aircraft is then cleared for start-up and asked to contact Ground Movement Controller (GMC) in the Tower for further clearance. At this point, GMP passes the strip for that aircraft to GMC.

The pilot calls GMC for two stages of clearance, pushback and taxiing. On the first occasion, GMC checks to see whether there are any conflicting aircraft in the vicinity before clearing him for pushback. Once pushback is complete and the aircraft is ready to taxi to the holding point for departure, GMC gives him clearance to proceed and then ensures that he is integrated into the flow of aircraft and vehicles around the taxiways, contacting the pilot as necessary to give further instructions. As soon as the aircraft is in a position to safely make his own way to the holding point, he is asked to call the Air Departures Controller in the Tower. GMC then passes the strip to Air Departures.

The Air Departures Controller has the job of optimising the flow of departures from the airport, taking into account required separation between aircraft and 'slot' times. On receipt of the strip from GMC he begins to decide where the aircraft should fit into the order of departures, and instructs the pilot where to hold. When the right time arrives, he instructs the pilot to take up position at the threshold of the runway, and then clears him for departure. After checking that the aircraft has taken off safely, Air Departures asks the pilot to contact LATCC.

The pilot makes his next call to one of the London TMA sectors at LATCC. The Sector (Radar) Controller concerned will have received already a flight progress strip for this aircraft, printed by computer on instructions from Heathrow and passed to him by the Wing Man or

ATCA, and he can check via a television data display the status of the aircraft up to and including departure time.

Almost immediately after the aircraft is airborne, the ATCO will be able to see the aircraft on his radar display together with an alpha-numeric readout of its callsign and flight level. When the pilot calls him he will integrate the aircraft into his traffic pattern, clearing it as appropriate to a higher level and ensuring that it is not in conflict with any other traffic before handing it over to the appropriate En Route Sector for the next stage of the flight.

The En Route Controller too has received a flight progress strip for the aircraft, and when the pilot calls him he will aim to clear the aircraft to its requested cruising level, free of all conflicts and on an appropriate heading before handing it over to the European ATC Centre responsible for the next phase of the flight.

The second example is of a scheduled flight from one of the major European airports to Heathrow Airport. In many respects the progress of the flight through LATCC's control is similar to that of the previous example, except that this time the object is to descend the aircraft to an approved level before handing over to Heathrow Approach. One difference is that the flight progress strip will be printed on the instructions of the Wing Man or ATCA on the En Route Sectors receiving the aircraft from the European Centre, following a telephoned estimated time of arrival for the aircraft from that centre.

The TMA controller descends the aircraft to an approved level for the 'stacks', which are holding points around Heathrow, ensures that the aircraft is conflict-free and on a heading to the appropriate stack, and then contacts the Approach (Procedural) Controller at Heathrow to inform him of the aircraft callsign, its cleared level and its order in relation to other traffic into that stack. The Approach

(Procedural) Controller supports a controller known as the No. 1 Radar Director, whose job it is to take aircraft from LATCC approaching the stacks, integrate them into a safe and optimally expeditious traffic flow and put them on appropriate headings to enable them to make their final approach into Heathrow. There are two No. 1 Radar Directors, one controlling the two North stacks and the other the two South stacks. Although responsible for their own stacks and airspace, they co-ordinate with each other to achieve an expeditious and orderly flow of traffic from the four stacks.

The aircraft in our example may be instructed by the No. 1 Radar Director to take up the hold, which involves a short delay, or it may be cleared immediately through the stack. Once on a heading that will take the aircraft on to the final approach the No. 1 Director hands it over to the No. 2 Radar Director who integrates traffic from the four stacks and establishes all aircraft on their final approach with optimum separation between aircraft. For the final phase of its flight the aircraft is handed over to the Tower, from where it is cleared for landing by the Air Arrivals Controller if it is safe to do so, and once safely on the ground GMC sees it to its parking bay.

1.2.4 Organisation of ATCOs' Work

There are at present about 1,400 operational ATCOs in the U.K., of which about 300 are employed at LATCC and 75 at Heathrow. LATCC and Heathrow are organised on a five watch system to provide a twenty-four hour service all the year round. ATCOs work on a rotating shift system, each shift cycle lasting ten days. The systems differ slightly between the two Units, but in both cases there are three main duties each twenty four hour day; Morning, Afternoon and Night. Some of the ATCOs from the Watch operating on Nights act as Rotating

Day controllers or 'Spinners' to relieve the controllers on Morning and Afternoon duties.

All fully validated controllers at both Units rotate around different functional work positions during a cycle. At Heathrow, ATCOs may be allocated to either Tower or Approach for a particular duty, and rotate around the different positions during that duty, but during a cycle would normally spend some time on all operational positions in both Tower and Approach. A period of one to two hours on a particular position is normal before taking a break and moving on to another position. At LATCC, ATCOs holding full radar licenses will rotate between radar, 'Wings', Flight Information, and perhaps Flow Regulation and Data System Support positions, although expecting to be allocated to one type of position only on any one duty.

ATC is characterised by a very flat organisational structure, so that many operational ATCOs will remain so for most of their working lives, unless they choose to leave ATC, this latter event being uncommon since ATCO training is naturally very specific to the needs of ATC.

1.3 POSSIBLE FUTURES FOR ATC

1.3.1 Forecast Need for Automated ATC

It has been apparent for some years that the existing approach to air traffic control, with its emphasis on ground-based, tactical, manual control, would be unable to handle a substantial increase in air traffic movements. The method of dividing up controlled airspace into sectors, and allocating sectors to human controllers, ensures that the capacity of each controller to handle traffic has a significant impact on the capacity of the system as a whole. A preliminary study of long-term air traffic needs in Europe (Department of Industry, 1977) showed that when any one of the controllers within a fully-manned sector becomes overloaded, the limit for that sector is reached.

There are practical limits to the extent to which sectorisation may be taken, since further sectorisation imposes extra workload on the controllers, for example in the form of increased co-ordination, which eventually more than offsets the gains to be made from smaller sectors. Further sectorisation also necessitates increased numbers of controllers, when the existing system is already labour-intensive and therefore costly.

It is clear,however, that systems capacity will have to be increased if current forecasts of air traffic movements from 1990 onwards are reasonably accurate. The Department of Industry (1977) study estimates that in Europe, by the year 2000, there may be two to three times the present rate of air traffic movements. A forecast of air traffic movements in the United States (Federal Aviation Administration, 1975) predicts that by 1987, total aircraft operations - that is take-offs and landings - at airports will have doubled, and that en-route traffic handled by FAA Control Centres will be two-thirds as high again as present levels. This latter forecast reflects the impact of more rapidly rising fuel prices and a slower rate of real income growth that first had an effect in the early 1970's.

It should be remembered that the forecasting of future air traffic movements, in common with most forecasting, involves considerable uncertainty when looking so far ahead. The position of fuel alone is extremely difficult to predict, even to the extent of knowing whether there will be sufficient fuel supplies to maintain a significant civil air transport service by the end of this century. It seems reasonable, however, to allow for a more flexible ATC system that can cope with a changing environment, since as Ratcliffe (1976) points out, air traffic control is in many ways a parasite that must adapt to its host in order to survive. Automation is seen at the very least as a way to remove some routine tasks from the human controller and thus increase the capacity of the system. Later on in this chapter, some specific concepts will be discussed in which automation could play a much more significant role in ATC in the future.

Pressures towards automation have increased too in response to the rising costs of fuel. The existing manual system is stretched at times even at present traffic levels, and when this occurs it is the expeditious flow of air traffic that suffers in order that safety standards may be maintained. The airline operator therefore is forced to accept the cost of shortcomings in the present system in the form of increased fuel consumption, caused by delays and sub-optimal manoeuvres. As fuel costs rise both in absolute and relative terms, the airline operator finds that it becomes cost effective to pay for an automated ATC service that is more expeditious whilst being no less safe.

The International Civil Aviation Organisation (ICAO) has specified theoretical criteria for automation in ATC. These are that automation is justified:

"a) when any particular ATC functions or processes are becoming too burdensome or time consuming to be carried out efficiently by human operators alone;

or

b) when it becomes certain that substantive improvement with regard to regularity and expedition of operations cannot adequately be maintained without automation while maintaining the required level of safety."

(International Labour Organisation, 1972, p.88)

It is the view of the Department of Industry (1977) study group that the second of these criteria will hold by the end of this century if not before and although objective measures of ATC system effectiveness have proved elusive, the subjective views of ATCOs and their supervisors expressed at the major ATC units in this country suggests that the first criterion has been met already in some peak traffic situations.

1.3.2 Systems Concepts for Future ATC

Several ATC systems concepts were advanced in the 1970's in the U.K. and the U.S.A., four of which will be reviewed briefly to give an idea of the possible shape of ATC in the foreseeable future. Their inclusion does not necessarily indicate current interest in them by the national aviation authorities.

The Royal Signals and Radar Establishment at Malvern has been involved in systems research and design for the CAA for more than a decade, and two of its systems concepts will be discussed here. The earlier concept, Computer Assisted Approach Sequencing (CAAS), was developed in response to a requirement for computer assistance to ATC in the intermediate and final approach areas for London Heathrow Airport so as to increase the airport capacity. The system, which was developed to the stage of feasibility trials, offered computer-generated decision making with regard to the required flight path that an aircraft on intermediate approach should follow so that it arrived at the landing threshold at the optimum distance behind a preceding aircraft and without conflict with other aircraft in the approach area. A feature of the system was an electronic data display and transfer system.

The system was shelved shortly after the trials took place, and there is little doubt that the trial version would have been modified considerably before any introduction could be considered. Nevertheless, it is possible to see the general form which such a system would take.

The computer would be unable to handle all situations adequately, so human controllers would be required to maintain an active involvement in the traffic situation although adopting the role of monitor to a much greater extent than at present. A large proportion of the routine determination of headings, speed and levels would be carried out by the computer, together with the appropriate timing of manoeuvres. Distinct advantages might be obtained in allocating to the computer functions formerly requiring co-ordination between controllers, since such co-ordination can prove difficult in practice, particularly under heavy traffic conditions. CAAS in this form uses the human controller as support to the computer; at least that was the impression gained by controllers involved in the trials (Fearn, 1975).

A more recent concept developed by RSRE, that of Interactive Conflict Resolution (ICR), used the computer in a much more supportive role in decision making than had CAAS, adhering much more closely to the idea of 'computer assistance'. ICR was developed for an en-route air traffic environment, and assumed greater consistency of aircraft adherence to three-dimensional trajectories. It applied trajectory prediction for aircraft up to twenty minutes ahead, and by presenting such information on request to the human controller extended and enhanced his ability to predict future traffic configurations and conflicts and thereby to determine suitable solutions to the traffic situation. The computer program also ran automatic conflict searches up to twenty minutes ahead, and presented warning of predicted conflicts to the controller. The controller was able to use this facility in an interactive mode by initiating a conflict search in order to validate a proposed flight path modification.

The basic philosophy of ICR, as Whitfield (1978) notes, was to "vest the ultimate decision-taking in the controller". The computer continuously monitored the present and future situation, acting as a back-up to the controller, detected conflicts, and might even suggest solutions, but invariably the controller was left to make the final decision. Detailed descriptions of ICR are presented in Ball, Lloyd and Ord (1975) and Ball (1976).

A more general study of an ATC systems concept was carried out in the U.S.A. between 1971 and 1973 by the Transportation Systems Center, to suggest an advanced air traffic system that could cope with demand levels from 1990 onwards. (Jenney and Lawrence, 1974). The two major aims of the new system were to reduce operating costs of the ATC service, whilst improving the extent and quality of the service. The resulting systems concept was called an Advanced Air Traffic Management System (AATMS) which was characterised by a higher level of automation and a greater degree of centralisation and strategic control.

AATMS was based on certain assumed changes in flight deck, navigational and communications technologies. The most important of these were, firstly, that aircraft would be equipped with an advanced form of transponder which would send aircraft data to the ground in response to discrete interrogation; secondly, that navigation would permit aircraft more freedom than at present to select a route from departure to destination; and thirdly, that communications would use automatic data link for routine control messages between ground and air.

One effect of the new surveillance and communications systems would be to allow the human controller to be 'remoted' from the vicinity of the aircraft; there would be no need for a controller to be tuned to one radio frequency dealing only with aircraft within that transmitter range. In the terminology of the authors, the controller would also be 'remoted' from routine decision-making and tasks, since these would be automated.

The fundamental change, however, would be from the present airspace-centred approach, based on sectorisation with its inbuilt inflexibility, to a traffic-centred approach, in which aircraft are allocated either to the computer or to a human controller according to their needs. Although the human controller would still retain responsibility for critical operational tasks, especially those involving complex decision-making, judgment and non-routine communications with aircraft, he would have a much greater regulatory and managerial role in the system together with a much reduced involvement with the direct and continuous control of aircraft.

A quite different, and arguably less significant, approach to improving the ATC service in the U.S.A. in the future, was taken by McFarland and Horowitz (1974). They addressed themselves only to the problem of collision-avoidance in developing the concept of a highly tactical collision-avoidance service for aircraft called Intermittent Positive Control (IPC), which would be provided by a totally automatic ground-based system. The system would not replace the human controller, but would act independently from him in warning a pilot of other traffic in proximity or in potential conflict with him. The system would also provide commands to the pilot of either a "Don't" or a "Do" nature in the event of conflict. In this event the IPC system informs the human controller that one of his aircraft is in conflict with another controlled or uncontrolled aircraft. The IPC system might be seen therefore as an independent back-up to the human controller, exemplifying the 'redundancy of principle' referred to by Ratcliffe (1976), without fundamental change being made to the role of the controller nor to his ability to handle larger numbers of traffic movements.

1.4 IMPLICATIONS OF FUTURE AUTOMATION FOR THE HUMAN CONTROLLER

Most of the writers mentioned so far make specific reference to the need to accept what Mertes and Jenney (1974) call 'incremental automation'; that is to say, that changes towards automation in ATC will be gradual. Implicit in this statement are two corollaries:

a) There is no question at the moment, nor in the foreseeable future, of total automation of ATC, and

b) A balance between man and machine, or 'man-machine symbiosis' (Licklider, 1960) is the generally approved design philosophy of the specialists in this field, (ILO, 1972; Mertes and Jenney, 1974; Whitfield, 1978).

Furthermore, man-machine symbiosis is a philosophy that has been approved by ICAO in its guidelines on the application of automation in ATC. There seems little doubt, therefore, that the human controller will continue to play a major role in ATC for the forseeable future, probably well into the next century.

Equally there is not much doubt that the job of the ATCO will be subject to considerable change as a result of technological change. This aspect of change to the ATCO's job has led interested parties in ATC to express concern over the possible effects on the ATCO's job satisfaction and thereby on system and organisational effectiveness. The ATC Systems Committee (1975) stated that "the controller should not operate solely in a monitoring capacity, nor should his task be concerned only with routine data entry and retrieval within a highly automated system. Not only may the monitoring function impose unacceptable strains upon the controller, but any task which allows no scope for the exercise of his experience, judgement and skill must be expected to lead to a loss of job satisfaction and a consequent lowering of morale and efficiency."

This same opinion is expressed by Hopkin (1975), who goes on to explain why traditionally systems design has failed to take job satisfaction and motivation into account. "Automation, when introduced into a man-machine system, entails that the system, and all parts of it, are assessed in machine terms, since no other terms can be used." The problem is that machine terms make no allowance for emotions, motivations and needs.

Hopkin had first-hand experience of the possible effect of automation on ATCOs' job satisfaction when he conducted interviews with them during the CAAS trials mentioned earlier. In his summary of the findings he was moved to write:

"..... the problem of matching this aid with the responsibilities, status and job satisfaction of the controllers was raised spontaneously and not in response to a question on this theme. Such spontaneous remarks are usually an indication of fairly strong feelings on the matter. Some controllers were obviously antagonistic to a form of assistance in which they seemed to be helping the computer rather than receiving assistance from it. Some felt that their skills as a controller were being reduced or dispensed with by the provision of this aid. Some had come to terms with it and were beginning to realise how they could use it to their advantage. Even these felt that the device could potentially reduce job satisfaction ...." (Fearn, 1975).

1.5 OBJECTIVES OF RESEARCH AGREEMENT

It was in the light of the general anxieties expressed by such as the ATC Systems Committee and the specific findings from the CAAS trials that the CAA asked the Ergonomics Development Unit at Aston University to explore these issues in a way that would be useful to systems designers in ATC.

The stated objectives for the research were:

a) To predict the effects on ATCO attitudes of increasing automation.

b) To evaluate the 'cost' of such effects for the overall system.

c) To suggest guidelines for the allocation of tasks between ATCO and computer in the light of (a) and (b).

The research was not tied to any specific systems concept or design project; on the contrary, it was to be applicable to any systems design in the future. It was envisaged by the sponsors that implementation of any system incorporating advanced ideas of computer assistance in or automation of decision making was several years away, perhaps in excess of 10 - 15 years. It was obvious, therefore, that the approach of the research would have to be on the lines of establishing general guidelines or principles for systems design in ATC, which could be applied to any aspect of ATC and any typical group of ATCOs in the foreseeable future.

It seemed appropriate, therefore, that the focus of the research should be on the 'building blocks' of systems design, that is to say, functions or tasks. Furthermore, the overall objective of the research was to optimise future system and organisational effectiveness. The exercise was not to be one of improving or safeguarding quality of working life per se. Finally, the research was to be relatively self-contained, with no prospect of applying the results in a design situation.

2. THE LITERATURE

2.1 HISTORICAL OVERVIEW

The concept of 'job design' dates back to the Industrial Revolution in Britain in the eighteenth and nineteenth centuries. Davis and Taylor (1979) suggest that it was only then that society had to accept "a new central relationship - that between the person and the machine, replacing the relationship of the previous era - that between the person and nature." (p.2). The initial concern with job design was directed purely towards increasing quantity of output and the reduction of manufacturing costs. Adam Smith, as early as the mid-eighteenth century, referred to the benefits that division of labour could achieve through changing the way that people worked; by an increase in dexterity in every workman, by saving time previously spent moving between different types of work, and by enabling each person to do the work of many. These ideas provided the threads of job design.

The aim then was to exploit fully the new and expensive machinery. Babbage (1832) understood this perfectly well, and he was probably the first writer to suggest that managers and owners could achieve cost reductions by systematically designing and organising the jobs in their factories to improve employee effectiveness. He followed Smith's thinking quite closely by arguing that job specialisation would reduce apprentices'learning time, cut down on time and materials wasted in production, and increase the employees' skill level. Most important of all, Babbage's final principle was that:

"..... the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill or of force, can purchase exactly the precise quantity of both which is necessary for each process ....." (p.v.). Thus were sown the first seeds of what, under F.W. Taylor, was to become scientific management, and under Munsterberg the beginning of industrial psychology some eighty years later. At the time, however, Babbage was regarded as an impractical eccentric. (Hobsbawm, 1969).

There was really no pressure to introduce job design until the latter part of the nineteenth century for many reasons, economic and social. The introduction of new, powered machinery had increased enormously the capacity of each employee, and until the decline of certain sectors of the British economy at the end of the nineteenth century this seemed enough in itself without the need for further cost savings. The impetus in the USA came with the discovery of a mass market for consumer products, where cost saving and efficiency of production were vital. (Hobsbawm, 1969).

The social impetus to job design that prevails today was absent for one clear reason. The Industrial Revolution had brought with it social revolution, and there were immense social problems by comparison with which the content of one's job would have been of little consequence. It was true that factory mechanisation had brought with it "a regularity, routine and monotony quite unlike pre-industrial rhythms of work, which depend on the multiplicity of tasks in occupations unaffected by the rational division of labour, the vagaries of other human beings or animals, or even a man's own desire to play instead of working . (....) And since men did not take spontaneously to these new ways, they had to be forced. (Hobsbawm, 1969, p. 85/6).

However, overriding such intrinsic factors were the new living conditions and working conditions faced by the labouring poor. The fast-growing cities were unable for many years to cope with the pressure of migration from the rural areas; sanitation was appalling. In Sheffield, for example, the average life expectancy at the time Babbage was writing was twenty-four. (Vickers, 1978). Within the factory, the kinship system which developed initially in response to the inescapable need for wives and children to work was broken down by a combination of technological innovation and ironically, factory legislation. The shift of responsibility for discipline from the family group to foremen and managers made working conditions intolerable, and the early waves of protest were against "harsh conditions, immorality and long hours". (Mathias, 1969, p.203). The appalling poverty, together with the unfamiliar total cash economy, meant that jobs were seen largely in instrumental terms - that is, as a means to stave off starvation.

The values underlying the writings of Adam Smith and Charles Babbage were embodied in the scientific management movement pioneered by F. W. Taylor (1911). His main concern was to increase industrial efficiency, and he strove to achieve this by focussing on two areas: the efficient design of jobs, and the motivation of employees in those jobs.

Efficient job design was to be achieved by 'scientifically' analysing the job concerned by careful study of the most skilful workers to arrive at an optimum allocation of tasks between workers, and a 'best method' of working. All workers were to be selected so that they closely matched the job requirements, and then trained in the best method of working. Taylor then introduced the concept of the 'task idea', which he stated was "the most prominent single element in modern scientific management." (1911, p.59). This involved management - who now planned all the work for the workers - presenting each worker with specific task goals for the day and time limits within which to achieve them; closely supervising the performance of the tasks to ensure adherence to the plan; and rewarding the worker when the goal was achieved satisfactorily. Braverman (1974) suggests that scientific management embodied three principles: the dissociation of the labour process from the workers' skills; the separation of conception from execution; and the use of monopoly over knowledge to control each step of the labour process and its method of execution.

The second area on which Taylor focussed was motivation. He assumed a rational-economic model of human behaviour, such that the worker was thought to constantly measure his own performance against the required standard and to work at optimum speed only if he was assured of a substantial and permanent pay increase. The economic reward was to be linked to performance so as to ensure increased performance and efficiency for the organisation and increased satisfaction for the worker.

The influence of scientific management should not be underestimated. Financial incentive schemes are now in use throughout the industrialised world, and the practical developments of Taylor's job design approach are still in evidence widely. Blackler and Brown (1978) argue that there has been a tendency for behavioural scientists to assume wrongly that Taylor's naive view of human motivation has been superceded by subsequent models, and that his approach to the design and control of work is accepted as being outmoded. This may be true within the behavioural sciences, but as Braverman (1974) asserts, it represents "a woeful misreading of the actual dynamics of the development of management (.....). If Taylorism does not exist as a separate school today, that is because ...... it is no longer the property of a faction, since its fundamental teachings have become the bedrock of all work design." (p.87).

Insofar as the behavioural sciences contributed to job design in those early days, it was mainly in the form of "fitting the man to the job". Industrial psychology, under the guiding hand of Munsterberg (1913), was mainly concerned with the development of selection methods and tests. Technology was accepted as a given. The other area of concern was psychophysical conditions of work, in particular fatigue. Several pioneering studies were carried out in the U.K. on the effects of hours of work and rest pauses on fatigue and performance by the Industrial Fatigue Research Board (Vernon, 1921: Wyatt, 1927).

It was studies of psychophysical conditions of work however, that led to the 'discovery' that scientific management and job specialisation created labour problems that were unresponsive to existing methods of designing jobs and motivating people. Vernon (1924) found that employees on simplified short cycle jobs very often were bored and as a result took unauthorised breaks from their work whenever possible. The most influential studies, however, were those conducted in the 1920's and 1930's by Elton Mayo and his associates at the Western Electric Company of Chicago which have entered the history books as the 'Hawthorne Studies' (e.g. Roethlisberger and Dickson, 1939). The Hawthorne research began as an in-house study of the influence of physical factors of work on performance. The management was worried by poor productivity and suspected dissatisfaction amongst the employees. The objective of the initial studies was to increase individual output and efficiency, and it was assumed that this could be achieved within the accepted framework of Taylorism and industrial psychology. These initial studies were abandoned when results failed completely to support the assumption, and further studies were instigated under the supervision of Elton Mayo. Details of the research programme have been summarised by a number of writers (e.g. Warr and Wall, 1975).

The investigations purported to show the strong influence on organisational and individual performance of the informal social organisation, with particular reference to the nature of interpersonal relationships as exemplified by work groups and by supervisory practices. Roethlisberger and Dickson (1939) summarised their view as follows:

"What the Relay Assembly Test Room experiment showed was that when innovations are introduced carefully and with regard to the actual sentiments of the workers, the workers are likely to develop a spontaneous type of informal organisation which will not only express more adequately their own values and significances but also is more likely to be in harmony with the aims of management." (p.562)

They also expressed the view that workers were more interested in social relationships than money, and that in many cases they failed to make meaningful economic calculations concerning the relationship between productivity and reward. The conclusions drawn by the Hawthorne researchers, in particular those pertaining to money, have been seriously called into doubt by subsequent writers, both on methodological (Carey, 1967) and empirical grounds. (Roy, 1952; Walker and Guest, 1952). Blumberg (1968) criticises the researchers, and subsequent writers, for underplaying or even omitting to mention the importance of 'self-determination' or worker participation on the results from the Relay Assembly Test Room study. Presenting a well argued case at length, Blumberg shows that the Test Room study involved a radical shift of industrial power or authority such that the workers participating in the experiment were also encouraged to participate in the design and control of their own work. There were many references to this change by the employees in the early reports of findings, expressing considerable satisfaction with this new state of affairs. By the end of the study however, this aspect of the study was barely mentioned, and then only in the context of 'supervisory practices'.

The lesson for industry and work design was twofold. Firstly, Hawthorne revealed that the technical organisation of a factory was inseparable in practice from the social organisation, especially when the practical effectiveness of the factory was considered. If you ignored the social organisation, as Taylor had done, it will develop spontaneously and probably in a way counter to the requirements of effective production. Secondly, Taylor's naive model of human motivation expressed solely in terms of financial reward was inappropriate as a basis for motivating and satisfying employees. 'Rational-economic man' had been superceded by 'social man'.

Whatever the criticisms that can be made of the Hawthorne studies, and in particular of the conclusions drawn by the researchers from their data, there is no doubt that they have had a powerful and lasting effect. As Blackler and Brown (1978) point out, from 1939 onwards social scientists were able to make an identifiable and unique contribution to organisational and work design, focussing on the human being as a resource of equal importance to equipment or materials.

However, one of the beliefs that originated in the Hawthorne studies was that good human relations led directly to high productivity. This belief was derived from the finding that 'bad' human relations were associated with reduced productivity due to informal group norms being set. It was founded additionally on the consensus view of management and labour put forward by Roethlisberger and Dickson (1939) when they claimed that "in the human organisation we find a number of individuals working together towards a common end: the collective purpose of the total organisation." (p.554). It is not a view shared by many social scientists (e.g.Fox, 1973), although it is a view often expressed by leaders of industry. However, it encouraged management to believe that if they fostered good human relations both management and the workers would work towards common objectives. This supposed relationship between satisfied employees and good performance has been at the root of much subsequent research in the field, and it is the subject of discussion later.

Following the Hawthorne studies, there were two avenues of research influencing work design, frequently but not always overlapping. The first was based on empirical studies of attitudes to work, in particular those involving job satisfaction and dissatisfaction, which have taken as their focal point the problems caused by job simplification and the practice of scientific management. The second has focussed on the development of models of work motivation, and although influenced by studies of job satisfaction it has been equally influenced by theories derived from clinical psychology and group dynamics.

2.2 WORK ATTITUDES: STUDIES OF JOB SATISFACTION AND DISSATISFACTION

2.2.1 Introduction

One of the few points of clear agreement amongst writers on job satisfaction is that the literature on the subject is huge! Locke (1969) estimated that over 4,000 articles had been published, whilst Lawler (1970) suggested over 5,000. The past decade has seen no let-up in the number of publications on the subject. Much of the literature is of little direct relevance to work design however, and the reader is referred to a number of reviews (Brayfield and Crockett, 1955; Herzberg, Mausner, Peterson and Capwell, 1957; Srivastva et al, 1975; Vroom, 1964).

The motivation behind many studies of job satisfaction seems to have been of two types: (a) the desire to improve productivity or, more generally, efficiency; and (b) the desire to improve the quality of working life. The results of the Hawthorne studies provided the impetus for much of the early research, despite previous evidence on the subject from the Industrial Fatigue Research Boards in the 1920's and an intensive study by Hoppock (1935). From the very beginning researchers regarded job satisfaction as both a dependent and independent variable, and effort was directed to discover the determinants of it on the one hand, and the effects of it on the other. The Hawthorne studies purported to offer evidence of both sorts. Putnam (1930) was convinced by the comments from the Hawthorne employees that "the relationship between first line supervisors and the individual workman is of more importance in determining the attitude, morale, general happiness, and efficiency of that employee than any other single factor." (p.325)

As the literature has grown, and the subject become characterised by controversy, increasing attention has been directed towards the nature of job satisfaction as a concept. These three aspects of the Determinants, Effects and Definition of job satisfaction form the basis of the following three sections.

2.2.2 Determinants of Job Satisfaction

The consensus view is that job satisfaction is the result of an interaction between the person and his environment, taking the form of an evaluation process by the person (Locke, 1969; 1976; Vroom 1964; Warr and Wall 1975). Thus the causes of it do not reside solely in the job on the one hand or in the person on the other. As Locke (1969) says, "the prediction of job satisfaction necessarily requires an interactive approach ...... because of the nature of man and of the evaluation process." (p.319). Although some research has been conducted to discover individual difference determinants of job satisfaction, the greatest amount of effort by far has been directed towards the identification of job dimensions influencing satisfaction.

At this stage it might be helpful to the reader if a brief definition of job satisfaction is presented, although it will become apparent later that no single definition is wholly satisfactory. Locke (1969) states that "job satisfaction is the pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values." (p.316). Stated most simply, job satisfaction is a positive attitude towards one's job, whereas job dissatisfaction is a negative attitude towards the same; the former signifies liking, the latter disliking.

As evidence accummulated, it became recognised that job satisfaction was a multidimensional concept. Studies obtaining a single measure of 'overall' job satisfaction have found persistent and widespread reporting of satisfaction with one's job (Quinn, Staines and McCullough, 1974; Thurman, 1977). This contrasts with equally widespread dissatisfaction expressed towards specific facets of jobs, and because of this the single unidimensional measure has now been discarded in favour of separate measures of satisfaction with facets of the job. It was the realisation that job satisfaction was multidimensional that persuaded researchers to identify dimensions of the job influencing satisfaction.

The typical job dimensions that previous research has identified and studied have been summarised a number of times in the literature (Gruneberg, 1979; Herzberg, Mausner, Peterson and Capwell, 1957; Locke, 1976; Vroom, 1964). They include (1) Pay, (2) Promotions, (3) Security, (4) Supervision, (5) Work Groups, (6) Conditions of Work, (7) Company Policies and (8) the Job Itself. Each of these factors can be broken down into various sub-dimensions, and indeed many studies have attempted to do so. Thus 'Pay' for example, has at various times been sub-divided into absolute level of pay, pay equity, method of payment, frequency of raises and so on.

There have been several attempts to classify the dimensions for purposes of conceptual clarity, the most frequently used classification being that of Intrinsic and Extrinsic job factors, or Content and Context factors as they are sometimes called. The first seven factors listed above are all extrinsic, only the Job Itself counting as an intrinsic factor. A different classification, yet to be exploited in empirical studies, distinguishes between Events or Conditions (factors 1, 2, 3, 6 and 8 above) and Agents (all the other factors), on the grounds that every Event or Condition is ultimately caused by an Agent. (Locke, 1976, p.1302). Locke argues that these two classes are at different levels of analysis, and should therefore be kept separate in empirical research.

The remainder of this section examines the importance of intrinsic factors in more detail, since the emphasis of the present research is on the effect of systems design on job content.

The first studies to emphasise the effect that intrinsic job factors could have on job satisfaction were those carried out for the Technology Project of the Institute of Human Relations at Yale University by Charles Walker and his colleagues (e.g. Guest, 1955: Walker, 1950; Walker and Guest, 1952). The investigation of over 1,000 assembly line and associated workers at a car factory found a strong relationship between the degree of repetitiveness, low skill requirements and mechanical pacing of the job on the one hand and job dissatisfaction on the other. Repetitiveness was defined by the number of operations performed by the employee, and this factor alone discriminated between the satisfied and dissatisfied employees. 69 per cent of those performing more than five operations rated their job as fairly or very interesting; 44 per cent of those performing two to five operations responded in the same way; but only 33 per cent of those performing a single operation were interested in their work.

The relationship between repetitive work and job attitudes has been verified by several studies, both before and since those of Walker (e.g. Argyris, 1957; Blauner, 1964; Davis, 1957; Kornhauser, 1965; Likert, 1961; Wyatt, Fraser and Stock, 1928). These findings are clearly of interest to those who question the efficacy of scientific management.

Despite the relative consistency of such findings, Vroom (1964) was still able to report that there had been a "comparative neglect of the effects of job content." (p.126). Most writers credit Herzberg and his colleagues with directing attention towards the psychological effects of job content, the reason being that Herzberg asserted that intrinsic job factors were the main determinant of job satisfaction and motivation whilst job dissatisfaction was mainly caused by inadequate job context factors. (Herzberg, Mausner and Snyderman, 1959). The validity of Herzberg's model of motivation and satisfaction will be discussed later; for now it will suffice to mention that the intrinsic factors contributing to job satisfaction in his model are (1) Work Itself, (2) Responsibility, (3) Advancement, (4) Achievement and (5) Recognition; the first three being of greater importance for lasting change of attitudes, although the last two were mentioned in interviews more frequently.

The interpretation of results by Herzberg is inconsistent with the results of Walker and Guest's (1952) study, in which job content was found to be a major source of dissatisfaction. Furthermore, it is inconsistent with Herzberg's own earlier review of the literature (Herzberg, Mausner, Peterson and Capwell, 1957) in which it was found that intrinsic job factors contribute both to satisfaction and dissatisfaction. Reviewing over 150 studies, Herzberg and his colleagues found that 'Intrinsic aspects of the job' was the most frequently mentioned factor, although not apparently the most important determinant of job satisfaction as ranked by employees. It is possible that this factor is mentioned most frequently largely because it is the most multidimensional as perceived by employees; Herzberg lists 32 different aspects within this factor, as distinct from 22 in the next most frequently mentioned factor (Supervision) and only three in the least frequently mentioned (Benefits).

The problem with Herzberg's earlier review, as he admits himself, is that many studies used questionnaires of indeterminate reliability and validity. Unreliability seems also to be a function of the type of question asked. In summarising several large-scale studies, Stagner (1950) pointed out that employees attach different rank importances to job factors depending on whether they are questioned about them directly or indirectly. A later review of the literature (Vroom, 1964) found that job attitudes were affected not only by the degree of specialisation, control over work pace and use of skills and abilities - confirming Walker and Guest's findings - but also by job level, control over work methods, success and failure in work performance, and interruptions of work on tasks.

A problem with many of these earlier studies and reviews is that the identification of job dimensions often occurs in a fairly arbitrary way. Herzberg's intrinsic factors for example include 'Recognition', which could be assigned equally to the Supervision category; indeed in the earlier review (Herzberg et al, 1957), 'Recognition'is included under both 'Intrinsic Job Aspects' and 'Supervision'. Several other examples of logical inconsistency occur in Herzberg's incident classification system, and are pointed out by Locke (1976). It could be that these inconsistencies are due to the confusion between the event or condition that causes the employee to feel satisfied or dissatisfied, and the agent which caused it to come about (Locke, 1976, p.1311).

In Vroom's review too, the division of job content into 'job level', 'control over workpace', 'control over work methods' and so on does little to help the reader understand the underlying relationship between job content, job satisfaction and dissatisfaction. Part of this confusion may have arisen, again suggested by Locke (1976, p.1301), because of the widespread use of factor analytic techniques, which have resulted in almost as many factor structures as there have been studies. Items that correlated were sometimes grouped together by the researcher when they might have shown different relationships to other variables and be conceptually distinguishable. Conversely, sub-divisions of a dimension that might overlap conceptually and empirically (a good example being 'job level' and 'control over work pace') remained separate entities in the literature simply because of the particular items included by different researchers in their investigations and the type of jobs studied.

What was needed was a new structure and approach to the study of job content, and this was provided initially by Turner and Lawrence (1965) and later developed by Hackman and Lawler (1971). Turner and Lawrence brought together for the first time many of the job features studied and identified by earlier investigators, focussing on the task characteristics of jobs. Their objective was to provide more systematic data than had been available previously on how intrinsic task characteristics affected employees' satisfactions and attendance. They developed operational measures of six 'Requisite Task Attributes" which, on the basis of a literature review and an *a priori* taxonomy derived from the earlier work of Homans (1950) and Brown (1960), were predicted to relate positively to employee satisfaction and attendance. The attributes are: (1) Variety; (2) Autonomy; (3) Required interaction; (4) Optional interaction; (5) Knowledge and skill required; and (6) Responsibility. The authors measured 47 jobs on each of the attributes by observation and interviews, and found that small town employees were more satisfied with jobs that scored highly on the attributes, although urban employees reported less satisfaction with high scoring jobs.

Following the shift of emphasis toward task characteristics, intrinsic job satisfaction has become part of a general model of how job design motivates employees. This will be discussed in more detail in a later part of this chapter. The discussion now moves to an examination of the effects of job satisfaction and dissatisfaction.

2.2.3 Effects of Job Satisfaction and Dissatisfaction

It was suggested earlier in the chapter that a prime reason for the interest in job satisfaction has been the widely held view, evident in the writing of the Hawthorne researchers (e.g. Putnam, 1930), that a person's job satisfaction or lack of it influences his performance. To this must be added the supposed effects on absenteeism and turnover, which also have been widely discussed in the literature. These and other supposed consequences of job satisfaction and dissatisfaction provide the basis for this section.

2.2.3.1 Performance

The Hawthorne findings provided no evidence for a causal relationship between job satisfaction and performance (Carey, 1967; Locke, 1976). Nevertheless, the Hawthorne researchers' mistaken suggestion that there was such a relationship had a substantial influence, particularly on the human relations movement.

The history of the relationship between job satisfaction and performance is quite complex. In large part this must be due to the lack of clear definition of what was being measured. The confusion surrounding definitions of job satisfaction will be discussed later; but there has been comparable confusion with performance too. Few people would agree with Hackman and Suttle's (1977) use of the term 'productivity' to include not only the quantity of individual output, but also work behaviours such as "turnover, absenteeism, defiance of rules and authority, grievances, strikes, union activity, sabotage, theft, accidents, and especially the quality of work output." (p.10).

A more specific and, to this writer's mind, far more useful definition of performance is provided by Srivastva et al (1975), who include 'productivity', 'efficiency', 'production rate', 'performance ratings by supervisor' and 'quality of work' as the sort of variables to include under the performance category; absenteeism and turnover were classed as forms of withdrawal.

The earliest review of the literature on the relationship between job satisfaction and performance was by Brayfield and Crockett (1955). They distinguished between those studies involving on-the-job performance and those involving withdrawal behaviour, following the recommendation of Katz and Kahn (1952) that in social structures one should distinguish between (1) the motivation to remain within the system and (2) the motivation to act in a differential manner within the system. In their review they note that in many jobs it is impossible to obtain a valid measure of productivity because "a certain amount of work is required during the day and no more is produced, because adequate records are not kept, because the product depends on group rather than individual performance..... " (p.410). In such circumstances, researchers frequently fall back on subjective evaluations of performance which are fraught with problems of reliability and validity. It was not just the measures of performance which were unreliable. Many of the studies reviewed by Brayfield and Crockett failed to define job satisfaction, and the operational definitions that could be derived differed from study to study. Only three used a standardised measure of job satisfaction, the Brayfield-Rothe Job Satisfaction Blank.

Thus, given the almost total absence of either clear definition of terms or consistency of measurement technique across studies, it is perhaps not surprising that Brayfield and Crockett found little evidence of a relationship between job satisfaction and performance. They concluded that "satisfaction with one's position in a network of relationships need not imply strong motivation to outstanding performance within that system, and .... productivity may be only peripherally related to many of the goals towards which the industrial worker is striving." (p.421)

Vroom (1964) in his later review confirmed that no simple relationship existed between job satisfaction and performance. The median correlation between the two variables on 20 studies was +0.14, which Vroom stated has little theoretical importance, and the range was from +0.86 to -0.31. It should be noted that in summarising the data from the 20 studies, Vroom opted for the most comprehensive measure of job satisfaction where more than one measure had been used in a study. Whilst making the data more comparable across studies, it meant that Vroom omitted to investigate whether the strength of the relationship varied with different facets of job satisfaction. Had he done this, however, a larger sample size would have been necessary.

By far the most comprehensive review of the job satisfaction literature is contained in the recent publication by Srivastva et al (1975). Their search for post-1959 empirical (quantitative) field studies relevant to organisational decision-making in the area of improving productivity and the quality of work life revealed over 600 of this type out of a total of 2,000 studied. Of the correlational studies, 31 were found in which a positive relationship existed between job satisfaction and performance. The authors suggest that this relationship can be viewed "with a fair degree of confidence" (p.25) despite the fact that there was considerable variation in the findings.

In conclusion, the question of whether or not there is a positive relationship between job satisfaction and job performance is shrouded in uncertainty, and the view of researchers in the area seems to reflect their value orientation as much as it does any clear empirical findings. For example, Herzberg et al (1957) concluded that "there is frequent evidence for the often suggested opinion that positive job attitudes are favourable to increased productivity. The relationship is not absolute, but there are enough data to justify attention to attitudes as a factor in improving the worker's output. However, the correlations obtained in many of the positive studies were low." (p.103). The data on which this rather positive conclusion was based were similar to those that led Brayfield and Crockett (1955) to state that there was little evidence for any simple or even appreciable relationship between attitudes and performance.

Whereas Vroom (1964) notes "the absence of a marked or consistent correlation between job satisfaction and performance" (p.187), Lawler and Porter (1967a) prefer to emphasize that, since twenty of the 23 correlations cited by Vroom are positive, "the consistency of the direction of the correlation is quite impressive ..... such consistency would occur by chance less than once in a hundred times." (p.22). The same authors writing elsewhere (Lawler and Porter, 1967b) shift the emphasis slightly by commenting that "the research findings prior to 1955 did not show strong positive relationships between job satisfaction .... and productivity;"(p.123) and of Vroom they add that "his survey findings differ little from those previously mentioned." (p.124).

None of the correlational studies reviewed above prove in themselves that satisfaction causes performance, since a significant correlation indicates only that two variables are associated, not that one causes the other. As Srivastva et al (1975) note, in order to infer that X causes Y, it must be shown not only that X and Y covary, but also that (1) Y did not precede X in time; and (2) that there are no alternative explanations (e.g. other variables) which could reasonably account for the change in Y. Not one of the studies reviewed above can satisfy the condition that performance did not precede, and therefore cause, job satisfaction. This alternative interpretation of the correlational data has gained popularity and credibility since it was first suggested by Vroom (1964, pp.262/3) and elaborated by Lawler and Porter (1967a and b). It will be discussed later in the context of models of motivation.

2.2.3.2 Absenteeism and Turnover

There are rather stronger *a priori* grounds for expecting job satisfaction and dissatisfaction to be related to absence from work and employee turnover than for performance. Vroom (1964) comments that if one measures *anticipated* satisfaction from the job, then a high score should be related to the strength of force on the person to stay in his job (p.175). His argument is that most measures of job satisfaction reflect not just the actual satisfaction with a facet of the job already existing (e.g. the pay I receive now) but also the valence, or anticipated satisfaction, of the job (e.g. the pay I expect to receive next year). This being the case, then job satisfaction and absenteeism and turnover should be related. Locke (1976) draws the same conclusion from a different model of job satisfaction. In an earlier article, Locke (1970) had argued that emotions involve action tendencies, or felt urges to action, the two most basic being approach and avoidance of the valued or disvalued object or situation. Following this logic, the most obvious behavioural consequence of job dissatisfaction (i.e. disvaluing the job) should be such avoidance actions as absence and termination. Nevertheless, the relationship should not be clear cut. Locke (1976) notes that there are many alternatives to absence and termination as a consequence of job dissatisfaction, and Hulin (1966) points to factors such as the condition of the labour market, workers' ages, chances of obtaining another job, and financial responsibilities which may influence a person's decision to leave the job.

In contrast to the findings on performance, nearly all major reviews of the literature have found a significantly negative relationship between job satisfaction and levels of absenteeism and turnover, although the evidence is stronger for turnover than for absenteeism. (Brayfield and Crockett,1955; Herzberg et al, 1957; Muchinsky, 1977; Porter and Steers, 1973; Schuh, 1967; Srivastva et al, 1975; Vroom, 1964). However, as with most concepts related to the measurement of job satisfaction, the evidence has been conflicting, in large measure because of the inconsistencies and ambiguities in the definition and measurement of both turnover and absenteeism. For example, Gaudet (1963) reported that at least 41 different measures of absenteeism had been used in the past. Muchinsky (1977) points to a fundamental problem with measures of absenteeism, namely that many suffer from poor reliability or even complete unreliability; moreover, results are inconsistent across studies. The most reliable index of absenteeism appears to be frequency. (Chadwick-Jones, Brown, Nicholson and Sheppard, 1971; Huse and Taylor, 1962; Muchinsky, 1977).

The findings with regard to absenteeism are that in all but a few studies overall job satisfaction has been negatively related to it. However, studies of job facet satisfaction reveals a more complex relationship between job satisfaction and absenteeism. Most studies have found no significant relationship between absenteeism and satisfaction with pay, promotions, supervision and co-workers. Satisfaction with work itself, however, has been found to have a consistent negative relationship to absenteeism. (for exception cf. Nicholson, Brown and Chadwick-Jones, 1976). Furthermore, Steers and

Rhodes (1978) noted that a wide variety of field experiments had shown that job enrichment substantially reduced absenteeism. Despite the greater consistency of findings with absenteeism, there are dangers in generalising about the results, and in attributing a causal relationship between job satisfaction and absenteeism. (Nicholson et al, 1976; Redfern, 1978).

Dissatisfaction with the work itself has emerged also as a consistent and strong predictor of intention to leave a job. (Nicholson, Wall and Lischeron, 1977). However, it is not suggested that absence and termination are necessarily equivalent behaviours. For some researchers, absenteeism is a weaker withdrawal behaviour, acting also as a predictor of future termination (e.g. Herzberg et al, 1957; Lyons, 1972). Thus the two behaviours may be seen as different points on a continuum. Another point of view is that absenteeism is an alternative form of withdrawal behaviour to termination; it may occur when alternative employment is not easy to find, for example. (Hill and Trist, 1955). Muchinsky (1977) points to the difference in findings from individual and group studies. In the former, absenteeism and turnover are clearly related positively, with an indication that withdrawal progresses from absence through to resignation. With group studies on the other hand there is little support for the hypothesis that the two behaviours are related. More recently, Beehr and Gupta (1978) showed a relationship between four categories of withdrawal behaviour: (1) low involvement; (2) lateness; (3) absenteeism; and (4) turnover.

Porter and Steers (1973) found a positive relationship between job satisfaction and turnover in all but one of the studies they reviewed. Hulin (1966) for example, looking at the turnover of female clerical employees, found that leavers had significantly lower mean satisfaction scores in the months before they left than did the stayers. In a follow-up study (Hulin, 1968) he found that when management took steps to increasing job satisfaction, turnover fell from 30 per cent (1966 study) to 12 per cent (1968 study). Job satisfaction had increased on four of the five scales in the Job Description Index (Smith, Kendall and Hulin, 1969).

It is not suggested that increasing job satisfaction in Hulin's study caused the fall in employee turnover. A plausible hypothesis is that the job factors which were changed to increase job satisfaction also influenced withdrawal behaviour; in other words, the two variables had common correlates.

The consensus view, therefore, appears to be that there is a consistent inverse relationship between job satisfaction on the one hand, and absenteeism and turnover on the other, this relationship being particularly strong when satisfaction with the work itself is considered, and when individuals as distinct from groups are studied.

2.2.3.3 Other Correlates of Job Dissatisfaction

Although most research has examined the relationship between job satisfaction, performance, absenteeism and turnover, there has been a small group of studies over the years revealing possible relationships with other individual and organisational variables. These variables include physical and mental health, and union activity.

It is logical to expect an individual's job satisfaction and life satisfaction to be related, since one's job is a part of one's life, and for many people a central part of their lives (Abrams, 1973; Klein, 1976). Kornhauser (1965) found that indeed this was so, but furthermore that certain factors experienced in work and expressed as job dissatisfaction are important determinants of people's mental health. The strongest relationship he found was between the opportunity to use abilities and mental health. He concluded that "by far the most influential attribute (of jobs) is the opportunity work offers - or fails to offer - for use of the worker's abilities and for associated feelings of interest, sense of accomplishment, personal growth and self-respect." (p.363). Perhaps it goes without saying that routine, repetitive jobs were seen to provide few opportunities of this kind. The interpretation of such data is difficult however, and the relationship is probably of a low order (Gruneberg, 1979).

Physical sickness has not often been studied separately in relation to job satisfaction; one reason is that illness is the most important cause of most absenteeism (Miner and Brewer, 1976). In a review of the literature, Jenkins (1971) finds some evidence for a relationship between heart disease and job dissatisfaction, although the nature and direction of the relationship is unclear. Singer and Rutenfranz (1972) found a close correlation between job-related health disturbances and job satisfaction amongst West German ATCOs, although age and length of service factors were also influential.

A study often quoted is that by Palmore (1969), who found that the single best predictor of longevity was work satisfaction. Work satisfaction was defined as a feeling of general usefulness and ability to fulfill a meaningful social role. This definition would exclude much routine assembly line and associated work which has been found to induce a feeling of uselessness in its incumbents (Blauner, 1964).

A recent study by Hamner and Smith (1978) suggested that employees who are dissatisfied with their work are more likely to participate in union activities. The evidence with respect to grievances and disputes has not been studied much, although there is some empirical evidence to support the hypothesis that increasing satisfaction reduces grievances. (Ford, 1969; Maher, 1971).

2.2.4. Definitions of Job Satisfaction

Many reviews of empirical studies of job satisfaction, in particular the early reviews (Brayfield and Crockett, 1955; Vroom, 1964) note the inconsistency of findings across studies. In large part this is due to the lack of clear definition of the concept of job satisfaction. Operational definitions abound in the literature, some explicit whilst others are only implicitly revealed by the nature of the questions asked. Part of the problem lies in the apparent simplicity and generality of the concept; it was in lay usage before social scientists began to use it. Very few studies before those of Smith and her associates (e.g. Smith, Kendall and Hulin, 1969) employed a standardised measure. The common approach of too many studies has been 'correlation without explanation' (Locke,1969). The extent of the problem is revealed by Bowles (1976) and Wanous and Lawler (1972) who showed that there can be very poor correlations between different measures of job satisfaction employed on the same population.

Job satisfaction and dissatisfaction are attitudes expressed by individuals towards their jobs, broadly reflecting the extent to which their jobs fulfill their needs. Indeed, Vroom (1964) points out that the terms job satisfaction and job attitude have typically been used interchangeably; positive attitudes towards the job are equivalent to job satisfaction, whilst negative attitudes are equivalent to job dissatisfaction. It will become apparent later in this section that the inclusive nature of such a definition of job satisfaction is not accepted by everybody.

Although all definitions of job satisfaction support the concept as being an attitude, there are differences between definitions in the extent to which they assign cognitive or affective emphasis to it. The majority, however, describe job satisfaction in largely affective terms. For example, as mentioned earlier in this chapter, Locke (1969) defines job satisfaction as "the pleasurable emotional state resulting from the appraisal of one's job as achieving or facilitating the achievement of one's job values." Job dissatisfaction, on the other hand, "is the unpleasurable emotional state resulting from the appraisal of one's job as frustrating or blocking the attainment of one's job values or as entailing disvalues." (p.316). Locke then goes on to say that "job satisfaction and dissatisfaction are a function of the perceived relationship between what one wants from one's job and what one perceives it as offering or entailing." Whilst just falling short of an operational definition of the construct, this last phrase clearly fits into what Cameron (1973) calls a discrepancy theory of job satisfaction.

The notion of present satisfaction, that is to say actual satisfaction with what one now possesses or has achieved, is typical of affective definitions of job satisfaction. However, Vroom (1964) distinguishes between the notions of actual satisfaction which he calls 'value', and anticipated satisfaction from an outcome, which he describes as its 'valence'. (p.15). The term valence derives from Lewin (1951), and as used by Vroom it refers to the perceived positive or negative value assigned by a person to various outcomes of performance on the job. Valence is therefore anticipated value.

Although Vroom begins by stating explicitly that valence is used by him to refer to "affective orientations towards particular outcomes" (p.15) it becomes clear later that there is a significant cognitive component to the construct. He mentions the views of Peak (1955) on instrumentality of outcomes, whereby an outcome can have valence because it leads to other consequences and not for its own sake. The perceived instrumentality of an outcome or object for the attainment of other outcomes is a cognitive attitude akin to belief. Whilst accepting that some things have valence for their own sake, Vroom offers the proposition that "the valence of an outcome to a person is a monotonically increasing function of the algebraic sum of the products of the valences of all other outcomes and his conceptions of its instrumentality for the attainment of these other outcomes." (p.17)

Vroom does not really attempt to explain satisfaction in his book, being mainly concerned with producing a model of motivation that will explain choices between actions. Nevertheless, he goes so far as to state that "the term job satisfaction .... is the conceptual equivalent of the valence of the job or work role to the person performing it." (p.101). He notes that in common parlance satisfaction is referred to only in the sense of actual satisfaction, and informs the reader that in discussing the literature he will adhere to convention and use job satisfaction in this sense. However, he urges the reader to bear in mind, "particularly in theoretical discussions, the assumed correspondence between satisfaction and valence." (p.101).

In view of this, it is impossible to agree with Locke's (1969) criticism of Vroom's model (1964) that it contains a double usage of the concept of 'valence'. He writes:

"On the one hand, the valence of an object or outcome is defined as one's <u>anticipated</u> satisfaction with something not yet attained (1964, p.15). The term valence is also taken to be synonymous with one's <u>actual</u> satisfaction with objects which one now possesses. (pp.100-101)." (p.322). It is quite clear from careful study of the relevant pages that Vroom uses valence in his model in only one sense, whilst referring to job satisfaction elsewhere in two senses. It is in the sense of valence, however - that is, as anticipated satisfaction - that Vroom primarily wishes job satisfaction to be understood, at least theoretically.

Some writers have suggested that anticipated satisfaction should not be subsumed within the concept of job satisfaction, but should be kept conceptually distinct. Thus Graen (1969) defines anticipated satisfaction for an outcome as 'attraction'. Wanous and Lawler (1972) support this distinction, whilst emphasising that it is one of degree and not of kind, on the grounds that there are a priori reasons for expecting job attraction to be more strongly related to, and therefore a better predictor of, absenteeism and turnover. Their definition of job attraction is elaborated and operationalised by Barth (1976).

One problem that such a distinction cannot overcome operationally is that people may well include job attraction, or anticipated satisfaction, in rating their overall satisfaction with the job. This is one of several reasons why, as Wanous and Lawler (1972) point out, "asking a person simply to rate his (overall) job satisfaction produces different results than asking him to rate his job on two scales and then taking their difference or product as a measure of satisfaction." (p.103).

There is reason to believe that the degree of relationship between job satisfaction (i.e. actual satisfaction) and job attraction is a function of the social class of the individual. Barth (1976) found that for a sample of engineers, overall job attraction was most highly correlated with measures of job facet satisfaction, whereas for a sample of blue-collar employees it was most highly correlated with measures of job facet attraction. He suggests that this difference might be accounted for by differences in Internal and External control (Rotter, 1966) between the samples. However, markedly different orientations towards what Swift (1969) calls the "time-span of attention to the world" have been identified in the different social classes, central to which are the concepts of immediate and deferred gratification. Swift comments that the archetypal lower class person has "an immediate orientation. Things happen now ..... In contrast the ideal-type middle class life is future-orientated .... Deferred gratification for the sake of future benefits is the keystone of life." (p.75). One could hypothesise therefore that for the middle class person, anticipated satisfactions are of greater significance and contribute more towards overall job satisfaction than they do for the working class employee, who is more oriented towards predictable short-term goals and satisfactions. This would imply that job attraction as defined by Wanous and Lawler (1972) is a more relevant concept for middle class employees than is job satisfaction with its typically affective emphasis on present satisfaction with outcomes already achieved.

Wanous and Lawler (1972) attempted to bring some order to the many operational definitions of job satisfaction. A preoccupation with many of the studies has been to define how overall job satisfaction is derived from job facet satisfaction, and how to measure job facet satisfaction in the first place. Overall job satisfaction is derived usually by combining facet satisfaction data in either a multiplicative or additive manner. Measures of facet satisfaction mostly imply either a simple fulfillment theory of job satisfaction (e.g. Alderfer, 1969; Schaffer, 1953), whereby the employee is asked to state either how satisfied he is with each facet or how much of each facet there is now in his job; or a discrepancy theory (e.g. Lofquist and Dawis, 1969; Porter, 1961) which measures the difference between the individual's values or needs and the existing amount of each in the job. Different studies, however, have often disagreed as to the right kinds of facet to measure, or even what they mean by a facet. Moreover, Locke (1969) comments that there has been much inconsistency in the use and definition of other relevant terms in these studies: value , need and expectation for example.

Sadly, it must be concluded that our understanding of the determinants, correlates and concept of job satisfaction has progressed very little as a result of empirical approaches to it. It is only recently that it has been fully appreciated to what extent different operational definitions can influence empirical results. If one adds to this the inconsistency in defining variables supposedly related to job satisfaction (e.g. absenteeism, performance, job facets) it must be said that such relationships with job satisfaction as have been identified, most of them weak and inconsistent, are as yet poorly understood.

The concept of job satisfaction could not be understood adequately until it became included in a model of work motivation and job behaviour. The next section reviews a number of models of work motivation which have helped to advance our understanding of people at work and to adopt appropriate strategies for work design.

2.3 MODELS OF MOTIVATION

There is general agreement that motivation is a concept that explains the instigation, direction, amplitude, maintenance and termination of an individual's behaviour, (Campbell and Pritchard, 1976). Theories of motivation have reflected the major trends in psychology as a whole; thus at different times motivation has been explained in psychoanalytic, mechanistic and most recently cognitive terms. The major models of organisational behaviour are cognitive, allowing for several cognitive processes to intervene between stimulus and response.

A most useful framework within which to discuss the motivational models is provided by Campbell, Dunnette, Lawler and Weick (1970), distinguishing between process and content models or theories.

2.3.1 Content Theories

The focus of attention of content theorists has been the identification and classification of variables that are thought to influence behaviour, much less attention being paid to the processes by which they motivate behaviour. The two theories to be discussed below have attempted to identify, by widely differing methods, the needs and outcomes that are most influential in motivational terms.

One of the most influential theories has been that of Abraham Maslow (1943; 1970), whose interests were clinical rather than organisational, and humanistic rather than scientific. He postulated that there are five basic classes of human needs, arranged in a hierarchy of potency. The five classes of needs, in hierarchical order from lowest to highest are: (1) physiological needs, including hunger and thirst; (2) safety needs, involving a wish for freedom from physical danger; (3) belongingness or social needs, including the need for friendship, affection and love; (4) esteem needs, involving a desire for self-respect and for respect from others; and (5) self-actualisation needs. This last category is the most difficult to define, but is akin to the desire for self-fulfillment or growth towards an idealised potential.

Although it is usual to refer to self-actualisation as the highest level of needs, the prepotency of the physiological needs is posited to be greatest, and Maslow argued that lower order needs must be 'largely' satisfied before the next higher level of needs becomes active. Nevertheless, it is the higher-level needs of esteem and self-actualisation which are said to be of most importance in contemporary industrialised societies, since the lower level needs have been satisfied or fulfilled for most people by more than adequate standards of living.

Maslow's theory came to have a considerable impact on management and the work design movement through the writings of McGregor (1960) and Herzberg (1966). Their interpretation of present day job design and management styles was that both were mainly inappropriate to the motivation of employees. Arguing that, on the one hand most employees' needs for food, drink, security and belongingness were satisfied already, and on the other that esteem and self-actualisation needs were possessed by most human beings, they criticised many jobs for failing to provide any opportunity for higher level need fulfillment, and managers for assuming that their employees desired only lower level need fulfillment from their work. The solution offered by both writers was to enrich jobs in order that higher order needs could be fulfilled by work.

Despite its intuitive appeal, Maslow's theory has come in for some strong criticism. Blackler and Williams (1971) note that whilst interpretation of situations in terms of Maslow's model has proved easy and in some cases fruitful, empirical testing of it has proved very difficult. There are two reasons for this difficulty; firstly, the problem of defining self-actualisation clearly in either conceptual or operational terms, and secondly the requirement for longitudinal studies to support Maslow's claim that the prepotency of needs will change over time. Maslow's own explanations of self-actualisation are often vague, inconsistent, and frequently expressed in a metaphysical jargon. The term is used to refer both to a process and to a subjective, momentary experience. He writes that self-actualisation "refers to the desire for self-fulfillment, namely, to the tendency for one to become actualised in what one is potentially. This tendency might be phrased as the desire to become more and more what one is, to become everything that one is capable of becoming." (1943, p.382). It is possible to understand the meaning and agree with the values adhered to by Maslow yet sympathise with Locke's (1976) objectivist conclusion that "it is virtually impossible to find an intelligible definition of the concept of self-actualisation in Maslow's writings ...... As Maslow defines it, the term self-actualisation has no coherent meaning and cannot be used to explain anything." (p.1308).

There has been criticism, too, of Maslow's classification of needs, since there are no clear empirical or a priori grounds for distinguishing five classes. Porter, Lawler and Hackman (1975) note the evolution from one-factor motivation theories, such as the hedonism principle, to attempts to identify and classify lists of human instincts, drives and needs. Murray (1938) for example, identified about twenty basic needs, whereas Alderfer (e.g. 1972) has reformulated Maslow's list into three basic needs labelled existence, relatedness and growth needs. These alternative need classifications are at different levels of abstraction, and it is arguable whether the term 'need' is appropriate to describe all the items.

There is considerable evidence of overlap between the supposedly separate classes of needs listed by Maslow and alternative clustering of needs have been found, (Payne, 1970; Schneider and Alderfer, 1973). Alderfer (1972) however has collected empirical evidence that his classification exhibits convergent and discriminant validity to a greater extent than Maslow's. Although there is strong support for the prepotency of existence needs, and some support for the notion that security needs take priority over higher order needs (Cofer and Appley, 1964; Alderfer, 1972), there is very little evidence for Maslow's hierarchy above the security level (Lawler and Suttle, 1972).

Herzberg's two-factor theory of motivation (Herzberg, Mausner, and Snyderman, 1959; Herzberg, 1966) was discussed to a limited extent earlier in this chapter with respect to the evidence that his research provided on determinants of job satisfaction and dissatisfaction

The most controversial and influential aspect of his findings was the distinction between two types of job factors, intrinsic and extrinsic, having differential effects on job attitudes and behaviour, and the dichotomising of the job satisfaction - dissatisfaction dimension. Herzberg asserted that factors extrinsic to doing the job itself would lead to job dissatisfaction if they were inadequate; but, in the same way that improving hygiene only removes disease and does not help a person to become fit and healthy beyond a minimum description of that state, so improving the extrinsic factors only serves to remove dissatisfaction, not to increase positive satisfaction. To increase job satisfaction and motivate one's employees, Herzberg said, it was necessary to improve the factors intrinsic to work itself.

Herzberg (1966) interpreted these findings in terms of a model of human motivation, comprising two basic needs; the physical need for pain -avoidance, and a psychological need for growth or self-actualisation. He also argued that the intrinsic factors were both satisfiers and motivators without specifying in what way the two psychological states should be distinguished, if at all.

The current consensus is that the two-factor theory does not stand up to the test, and it seems most unlikely that this view will change. Criticisms of both a logical and empirical nature have been directed at the theory. Firstly, as with so much research in the area, there has been inconsistency by Herzberg and subsequent investigators as to the precise specification of the theory. King (1970) identified five distinct versions of Herzberg's theory that had been either explicitly or implicitly stated by Herzberg and others. Only three of these had been empirically tested, and none of the three could be said to be valid.

The major criticism of the theory is that it is method specific (House and Wigdor, 1967; King, 1970). Herzberg used the critical incident technique, which requires subjects to self-report incidents in their job history that caused them particular satisfaction or dissatisfaction. Studies which have used comparable methods tend to support the dichotomy of job factors, whereas researchers using different methods have failed to confirm Herzberg's results. It has been suggested that the supposed qualitative difference between satisfiers and dissatisfiers stems from defensive processes within respondents, (Vroom, 1964, p.129) which are more likely to occur using the critical incident method. A similar interpretation is offered by Farr (1977), who refers to Heider's (1958) attribution theory in suggesting that favourable job outcomes tend to be attributed to the self and unfavourable ones to the environment. This tendency is revealed also if use is made of Locke's distinction between Events and Agents (Locke, 1976).

Other criticisms of Herzberg's theory relate to (1) the generalisations from the use of frequency data (Locke, 1976; Vroom, 1964) since it is possible that the frequency of particular factors being mentioned is due to the nature of the jobs being investigated, not to the propensity of those factors to cause either satisfaction or dissatisfaction; (2) generalisations to individuals other than those measured, since not all employees want enriched jobs (Ford, 1969; Hulin and Blood, 1968).

The great value of Herzberg's theory, despite its apparent invalidity, is that it has directed attention towards the content and design of people's jobs as a critical factor in motivation, for no-one now denies that intrinsic factors are of major importance in work motivation. It has been suggested that, rather than intrinsic factors contributing mainly to job satisfaction, they are more potent variables affecting both satisfaction and dissatisfaction with the job (Ewen, Smith, Hulin and Locke, 1966; Wall and Stephenson, 1970).

As a result of Herzberg's theory, many organisations have tried redesigning jobs in such a way as to increase factors such as achievement, recognition and responsibility. The emphasis has moved away from attempts to improve physical working conditions, which characterised the contributions to work design of psychologists in the early part of this century, through 'humanising' social relationships in the workplace following the Hawthorne studies, towards a direct involvement in the design of jobs that arguably is of equal importance to the engineer's contribution. The combined message from Maslow and Herzberg was that people's needs cannot be satisfied solely by financial reward and a pleasant working environment. In order to motivate them, it is necessary to provide them with jobs that challenge and stretch them, enabling them to 'grow' in a psychological sense. On both counts then - the simplification of jobs and the motivation of employees - Taylor was said to be wrong.

2.3.2 Process Theories.

Whereas content theories focus on the sorts of needs and outcomes that motivate people, process theories attempt to specify and define the major variables that are involved in the process of motivated behaviour, and the interaction between those variables that influence dependent variables such as performance. In contrast to the explanatory approach of content theories, process theories have tended to stress the prediction of people's behaviour; for example, when will someone choose to work hard at a job, and when will he choose to withdraw from a job or organisation?

The cognitive process theory of motivation that dominates the organisational psychology literature is expectancy theory, or expectancy-instrumentality-valence theory (VIE) to give it its full title. The origins of this theory may be found in Lewin's (1951) model of human behaviour, which included the construct of valence, defined as the perceived attractiveness of various actions or outcomes, and described the influence of tension-producing needs on the valence of outcomes. Lewin perceived motivation as a force on an individual which was a product of the push of need tensions and the pull, or attraction, of valent outcomes.

This essentially ahistorical model was elaborated for organisational settings by Vroom (1964), in an attempt to explain and predict (1) the choices made by people between tasks, (2) the extent of their satisfaction with the chosen task; and (3) the level of their performance or effectiveness on the chosen task. The model contains three basic constructs: valence, instrumentality and expectancy. Valence was defined earlier in this chapter as the anticipated satisfaction from an outcome, or the perceived positive or negative value assigned to it. Instrumentality refers to the perceived contingency that one outcome has for others. In other words, an outcome may acquire valence not just, or at all, for its own sake but because it leads directly or indirectly to other outcomes. Thus promotion may acquire high valence because it leads to higher pay and a higher social status. Finally, expectancy refers to the perceived relationship between a particular act and a particular outcome, in terms of the likelihood that the former will lead to the latter. Vroom proposed that "the force on a person to perform an act is a monotonically increasing function of the algebraic sum of the products of the valences of all outcomes and the strength of his expectancies that the act will be followed by the attainment of these outcomes." (1964, p.18). This proposition is later adapted by Vroom (1964, p.284) to explain how a person chooses not only between actions or tasks but between different levels of effort within a job or task. The force on the person in this case is a function of the valences of different levels of performance and the expectancy that specific levels of effort will result in their attainment.

It has been pointed out (e.g. Deci, 1975) that Vroom's model is essentially one of extrinsic motivation, that is, behaviour motivated by extrinsic rewards. This is largely true, for the first proposition in his model defines the valence of a particular outcome only in terms of the valences of all other outcomes to which it might lead. There is therefore no mention of the intrinsic value of direct, first-order outcomes. However, Vroom did not deny that first-order outcomes could have intrinsic value, for he notes that "some things are desired and abhored 'for their own sake'. " (1964, p.16). Galbraith and Cummings (1967) modified Vroom's model to allow for intrinsic motivation, by including in the description of valence a function of the valence of intrinsic rewards.

The matter of first-order outcomes having intrinsic value is an important one in the context of job design. The job design movement that started in the 1960's, with Herzberg's ideas at its base, perceived job redesign or job enrichment to be a strategy for <u>intrinsic</u> motivation. Herzberg (1968) contrasted traditional approaches which involved extrinsic work motivation, which he subsumed under the colloquial phrase KITA, with job enrichment which satisfied the need for psychological growth. Motivation was posited to be directed at performance on "tasks that induce growth ..... they are the job content." (p.56). Thus the employee was motivated to perform on tasks for the intrinsic satisfaction that such performance gave. What was needed was a process model of motivation that could encompass this possibility. Without it, the job design movement had a weak conceptual base.

This model was provided initially by Porter and Lawler (Lawler and Porter, 1967a and b; Porter and Lawler, 1968). Their model addressed two basic questions: (1) What factors determine the EFFORT a person puts into the job; and (2) What factors affect the relationship between EFFORT and PERFORMANCE? Two major determinants of effort are posited in the model, 'value of rewards' and 'effort-reward probability'. Value of rewards is defined as the attractiveness of possible rewards and outcomes to the individual. Lawler and Porter rely on Maslow's (1954) hierarchy of needs in suggesting that one expects someone to value rewards to the extent that he believes they will satisfy his needs for security, belongingness, autonomy and self-actualisation. They acknowledge too that values may change over time, in a manner similar to the subjective utility concept used in decision theories.

The second variable, the probability that rewards depend upon effort, refers to the person's subjective expectancy that rewards valued by him will follow from exerting certain levels of effort. This attitude is hypothesised by Lawler and Porter to be a combination of two subsidiary expectancies, namely (1) the probability that rewards depend upon performance, and (2) the probability that performance depends upon effort. For example, an employee may expect that if he exerts a particular level of effort directed towards the task, he will perform that task well. At the same time, he may not expect good performance to lead to valued rewards; promotion, for example, may depend upon seniority. In this case, the employee will not expect <u>rewards</u> to depend upon effort, and may therefore perform minimally - i.e. at a level sufficient to keep him in the organisation - rather than optimally.

The authors stress that the relevant variable is <u>perceived</u> probability or subjective expectancy, not the actual probability. Given this, the theory demands an attitude survey rather than an objective measurement or observational approach to the problem.

Two variables are hypothesised to moderate the relationship between effort and performance: firstly, the person's abilities, including personality traits, and secondly role perceptions. Whereas abilities do not change very much in the short term, although they may be modified, role perceptions are one of many situational factors which can be changed considerably in the short term. Another such variable is job design, which is of more interest in the context of the research that follows. Role perceptions, however, represent the kinds of activities and behaviours in which the person feels he should engage so as to perform the job effectively; thus they determine the direction of effort.

Lawler and Porter's model presents a set of attitude variables (effort-reward probability, value of rewards and role perceptions) which are hypothesised to influence job performance. In contrast to previous theories, however, job satisfaction is posited to be primarily dependent upon performance. Good performance results in a certain degree of job satisfaction whilst poor performance causes the person to be dissatisfied. However, if there is persistent satisfaction or dissatisfaction conditional on performance, then job satisfaction itself is a defineable outcome. Thus it becomes a positively or negatively valued reward or outcome which feeds back into the model, influencing future performance.

Another important type of feedback - at least from the point of view of its implications for job design - is provided by the reinforcement history of the individual. That is, over time his perceived effort-reward probability will change in the light of actual rewards both intrinsically and extrinsically mediated. This aspect of the model allows for the influence on intrinsic motivation of a change in job design. The next section examines more recent research which has elaborated on this aspect of VIE theory.

2.4 JOB DESIGN RESEARCH

2.4.1 Task Characteristics and Job Design

VIE theory provided a model of human motivation that for the first time offered a dynamic interpretation of how job content and job design affected employee motivation and behaviour. This interpretation was made initially by Lawler (1969), writing at a time when Herzberg's Two-Factor theory of work motivation was becoming discredited. Lawler explained that, according to expectancy theory, job design affected motivation by changing the probability that valued outcomes were dependent upon effort. Of the two kinds of outcomes, extrinsic and intrinsic, Lawler argued that it was the intrinsic rewards stemming directly from task performance itself that were most relevant in this respect. Enriching a job's content presented the employee with increased likelihood of experiencing feelings of accomplishment, achievement and of using valued skills and abilities in the event of effective task performance. These internally mediated rewards, because they followed immediately upon effective task performance, were therefore potentially excellent motivators. In VIE terms, higher effort-reward probabilities could be established for them than for externally mediated rewards.

The conceptual framework specifying which job characteristics resulted in intrinsically motivated employees was tackled by Hackman and Lawler (1971) following earlier attempts by both authors to specify them (Hackman, 1969; Lawler, 1969), and they developed further the process model linking job design with employee performance. Their contribution thus began to bring together the work of content theorists such as Herzberg and process theorists such as Vroom, providing a more integrated theoretical base for job design. This line of research has been developed further by Hackman in cooperation with Oldham (Hackman and Oldham, 1976).

Hackman and Lawler (1971) noted with dismay that despite many job design studies over a period of years, little knowledge had been accumulated regarding the effects and effectiveness of job redesign. Many studies in the 1950's and early 1960's had adopted a pragmatic approach to the problems created by job simplification and Taylorism (e.g. Kilbridge, 1960; for reviews cf. Aldag and Brief, 1979; Rousseau, 1977). The technique of job enlargement was used to reverse the trend of traditional job design procedures; this was defined as "the expansion of job content to include a wider variety of tasks and to increase the worker's freedom of pace, responsibility for checking quality, and discretion for method." (Kilbridge, 1960, p.357). Following the publication and propogation of Herzberg's Two Factor theory (e.g. Herzberg, 1966) the concept of job enrichment was invoked, distinguished somewhat vaguely from job enlargement by its emphasis on vertical enlargement of jobs by adding tasks that increase responsibility. Several large scale studies were carried out which seemed to show that job enrichment worked (e.g. Ford, 1969, 1973; Paul and Robertson, 1970). However, there were too some conflicting reports (e.g. MacKinney, Wernimont and Galitz, 1962) and by the 1970's there was some dissatisfaction with the progress that had been made in the job design field.

This could be explained largely by two deficiencies: (1) the lack of a systematic conceptual or theoretical basis for the studies: and (2) the absence of any suitable measure of job change (Hackman and Oldham, 1975). A third problem, though by no means exclusive to the job design area, was the dependence on case studies as opposed to experimental settings, with their lack of controls (Hulin and Blood, 1968).

There was no doubt that Herzberg's motivators were too general and too person-centred to provide a basis for systematic job redesign. It was not at all clear how a job should be changed to provide greater opportunity for feelings of achievement, for example. This problem had been tackled with some success by Turner and Lawrence (1965), although there had been little subsequent development of their RTA index. Hackman and Lawler noted that Turner and Lawrence's predictions regarding the effect of job characteristics on employee satisfactions and absenteeism were not fully supported. Their model seemed to be moderated by cultural variables, interpreted by some researchers in terms of alienation (Hulin and Blood, 1968).

Hackman and Lawler suggest five propositions based on expectancy theory which specify how employee motivation can be improved through job design: (1) To the extent that someone believes he can achieve valued outcomes by engaging in specific behaviours, he is more likely to engage in that behaviour; (2) Outcomes are valued by a person to the extent that they satisfy his physiological or psychological needs, or lead to other outcomes which are expected to do so. However, if an outcome fails to satisfy over time, it will reduce in value and eventually cease to be a motivator; (3) Thus, to the extent that job content enables an employee to best satisfy his needs by working effectively towards organisational goals, he will tend to work harder towards their achievement; (4) Most lower level needs, such as physiological and safety needs, are reasonably well satisfied for people in industrialised societies on a continuing basis and are therefore not usually powerful motivators. High level needs, on the other hand, can be satisfied without reducing the desire to obtain further satisfaction, and are therefore more powerful motivators. On the other hand, not everyone responds to them; (5) People wanting to satisfy higher order needs are most likely to do so when working effectively on jobs that allow them to accomplish something they believe to be worthwhile or meaningful, providing they receive feedback on their performance. (Hackman and Lawler, 1971, pp.262-3).

Adapting the six requisite task attributes and associated task attributes proposed by Turner and Lawrence, Hackman and Lawler described four measurable core job dimensions which were conceptualised as being essential to employee motivation and effective performance: variety, task identity, autonomy and feedback. The developed also a measure of the strength of a person's desire to satisfy higher level needs. The following discussion of the job design model, however, includes the further development of these ideas as presented by Hackman and Oldham. (Hackman and Oldham, 1975; 1976).

The job characteristics model incorporates three groups of variables, whose interrelationship is moderated by a fourth variable. Five "core job dimensions" elicit three "psychological states", which in turn result in a number of "personal and work outcomes". The relationships between the core job dimensions and the psychological states, and that between the psychological states and the outcomes, are moderated by the employee's 'growth need strength' (GNS) - that is, the strength of his desire to satisfy higher order needs through his work. Each of these components of the model will now be discussed in turn.

The three psychological states are described by Hackman and Oldham (1976, p.255) as the "causal core of the model". They are defined as follows:

1. <u>Experienced Meaningfulness of the Work</u>. The degree to which the employee experiences the job as one which is generally meaningful, valuable and worthwhile.
2. <u>Experienced Responsibility for Work Outcomes.</u> The degree to which the employee feels personally accountable and responsible for the results of his work.

3. Knowledge of Results. The degree to which the employee knows and understands how effectively he performs the job.

The model postulates that people will experience higher level need satisfaction to the extent that they learn (knowledge of results) that they have performed effectively on a task that they feel to be worthwhile (experienced meaningfulness) and for which they feel personally responsible (experienced responsibility).

Three core job dimensions are postulated to elicit experienced meaningfulness: Skill Variety, Task Identity and Task Significance. The first of these, Skill Variety, is defined as the degree to which a job requires a variety of different activities in carrying out the work, which in turn involve the use of a number of different skills and talents of the person. (Hackman and Oldham, 1976). This dimension is a combination of two of Turner and Lawrence's requisite task attributes, namely 'Variety' and 'Knowledge and Skill'. The former was classified as an activity, the latter as a mental state. Hackman and Oldham are primarily describing a job which requires the employee to use a variety of skills and abilities which he values, in the accomplishment of the task. That is, only variety which challenges the employee will be experienced as meaningful.

Task identity is defined as the degree to which the job requires completion of a whole and identifiable piece of work; that is, doing it from beginning to end with a visible outcome. This dimension is explained more clearly in the original Hackman and Lawler (1971) paper. Referring to Turner and Lawrence (1965), who classified task identity as an associated task attribute, they explain that jobs high on this dimension are characterised by (a) clarity of cycle closure; i.e. the job provides a distinct sense of the beginning and end of a transformation process; (b) high visibility (to the employee) of the transformation; (c) high visibility of that transformation in the finished product; and (d) a transformation of considerable magnitude.

This last component of Turner and Lawrence's task identity was eventually incorporated implicitly in a separate core job dimension, Task Significance, by Hackman and Oldham. They defined task significance as the degree to which the job has a substantial impact on the lives and work of other people, whether in the immediate organisation or in the external environment.

To summarise this part of the model, people will experience their jobs as being meaningful to the extent that they are required to use a variety of their valued skills and abilities, in doing a whole and identifiable piece of work of some significance.

Experienced responsibility is postulated to be the direct result of the degree of Autonomy in the job. This is defined as the degree to which the job provides substantial freedom, independence and discretion to the employee in scheduling the work and in determining the work methods and procedures. If the employee has such discretion in determining his own work methods and scheduling, the model predicts that he will feel strong personal responsibility for the success or failure of work outcomes.

Finally, the employee experiences knowledge of results to the extent that he receives Feedback. This, the fifth core job dimension, is defined as the degree to which carrying out the work activities required by the job results in the employee obtaining direct and clear information about the effectiveness of his performance. Hackman and Lawler (1971) explain that such feedback may come from doing the task itself, or from other people ('agents').

Before discussing the third set of variables in the model - outcomes - it should be explained that the five core job dimensions are combined in the model to provide an overall index of motivating potential for a given job. The most commonly described method of arriving at the Motivating Potential Score (MPS) is multiplicative, as follows:

$$1. \quad \text{MPS} = \frac{\text{Skill Variety} + \text{Task Identity} + \text{Task Signficance}}{3} \times \text{Autonomy} \times \text{Feedback}$$

However, as later discussion will show, the simple additive method is often as, if not more, valid. Thus:

2. MPS = Skill Variety + Task Identity + Task Significance + Autonomy + Feedback.

The approach adopted by Hackman and Oldham to putting numbers to these dimensions will be explained later in this chapter.

The model predicts that if a job is high on all five core job dimensions, such that the incumbent experiences it as being meaningful, he feels responsible for the outcomes of his work and he knows how effective his performance is, then a number of outcomes will occur. The employee is predicted to feel greater job satisfaction than someone in a job with low motivating potential; in particular, he is expected to be more satisfied with the opportunities for psychological growth and development. He will have higher intrinsic motivation, or internal work motivation as it is called in the model. The quality of his work will be higher. Finally, he is more likely to be a good attender and to wish to remain in the organisation. Hackman and Oldham do not specify quantity of work or productivity as an outcome in the model, although it might appear that the model implies such an outcome. In the earlier paper, Hackman and Lawler (1971) assert that "the harder and better an individual works on (a high MPS job), the more opportunities he will have to experience higher order need satisfactions and the more incentive there can be for continued effective performance." (p.263). In discussing the results of a study carried out to test the model, however, they conclude that high quality work is more likely to be perceived by the employee as a meaningful outcome than merely producing large quantities of work. (p.274). The validity of the model-predicted relationship between task characteristics and outcomes is discussed in a later section.

The fourth component of the model, in addition to job dimensions, psychological states and outcomes, is Individual Growth Need Strength (GNS). The earlier research of Turner and Lawrence (1965) and of Blood and Hulin (1967) suggested that not all employees derive greater satisfaction from enlarged or enriched jobs. These authors attempted to explain individual differences in response on a sociological level; that is, in terms of differences between town and city dwellers or in terms of alienation. Other research has identified individual differences in response to work according to the strength of need for achievement (McClelland, 1961), or the degree of instrumentality with which employees approached work (Goldthorpe, Lockwood, Bechhofer and Platt, 1968), or in terms of their internality or externality (Rotter, 1966).

Hackman and Oldham (1976) adopt an individual level of analysis, preferring to talk about individual growth need strength. This individual difference variable refers to the degree to which the person values personal growth and development resulting from effective performance on a job rating high on the five core job dimensions. Only those people with strong growth need strength are predicted to respond positively to high MPS jobs. The model shows that GNS moderates the relationship (a) between the core job dimensions and the psychological states, and (b) between the psychological states and work and personal outcomes.

2.4.2 Job Diagnostic Survey

Hackman and Oldham (1975) developed a measuring instrument based on the job characteristics model in order that they might diagnose jobs as a basis for job redesign, also that they might measure the effects of changes to job content, and in order that the model itself might be tested empirically. This instrument they called the Job Diagnostic Survey (JDS) (cf Appendix II). The JDS is administered as a questionnaire to job incumbents, and it provides measures of each of the variables contained in the job characteristics model and discussed above. The questionnaire is a development of earlier instruments used by Turner and Lawrence (1965) and Hackman and Lawler (1971). During its initial two-year developmental period, three major revisions of its content took place, based on psychometric and substantive considerations. Hackman and Oldham attempted to maximise both the scale reliabilities and the substantive 'richness' of the measures. However, since many of the constructs - such as Skill Variety - are complex and multidimensional, maximising the substantive richness entailed maintaining the heterogeneity of individual items which measured a given construct. This process, however, acted against the maximisation of scale reliabilities.

Each variable contained in the model is measured in two different sections of the questionnaire, using a different format in each section to improve reliability. Seven-point response scales are used in all but one section of the JDS; the exception, however, is converted to the equivalent of a seven-point scale when scoring. Each variable is measured by averaging the scores from a minimum of three questionnaire items. Some items are reverse scored, in order to reduce problems of response set and improve reliability.

2.4.3 Discussion of Job Characteristics Model

Some studies have been carried out in the U.S.A. to test the job characteristics model. These have found general support for the model, although there have been exceptions to the predicted relationships between variables in every study. (Brief and Aldag, 1975; Dunham, 1976; Hackman and Lawler, 1971; Hackman and Oldham, 1976; Hackman and Oldham, 1980; Hackman, Pearce and Wolfe, 1978; Klein, 1977; Oldham, Hackman and Pearce, 1976; Oldham, Hackman and Stepina, 1978; Umstot, Bell and Mitchell, 1976).

Although the model assumes that the five core job dimensions are independent, there is now substantial evidence that they are moderately intercorrelated (Oldham, Hackman and Stepina, 1978; Wall, Clegg and Jackson, 1978). As the authors themselves note, there is no a priori reason why the dimensions should be completely independent. Indeed, some intercorrelation is to be expected, if it is assumed that highly motivating jobs are 'good' in a number of ways, and that boring jobs are 'bad' in several ways. The strongest relationships are between Skill Variety and Autonomy (0.44), and Skill Variety and Task Significance (0.42), with an average intercorrelation between the five core job dimensions of 0.32. (Oldham, Hackman and Stepina, 1978, p.17). Recent factor analytic studies suggest that the JDS scale items for the five core job dimensions sometimes reduce to between two and four job dimensions. (Dunham, 1976; Dunham, Aldag and Brief, 1977). These differences in dimensionality appear to depend upon sample characteristics.

The intercorrelation between dimensions makes for an interesting comparison with work by Cooper (1973a). Applying a statistical procedure known as Hierarchical Linkage Analysis (McQuitty, 1960) to Turner and Lawrence's (1965) data, Cooper found that the several task characteristics fell into three basic clusters, which he termed 'physical variety', 'task uncertainty' and 'response uncertainty'. These last two clusters combined at a higher level to form a superordinate cluster which he called (confusingly) 'skill variety'. Within this superordinate cluster fell task characteristics which resemble quite closely the Hackman dimensions of 'skill variety', 'autonomy' and 'task significance'. These three dimensions, as was noted above, showed the strongest relationships in studies using the JDS (Oldham, Hackman and Stepina, 1978). This suggests that hierarchical cluster analysis of JDS data may reveal superordinate job dimensions. Rousseau (1977) suggests on the other hand, that the strength of intercorrelation between certain of the dimensions may indicate causal relationships between them. This aspect of the model requires further investigation.

The variable independency of the job characteristics has two important implications for the model. Firstly, if intercorrelations between the five job dimensions are high, indicating fewer empirically independent dimensions, then the multiplicative method of calculating the MPS may be inappropriate. Oldham et al recommend an additive method of deriving the MPS from the five dimension scores in these circumstances, and note that it is just as effective as the multiplicative index in most other circumstances. In general, therefore, the additive method is to be preferred. Secondly, to the extent that the job dimensions are intercorrelated, the purity of the relationship of job dimensions to psychological states is compromised. This has been found empirically and will be discussed below.

Results show that, as specified by the model, there is a substantial relationship between core job dimensions and their corresponding psychological states, with two notable exceptions. Firstly, Task Identity does not relate significantly to Experienced Meaningfulness (Oldham, Hackman and Stepina, 1978, p.19). In addition, the Autonomy-Experienced Responsibility linkage does not operate as specified in the model; this psychological state is affected almost equally by all five job dimensions. (Hackman and Oldham, 1976; Klein, 1977).

There are also direct relationships between Autonomy and certain outcome variables and Feedback and the same outcome variables, (Hackman and Oldham, 1976) greater than would be expected if the job dimensions operated indirectly via their respective psychological states. Hackman and Oldham suggest that the strength of the Autonomy - Outcome link may be explained by positing Autonomy as a summary measure of the overall complexity of a job, which therefore has a greater diversity of effects than the other dimensions. The Feedback - Outcome link they suggest is due to the attenuation of the Feedback - Knowledge of Results relationship owing to the omission of certain sources of feedback from the studies.

A more parsimonious explanation of both these anomalies, however, is that Autonomy and Feedback are the only two job dimensions that are by definition directly related to performance. Autonomy refers to the extent to which the employee is able to influence his own performance, whilst Feedback refers to information required by the employee to make his performance more effective. Since expectancy theory, on which the job characteristics model is based, posits satisfaction - another Outcome in the model - as being dependent upon performance, it is to be expected that these two dimensions show a moderate, direct relationship with certain job outcomes over and above that mediated by the psychological states.

There are additional problems associated with the Feedback dimensions. Although the JDS contains measures of both job-based and people-based feedback, only the former measure is used to calculate the MPS, and therefore to test the model. Hackman and

Oldham (1976, p.272) accept that the omission of people-based feedback is a possible weakness in the model at present, but do not specify the reason for its omission. The apparent reason may be deduced from Hackman and Lawler (1971, p.282), who report that no convergence was achieved between several measures of feedback, involving ratings of given jobs by employees, supervisors and researchers. This finding was duplicated by Hackman and Oldham (1975) with specific reference to the 'Feedback from agents' dimension. Recently (Hackman and Oldham, 1980) the authors have referred to the difficulty of defining this dimension operationally.

There is some debate as to the relevance of feedback as distinct from the managerial technique of goal-setting. Goal setting refers to the development, negotiation and formalisation of targets or objectives for which the employee is responsible. The strongest evidence for the effects of goal setting comes from Locke (1968; 1978; Locke, Feren, McCaleb, Shaw and Denny, 1980). A review of Locke's research on laboratory studies of goal setting concluded that "there is no effect of KR over and above that which can be attributed to goal setting." (Locke, Cartledge and Koeppel, 1968, p.482). This conclusion is further supported by a later review (Latham and Yukl, 1975). Most recently, a comparative review of field studies found goal setting to be second only to financial incentives as a motivator, and equivalent to job enrichment (Locke et al, 1980). The evidence suggests that high goal specificity and difficulty have a positive impact on performance, in particular on productivity. The evidence for the relationship between goal setting and job satisfaction however is far from clear (Umstot, Bell and Mitchell, 1976).

The consensus view of goal setting studies, therefore, appears to be that feedback affects motivation and performance only when related to goal achievement, and that it has no effect on motivation or performance in isolation from goal setting.

Two final comments should be made on the job dimensions aspect of Hackman and Oldham's model. Firstly, the complete omission from the model of any dimensions related to Turner and Lawrence's 'optional interaction' characteristics might be perceived as a weakness. The original diagnostic questionnaire developed and used by Hackman and Lawler (1971) included two interpersonal dimensions, 'dealing with others' and 'friendship opportunities'. The latter dimension was adapted from the 'optional interaction' characteristic of Turner and Lawrence, although it stressed the aspect of opportunities to develop friendships rather than the more general and less value-loaded characteristic specified by Turner and Lawrence. These authors had found that 'optional interaction on the job' was negatively and very significantly related to absenteeism, whilst 'optional interaction off the job' significantly and positively related to job satisfaction - for town workers at least.

However, the more specific dimension of 'friendship opportunities' was found by Hackman and Lawler to be insignificantly related to intrinsic motivation, absenteeism or performance, although it was positively and significantly associated with general job satisfaction, equivalent in strength to the task identity - satisfaction relationship. Despite this relationship with job satisfaction, Hackman and Lawler decided to omit 'friendship opportunities' from the final model of job characteristics, since it was not "relevant to the performance and motivation of employees as is the case for jobs high on the core dimensions." (1971, p.275). On that basis, using the author's own data (cf. Table 6, p.273) 'feedback' should also have been omitted since it showed no relationship with performance.

The effect of omitting the interpersonal dimension from the model is to increase the risk that job redesign carried out on the basis of the model's five job dimensions alone may not result in predicted job satisfaction if such changes alter the amount of optional interaction allowed. A more systems-orientated approach is called for.

Secondly, it is arguable that Hackman and Oldham's skill variety dimension is too 'rich', to use their own terminology, and as such may cover up important differences in job characteristics. The original task characteristics of Turner and Lawrence included two types of variety, 'object' and 'motor', and one called 'knowledge and skill'. The skill variety dimension of Hackman and Oldham is defined as measuring the degree to which valued skills are utilised in the job, although the JDS questions appear to tap both the level of skill required and variety. For example, one of the items in Section Two of the JDS states 'the job is quite simple and repetitive'.

There is substantial evidence that the characteristic referred to by Turner and Lawrence as 'motor variety' and the elaborated cluster called 'physical variety' by Cooper (1973a) is strongly associated with boredom and dissatisfaction. (Cooper, 1973a; Davies, Shackleton and Parasuraman, Notel; Guest, Williams and Dewe ,1978). Moreover, it may be equivalent to Herzberg's (1966) hygiene factors in that improving low variety may only remove boredom or dissatisfaction rather than resulting in positive reactions. Cooper (1973b) for example, comments that "it is doubtful if Variety is a true motivator. Its value is probably limited to routine, repetitive-type jobs which characteristically induce feelings of boredom .... higher levels of variety simply serve to make the job tolerable rather than positively attractive." (p.8)

To incorporate 'variety' into a dimension purporting to represent utilisation of valued skills, this latter characteristic being related to job challenge and positive reactions, may simply cloud the interpretation of data obtained by use of the JDS. It may be critical to know whether a job is high on variety (as a result of horizontal job enlargement for example) but low in challenge, as distinct from being low in both variety and challenge.

Evidence strongly supports the prediction of the model that a high MPS score results in high satisfaction and internal motivation, especially for people with high growth need strength. (Hackman and Oldham, 1975; 1976; Umstot, Bell and Mitchell, 1976). There is some evidence that jobs high in motivating potential can produce better performance from employees, although most of the evidence relates to quality, and not quantity of work produced. (Hackman and Lawler, 1971; Hackman and Oldham, 1976; Hackman, Pearce and Wolfe, 1978). Some studies suggest that absenteeism may be reduced by increasing motivating potential, although one found that absenteeism actually increased for people with high GNS when their jobs were enriched (Hackman, Pearce and Wolfe, 1978). These conflicting results may reflect the difficulty of obtaining meaningful and reliable measures of variables such as performance and absenteeism.

Although the job characteristics model specifies that a job must be high on all dimensions before high job satisfaction can result - implied in the multiplicative model of motivating potential - there is evidence that this need not necessarily be true (e.g. Klein, 1977). Indeed, the additive model recently recommended by Hackman and colleagues implies that a high score on one dimension can compensate for a moderate score on another. Support for this view comes from Katz (1978) in a study of the effects of job longevity on the relationship between job characteristics and job satisfaction. He found that, for new job incumbents with only a few months experience, high job satisfaction was more strongly associated with task significance if they were young and with feedback from the job if they were 'veterans' recently transferred to a new job.

The Katz study raises also the issue of the efficacy of growth need strength as a moderator of the interaction between job characteristics, psychological states and outcomes. The results of his study suggested that, at certain stages in a job incumbent's work history, needs other than 'growth' needs might predominate. The older worker, for example, faced with a new job appeared to be more concerned about the adequacy of his performance and his ability to learn new skills than the amount of challenge in the job. Moreover, for workers with more than ten years' experience in a job, the task characteristics were unrelated to satisfaction with the job.

Salancik and Pfeffer (1978) question the efficacy of individual traits or needs in general as predictors of behaviour and attitudinal responses in work settings. The need-satisfaction model adopted by Hackman for the job characteristics model assumes too that growth needs are relatively enduring traits of people and that situations have the potential for fulfilling or frustrating individual needs. An alternative approach proposed by Salancik and Pfeffer emphases the effects of context and the consequences of past choices. Their social information processing approach posits that people invoke psychological needs in order to rationalise their behaviour in the absence of unambiguous and salient external causes of that behaviour.

The implications of this alternative approach, which has yet to be tested empirically, are noted by Weiss and Shaw (1979). In a laboratory study using the JDS to rate tasks, they found that individual's judgements about 'objective ' task attributes were affected not only by the objective task requirements but also by awareness of the attitudes of other workers towards the task. This supports the view that situational factors can influence people's perceptions of the task.

To summarise, there has been substantial support for certain aspects of the job characteristics model, although certain anomalies have been found repeatedly. It is clear that, for people with high GNS, the model specified job dimensions have a direct relationship with job satisfaction and internal work motivation. There is, too, evidence of a moderate effect on absenteeism. However, the evidence suggests that the mediating effect of the psychological states does not operate as specified by the model,nor is there strong evidence supporting a relationship with performance. It is possible that a more rigorous testing of the model can occur if different statistical techniques are used. Arnold and House (1980) assert that hierarchical mulitiple regression analysis is required to test the model. They note that, since the JDS scales are at best interval in nature, and both zero and interval size are arbitrary, therefore any linear transformation of scales is permissible. Where linear transformations occur, there can result wide fluctuations in zero-order correlations between the product of two interval scales independent variables and a dependent measure. This latter technique has been employed in most studies to date to test the model.

2.5 SOCIO-TECHNICAL SYSTEMS DESIGN

Several writers have pointed to the inadequacies of the job design approach - that is, the focusing of attention on the characteristics and content of individual jobs - as a strategy for effective organisational change. Hackman (1975), noting the number of job enrichment studies which had failed to meet expectations, posited the need for a systems approach to the design of work. For example, enriching a job by increasing the level of autonomy may involve displacing a supervisory job related to the target job. Unless the effects of redesign are considered on the supervisor's job, and indeed on all related parts of the work system, negative effects on the surrounding system may attenuate the positive effects of job enrichment. This concern with a broader, systems approach may be seen in Hackman's recent research involving work groups and their interdependencies (Hackman, 1980). A similar call for an integration of different approaches to employee motivation to provide a systems approach is made by Lawler (1980). He writes that "the clear implication of the systems nature of organisations is that if motivation is going to be dealt with effectively in an organisation, it is important that a total systems point of view be adopted." (p.542/3)

In fact, a systems approach to work design has been in existence for over two decades, since Trist introduced the concept of socio-technical systems design (Trist, Higgin, Murray and Pollock, 1963). Conceived in response to the need for a new unit of analysis in organisations, the socio-technical system is any unit composed of a technological subsystem - the formal task, layout of the work, equipment availability - and a social subsystem having a common task or goal to accomplish (Rousseau, 1977). The social system embodies the relationships both between the people in the work unit and between each of them and the technology.

Like job design research, socio-technical systems theory views technology as malleable. Its supporters argue that it is impossible to optimise overall organisational performance without joint optimisation of the social and technological sub-systems. (Davis and Trist, 1974). This approach has been described as simultaneous, as distinct from sequential, design (Wilson, 1979), the latter approach characterising the contributions of scientific management, human relations, classical ergonomics and early industrial psychology.

Sociotechnical systems approach, therefore, is based on the concept of organisational choice, (Trist, 1971) with respect to the particular form that technology takes within the organisation. The potential problems caused by systems designed according to technological criteria were discussed in the early days by Davis and Canter (1955). Recently, these same problems were discussed again in the context of computer systems by Hedberg and Mumford (1975), who assert that such systems can be unpredictable and non-viable; i.e. systems which cannot survive or which will only survive in an instable state.

An archetypal product of sociotechnical systems theory is the autonomous work group, which embodies many of the principles of the theory, in particular that of minimal critical specification. This principle states that the system design should specify no more than is absolutely essential to establish self-regulating work units. For example, although the design may specify clearly what is to be achieved by the work group, the method of achieving it may be left to the group members to decide. The autonomous work group is allowed to deal with its own variances, or deviations from the specification: product quality, for example.

The theory also specifies characteristics of individual jobs which allow for joint optimisation, and in this respect it differs very little from job design theory, a point made clearly by Rousseau (1977). In addition to the job characteristics specified by Hackman and others, importance is attached to cohesive work groups (e.g. Trist and Bamforth, 1951) and learning (Emery, 1959). However, unlike job design theory, in particular the job characteristics model (Hackman and Oldham, 1976), sociotechnical systems theory has not specified clearly how job and organisational dimensions cause outcomes such as satisfaction.

The generality of the theory, as Hackman (1977) points out, although elegant in that it can be adapted easily to any organisational situation, presents certain problems all of which can be traced back to the lack of a sound theoretical base. However, to some extent

Hackman's arguments are weakened by his failure to consider the work of Enid Mumford at Manchester Business School (e.g. Mumford, Mercer, Mills and Weir, 1972; Hawgood, Land and Mumford, 1978).

Mumford has developed a diagnostic tool for use in organisations to quantify the degree of mis-match between individual and job, conceived in terms of the 'fit' on five types of exchange relationship between the employee and employer, described as implicit contracts (Mumford et al, 1972). Each contract represents the degree to which a certain kind of employee need is met in the work situation. The five kinds of contract are: (1) Knowledge contract, representing the extent to which the work fully uses their knowledge and skills and provides opportunities to learn new skills; (2) Psychological contract, being the extent to which the job meets the employees' needs for achievement, recognition, responsibility, status and advancement (Herzberg, 1966); (3) Support/control contract: originally described as the efficiency/reward contract, this refers to the extent to which the necessary technical and managerial support is available to enable the employee to perform effectively on the job, with the optimum level of control and reward; (4) Task contract, representing the motivating potential of the job design in task characteristic terms; and (5) Ethical contract, being the extent to which employees are treated by the company and its managers as they would wish.

Mumford's approach goes further than most of the sociotechnical systems research in specifying when job satisfaction will result. However, it has yet to be empirically tested in a systematic way. It is a global model of job and sociotechnical systems design, encompassing aspects of both the task characteristic and Herzberg job enrichment approaches, although there is a suggestion of overlap between some of the contracts. For example, the Knowledge contract would appear to be covered in part by the task contract, insofar as variety implies 'use of knowledge and skills'. In support of Hackman's argument, it can be seen that there is no clear theoretical model relating the contracts together. Adopting the job characteristics theoretical perspective, the responsibility component of the psychological contract should be a product of the task contract component 'autonomy'.

2.6. VALUES IMPLICIT IN JOB DESIGN AND SOCIOTECHNICAL SYSTEMS DESIGN

Although Lawler (1980) rightly points to the need for integration of the various approaches to organisational change and design, in the context of the present research it is worth noting a subtle distinction between the job design and sociotechnical systems design approaches, which may reflect a difference in values.

The job design school, exemplified by the job characteristics studies by Hackman, operates from within a management or 'establishment' value system, stressing the negative effects on organisational efficiency of poor job design and the potential benefits to productivity and task efficiency of good job design. There is benefit for the individual too, though it is largely perceived in terms of 'personal growth and development'. The authors of a standard text in the area write that "organisations should see themselves as potentially one of society's most powerful instruments for assisting individuals in improving and developing their skills." (Porter, Lawler and Hackman, 1975, p.29). Improved quality of life is a valid objective for the job design group, but with a total acceptance of the work ethic and the overriding needs of the organisation.

"For their part, organisation members would seem to have an obligation to help better the enterprise of which they are a part as well as themselves. It is organisations, after all, that provide the circumstances that permit most of us to realise many needs and aspirations. Individual performance that is clearly substandard or individual behaviour that contributes only to self-enhancement at the sacrifice of a more common good invites organisational responses that lead away from, rather than toward, an improved quality of organisational life." (Porter, Lawler and Hackman, 1975, p.27). The fundamental question in this context relates to the interpretation of 'a more common good'. Trade unions, after all, are pursuing a common good that frequently conflicts with management's idea of what is good for 'the organisation'.

It appears that the sociotechnical systems design approach offers a potentially more radical solution to the problem of quality of life in work organisations. Whilst economic goals are frequently referred to as a part of the approach (e.g. Emery, 1975; Hopwood, 1979), many of the researchers in the area, particularly in recent years, have offered solutions that involve redistribution of power within organisations and that have implications for society at large. Much current work is directed towards the involvement of employee work groups in their own job, work or systems redesign. (e.g. Elden, 1979; Hawgood, Land and Mumford, 1978). The autonomous work group might be perceived as a micro-model of a form of social organisation that is posited for society outside of work.

Blackler and Brown (1980) argue that most research in the area is not radical at all, and elaborate their point by a quotation from Fox (1973): 'Discussion may be about marginal adjustments in hierarchical rewards but not about the principle of hierarchical rewards; .... about financial rewards for greater efficiency, but not about the possibility of other types of (intrinsic) rewards with some sacrifice of efficiency, ... about how participants' interests can protect and advance themselves within the structure operated by management to pursue its basic objectives, but not about the nature of those basic objectives." (p.219)

Nevertheless, the sociotechnical systems design approach fits more easily into a socialist value system, and implies such radical changes as industrial democracy and decentralisation of power and ownership. It is no accident that much of the recent impetus for research in this area has come from countries such as Sweden. Even in that country, however, the full implications of sociotechnical systems are not easily accepted by management. For example, Blackler and Brown noted with disappointment the apparent regression at Volvo Truck Division in 1979:

"Our 1976 study had involved a study of the attitudes of top management in the Division towards dock methods and we had discovered then a lot of suspicion regarding them, ... Dock methods involve a loss of immediate control by management. (......) Some three years later it was clear that opinions had hardened along just these very lines. Senior managers told us they were convinced significant production savings could be achieved by dock assembly. Yet they felt that such methods were less reliable than conventional line assembly .. (.....) <u>Perhaps above all they were largely suspicious of a production method that allowed workers to complete their quota before the end of the working day and they wished this 'slack' to be controlled.</u>" (Blackler and Brown, 1980, p.325, emphasis added).

This last point perhaps illustrates a fundamental difference between the values implied in the job design and sociotechnical systems design approaches. The former would strive to redesign work in such a way that, by increasing the intrinsic motivation of employees, an organisation might benefit from increased productivity, whilst the employee benefited from a more satisfying job content. The latter, on the other hand, allows the possibility that employees will optimise their quality of life, not only by allocating work amongst themselves to achieve maximum satisfaction, but also by choosing to finish early having achieved a legitimate objective and therefore gain leisure time. The organisation in this context may benefit economically, but does not have the option of increasing productivity beyond a certain point.

It would be more accurate, perhaps, to say that there is nothing in the job design approach per se that implies exploitation of individual effort towards organisational goals. It is quite feasible that increased autonomy in a job, for example, might allow for the discretion to finish early. Nevertheless, by focusing on the individual-job relationship in isolation, the job characteristics model excludes much that would imply radical organisational change of the type attempted in Sweden and Norway.

2.7 RELEVANT LITERATURE ON ATCO JOB SATISFACTION AND JOB DESIGN

Since the growth and development of modern air traffic control, commensurate with that in civil aviation, there has been a steady stream of published research into various aspects of the ATCO and his job, much of it psychological in nature. Only in the past decade, however, has there been much interest in matters relating to job satisfaction and job design.

Studies of controllers in the USA, West Germany, Sweden and Switzerland have found that, in common with other occupational groups, over three quarters of them express general satisfaction with their job. (Grandjean, Witzka and Kretzschmar, 1968; Kennholt and Bergstedt, 1971; Singer and Rutenfranz, 1971; Smith, 1973). However, also in common with other groups, specific sources of dissatisfaction have been revealed. Research in the USA showed that the strongest source of dissatisfaction was management, followed by certain types of task - in particular those tasks not directly related to the control of traffic. (Smith, 1973). Particular sources of satisfaction were tasks such as working with radar, advising pilots, radio communications, and other control-related tasks. The amount of challenge in the job was also frequently cited as a source of satisfaction. However, the relatively inexperienced controllers and the older controllers responded more positively to moderate rather than to high traffic densities.

It is worth noting at this point that although the subject of stress in ATC has been investigated quite thoroughly (e.g. Crump, 1979; Melton, McKenzie, Polis, Funkhouser and Iampietro, 1971; Smith and Melton, 1973) most of the evidence suggests that heavy traffic situations are preferred by many ATCOs to light traffic. Smith (1973) commented that "approximately 56% of the controllers mentioned that they liked the pressure, the fast pace, and the lack of boredom on the job ..... ATCSs often said that when traffic was light the work was boring ..... it therefore seems reasonable to conclude that ATCSs, as a rule, like to be 'where the action is' .... " (p.926).

One criticism of the research into ATCO job satisfaction by Smith in the USA concerns his uncritical use of the Herzberg (1966) method of investigating sources of job satisfaction and dissatisfaction and of interpreting the data. It has already been noted that Herzberg's findings are in some respects method biased. It must be concluded, therefore, that the classification of sources of job satisfaction in these studies according to their importance is of dubious validity, especially as they so closely follow Herzberg's own findings.

There is a paucity of existing research into the effects of computer-assistance or automation on ATCO job satisfaction. The reactions of British ATCOs to the simulation trials for CAAS mentioned earlier in this dissertation (Fearn, 1975) were not studied systematically, only recorded spontaneously by the investigator monitoring the trials due to the frequency and intensity with which comments regarding job satisfaction were made. Some experimental studies using a simulated ATC task in the USA showed that performance on a monitoring task was inversely related to the degree of boredom-monotony as self-rated by subjects. Subjects who rated the task as being most boring and monotonous showed a significant increase in their longest response times to critical stimuli. (Thackray, Bailey, and Touchstone, 1975). A study of the impact of a computer-assisted system in the USA recorded only that the new system had increased productivity and reduced controller workload. (Kuhar, Gavel and Moreland, 1976).

Although there have been no previous studies in situ of the effects of job or systems design on ATCO motivation and job satisfaction, a recommendation for such research was made by Nealey, Thornton, Maynard and Lindell (1975) in response to a request by the American Federal Aviation Administration, with a view to aiding future systems design. They identified sixteen different research needs, including the following: (a) identification of the major determinants of ATCO satisfaction and performance; (b) worker-centred job analysis; (c) measurement of ATCO job satisfaction; (d) analysis of resistance to systems changes; (e) development of a method for studying ATCO reactions to proposed system changes; and (f) design and development of an interactive radar simulator.

Reviewing previous investigations of controller personality, Smith (1974) concluded that "controllers, because they are bright and action oriented, tend to be intolerant of routine ..... and capable of providing sophisticated input concerning the structure and management of the ATC system." (p. 6). Elsewhere, noting the importance of job content to the controllers' job satisfaction, he raised several questions to be considered in connection with plans for increased automation:

"Specifically, how will the planned changes affect the work tasks of the ATCS, and what changes in ATCS work loads will work for the benefit of the ATC system? If automation makes the task routine and less challenging, the morale and efficiency of ATCS's may suffer considerable loss, and so negate the system advantages of the automation program." (Smith, 1973, p.926).

At the time this present research commenced, and still at the time of writing, no reports had been published either in the USA or in the UK that attempted to provide any answers to the fundamental question quoted above.

3. DEVELOPMENT OF METHODOLOGY

3.1 Design of Complex Systems

The research objectives listed in Chapter 1 specified that, above all, the research outcomes should be relevant to systems design, and in particular those aspects pertaining to allocation of tasks. Clearly, therefore, it was of great importance that any guidelines, recommendations or other outputs from the research should be presented in a form that could be used by systems designers (Crawley and Spurgeon, 1979). Furthermore, since decisions taken in the systems concept stage imply constraints on eventual task allocation, it was important too that guidelines should be of use at this earliest possible stage in the systems research and design process. For example, a decision to examine the concept of an automated conflict prediction system immediately implies the re-allocation of some existing human tasks to the computer. If conflict prediction is central to intrinsic job satisfaction, it may be that the concept of automating it should be re-examined at the outset.

This issue of 'point of input' is especially important in the context of complex systems such as air traffic control. As the present author notes elsewhere (Singleton and Crawley, 1980), "the problem with high-technology systems is that there is usually a long period of systems research before the more concrete stage of system building and implementation is reached." (p.163). Thus an inappropriate decision to examine and develop a particular concept to a simulation stage may prove very costly, since several man-years of work may have been involved. There is the added incentive to get it right at the beginning in such systems since they tend to be unique to one client and therefore costs of research can rarely be shared. The consequences of an inappropriate decision, if it is unchanged throughout systems design and implementation, were discussed in full in

Chapter Two (cf. sections 2.2.3 and 2.5). The point simply needs emphasising that systems design, to be optimally effective, must be based on a sociotechnical perspective at every stage from concept to implementation. As has been shown, if the technological imperative goes unchecked in the early stages of design, the sponsoring organisation may be faced with very heavy research and development costs that prohibit fundamental redesign at a later stage. On the other hand, if it remains unchecked throughout the design stage, the sponsoring organisation may well be faced with heavy costs on and after implementation, in the form of dissatisfied employees and associated effects.

In order to determine what form of output would be of most use to systems research and design staff, an understanding of the process of systems design was necessary. In fact, systems design as a process from the human factors point of view is far from clear. Certain writers have referred to the 'systems approach' to systems design (e.g. Singleton, 1967) and have specified various stages in the process. A concise statement of the process of systems design within the systems approach is provided by McCormick (1976) as it relates to human factors input. At various points during the design, analyses are made of the tasks that would be involved. As the system develops, these task descriptions and analyses become more and more specific until, towards the end, they are equivalent to a specification of job content. If, at some point in the design process, such analysis suggests that certain tasks, either singly or in combination, could not be performed adequately by human operators, the design may be modified accordingly.

This statement, based on McCormick, fails to make clear the distinction between allocation of function between machine (e.g. computer) and people, and allocation of tasks between the people in the system to form a satisfactory set of jobs. The former process is characteristic of systems design, and requires decisions to be made from the outset as to the sort of functions or tasks suitable for automation. The latter process, allocation of tasks and combination of tasks to form jobs, is the substance of job design, although it might also comprise the later stages of systems design. Thus, adopting this framework, job design is seen to be subsumed within systems design. Furthermore, tasks are the elements underlying both processes. This framework also clarifies the way in which decisions made during the early stages of systems design can limit the flexibility of job design. This issue is central to the present research.

A point of particular relevance to this research is made by McCormick (1976):

"Since the 'system' does not exist as an entity during this process, and since there are, therefore, no personnel who actually are engaged in the jobs in question (since the jobs actually do not then exist), the task description and analysis must be inferred from an analysis of the physical equipment of the system as it 'exists' in the form of drawings, blueprints, and other descriptions, and of any intermediate prototypes or models that may be created." (1976; p.658)

Clearly, therefore, for much of the design process, detailed and accurate task analyses will not be available, only fairly approximate descriptions of the contents of jobs. This is often the case at RSRE Malvern, where even computer simulations of systems ideas are developed in something of a stylised form, often not representing closely the 'real' situation in the early and intermediate stages.

3.2 Limitations of Existing Approaches to Systems and Job Design

This sytems approach to design looked very promising in the early days, combining as it did the engineering and human factors inputs into a parallel and interdependent process. However, as Singleton (1971) points out, a serious practical difficulty that arose was "that techniques for systematic allocation of function did not emerge and have not emerged" (p.107). In particular no technique is available that enables us to incorporate motivational and attitudinal factors into the design of complex systems. The participative approaches gaining acceptance in the sociotechnical systems design field that were mentioned in the previous chapter present particular difficulties in the context of complex systems. Experience in the U.K. air traffic control system is that operational ATCOs have considerable difficulties relating to systems research which may be based on assumptions that are completely unrealistic in the current environment. For operational ATCOs to provide a useful input to complex systems design in ATC requires a considerable training effort. Perhaps most important of all, the participative approach is based on the assumption that the employees involved will operate the new system when it is implemented. No such assumption can be made in an environment where several years may pass before the design reaches implementation. At later stages of development, of course, these problems do not arise to the same extent, but the problem remains for the early and intermediate stages.

In addition to the lack of appropriate techniques for systematic allocation of function, there has been a lack of suitable criteria by which to decide whether a task should be allocated to computer or person. Previously, as stated by McCormick (1976), system design might be modified if it was found that certain tasks that had been allocated to people could not be performed adequately by them, or if it was thought that the computer could do them better. Criteria for this approach were provided by Fitts (1951). What are required additionally are criteria for allocating tasks on the basis of what people enjoy doing, what motivates them and what results in intrinsic satisfaction. This need provides the focus for this research.

The conclusion was drawn therefore that systems designers require an input in terms of tasks; that is to say, the 'building blocks' of jobs. They also require an input that is directly relevant to the specific design context; in this case, to ATC systems design. The limitations of existing approaches to sociotechnical systems design, at least those that offer a conceptual framework to support them, are: (a) that they are aimed at the job level, rather than the task level; and (b) that they are too general in the guidelines they offer to be of more than moderate use to a particular systems design team in a particular context.

For example, the principles presented by Hackman (Hackman, Oldham, Janson and Purdy, 1975) for implementing work redesign are (1) combining tasks, (2) forming natural work units, (3) establishing client relationships, (4) vertically loading the job, and (5) opening feedback channels. These principles offer little to the designer of systems with respect to the allocation of tasks between a human operator and a computer. He may not be in a position to think in terms of whole jobs and their interrelationship with other aspects of the work organisation until the later stages of the design process, by which time many general aspects of job content may have been determined. For much of the time tasks are considered in something of a vacuum, divorced from the eventual job and organisation of which they will form a part.

As for the generality of the guidelines, there is nothing in existing approaches that helps the system designer to appraise the importance or value to employees of different tasks. It may be of considerable importance to have structured information regarding the degree of motivation and satisfaction attached to specific tasks or types of tasks in the existing system, if they are potential candidates for change in systems design. Simply combining tasks, or increasing variety, are not hypothesised to increase motivation and satisfaction unless so doing results in the use of valued skills and abilities. (Hackman and Oldham, 1976).

Ideally, too, one would want to be able to compare new tasks created by the system design with old, in order that predictions might be made regarding the satisfactions or dissatisfactions that new tasks could provide. Once more, in terms of the job characteristics model, the satisfaction provided would depend on the extent to which tasks involved the use of valued skills and abilities.

The immediate purpose of this research, therefore, was to determine a methodology for eliciting ATCO attitudes towards tasks. This implied a two-stage process: (a) analysing or describing the tasks of ATCOs; and (b) eliciting attitudes towards them.

3.3 Task Analysis

There are two main functions to be served by a task analysis for the purpose of systems design in ATC. Firstly, there is the purpose outlined above whereby the task analysis would serve as a data base from which to elicit ATCOs' attitudes towards different tasks. Secondly, the analysis might, if carried out and presented in an appropriate way, be used by systems designers to assess the potential impact of their system on the ATCOs. This requires some explanation. In order that we might predict during the design stage the likely reactions of ATCOs to a particular system, it is necessary to have some means of comparing the existing tasks and jobs with those required by the new system. This entails some form of representation of tasks in existing jobs, in a form that can be related to the task analyses carried out during the process of systems design.

Before describing the reasons for choosing one particular form of task analysis, it is necessary to define more precisely what is meant by the term 'task' and to distinguish it from skills and abilities. It is rather ironic that, despite continuous debate regarding the definition of such concepts as job satisfaction, the job design movement should accept without question the concepts of task, skill and ability. However, these concepts are themselves the subject of debate in the psychological fields that fit people to jobs and vice versa; that is, the more traditional approaches to job change involving selection, training and ergonomics.

One problem in the literature is that the terms job, task, skill and activity are used interchangeably quite often, and the same is true for the terms job analysis, skills analysis and task analysis. (Patrick, 1980). Whilst distinctions have been made between them, these tend to become blurred at certain levels of analysis. A good example of the confusion in the area may be found if we compare the definitions of Miller (1953) and Stammers and Patrick (1975). The former defines a task as a group of discriminations, decisions and effector activities related to each other by temporal proximity, immediate purpose and a common man-machine input. The latter define a skill as "an organised and coordinated pattern of mental and/or physical activity in relation to an object or other display of information, usually involving both receptor and effector processes." (p.11). It is difficult in this instance to distinguish between the two definitions although they are concerned with different concepts; the overlap is more apparent than the differences.

Most definitions imply that a task consists of a set of means to achieve a particular objective. Thus it may be conceived of as a set of means-end relationships (Weick, 1965). For example, Thibaut and Kelley (1959) suggest that a task is "a problem, assignment or stimulus complex to which the individual responds by performing various overt or covert operations which lead to various outcomes." (p.150). A similar definition by Pepinsky and Pepinsky (1961) states that a task is the "confronting of an actor with a designated stimulus situation in which he is required to follow stipulated rules of procedure in responding to the situation, and in which he must attempt to satisfy specified criteria by which the amount of success of his acts is judged." (p.219). As Weick (1965) notes, this definition specifies that a task may involve the imposition not merely of an objective but also of a set of acceptable actions by which to achieve it.

A distinction is made by some people between the objective and subjective definition of a task. For example, Hare (1962) suggests that "the task is ..... what the group members subjectively define it to be as they respond to the situation in which they find themselves." (p.248). This definition, originating in studies of group behaviour, illustrates incidentally the wide usage of the concept 'task'. It implies, however, a redefinition of the imposed task by the performers of it. This distinction is drawn also by Hackman and Lawler (1971), with respect to the relationship between task and attitude. They assert that one should measure attitudes to the job as subjectively perceived by employees. The same distinction is implied by Meister (1976) when he asserts that "the task as we observe someone performing it is quite different from the task in its abstract (verbal-descriptive) form ..... The latter has no physical existence and is purely and simply a conceptual construct." (p.96).

The same author also raises the pertinent question of "where in the task are the trainable skills and knowledges that presumably can be extracted from it? Obviously these are deductions or inferences, not observables ...." (1976, pp. 96-97). This is central to the subject of the present research, because at best we can only infer that valued skills and abilities are being utilised in task performance, we cannot measure their use directly. It is relevant, too, to point out that skills and abilities are described and classified in terms meaningful to psychologists. There is no a priori reason why such terms should be meaningful to most employees with respect to sources of intrinsic satisfaction. Thus, although it is the use of valued skills and abilities that is hypothesised to lead to a job being experienced as meaningful, perhaps the best that can be achieved at the present state of knowledge is to elicit attitudes towards tasks. To achieve this, the tasks must be described in terms familiar to the employees. Then, at a later date, there is still the necessity to infer the skills and abilities underlying the valued tasks.

At present there is no one approach to analysing and classifying work performance that has been generally accepted by specialists in the field. (Meister, 1976). This is due in part to the different applications of such approaches. Some are utilitarian approaches with specific applications such as selection or training (e.g. Annett and Duncan, 1967; McCormick et al, 1972), whilst others are theoretical classifications from which it is hoped a number of applications might originate (cf. Fleishman, 1975). Extensive reviews of job analysis approaches are provided by McCormick (1976) and Prien and Ronan (1971). None of the existing approaches were designed specifically for systems design applications of the sort required by the present research, and as Fleishman (1967) comments, "it may well be that the kind of taxonomy most useful to one set of applied problems (e.g. training) may be different from the one useful for another problem (e.g. selection, system design)." (p.8)

Most of the approaches to task description and classification were inappropriate for the present research for a number of reasons, generally related to the purpose for which they were developed. Simple job inventories or task lists (e.g. Christal, 1974) were inappropriate to the systems design process since they were either at too general a level of analysis, or they were difficult to relate to prediction of job change because relationships between tasks were not shown. The ability requirements approach (e.g. Fleishman, 1972) described tasks in terms of the abilities which they required of the performer; this was at the wrong level of analysis for systems design.

Taking into account the dual purposes of the task analysis, what was required was an approach that expressed the tasks in terms of behaviours or operations, since this should be readily understandable to both the systems designers and to the ATCOs themselves. Furthermore, such an approach required the least amount of inference of underlying concepts, a procedure fraught with difficulties. Another requirement was that the descriptions should be expressed in terms similar to functional objectives, so that systems designers could apply them to performance either by people or computers.

An existing approach which appeared to meet most of the requirements was that of hierarchical task analysis (Annett, Duncan, Stammers and Gray, 1971). Hierarchical task analysis (HTA) was developed as a technique for analysing a job in terms of its component operations as a preliminary to training design. Because of its initial application certain aspects of the technique are directly related to the search for training implications, and therefore will not be discussed here. The reader is referred to publications by Duncan on this point (e.g. Duncan, 1975).

The analyst begins with a general statement of the overall task, described in operational terms and focusing on the objectives of the task. This task is then redescribed, or broken down, into a set of subordinate tasks together with a 'plan', or set of rules, which governs the selection, sequencing and timing of the sub-tasks. These subordinate tasks can be the subject of further redescription into a more detailed level of analysis. (Duncan, 1975; Shepherd, 1976).

The process described above is defined as 'progressive re-description', and is based on the assumption that skilled performance can be described at many levels with behaviour being hierarchically organised, (Miller, Galanter and Pribram, 1960) and goal-directed. However, despite this assumption, and despite the fact that some task descriptions may be made in terms implying psychological processes, Duncan argues that task statements must be regarded as psychologically 'celibate' for practical purposes, since the same performance may be underpinned by different psychological processes. He asserts, too, that "any method of task analysis which required human performance to be described by categorical statements about psychological processes would be unworkable, for it would assume that a complete, and theoretically consistent psychology exists." (Duncan, 1975, p.148).

The analyst must have some explicit criteria for deciding when to cease redescription of tasks. Annett and Duncan (1967), for example, suggest a 'stopping rule' based on training considerations. The application of stopping rules serves at least two purposes. Firstly, it imposes some rigour on the analytic process; and secondly, it has a pragmatic purpose of limiting the analysis. The latter purpose may be of considerable importance since it is possible to define a very large number of levels of description in principle, down to the level of psychophysiological or anatomical language.

The degree of rigour required by HTA seemed excessive for the purposes of the present study, as indeed other researchers have found

(Spurgeon and Young, 1981). To some extent the research was to be exploratory, and as such it was never envisaged that all aspects would be pursued exhaustively. There was to be a continual balancing of breadth of coverage against depth of coverage, bearing in mind too the limited resources available with which to study a very large and complex system. Thus one stopping rule applied in this research was whether further redescription of tasks was likely to lead to more redundant information than a broadening of the analysis into a different task area. The other stopping rule which it was decided to apply to the analysis was related to Annett and Duncan's work. Their rule was based on the product of 'p', the probability of inadequate performance, and 'c', the cost to the system of inadequate performance. If the product is acceptably low, then redescription ceases. For the purposes of the present research, further redescription depended on the probability of the job-holder being able to discriminate the task as a separate entity and being able to express affective reactions towards it. With respect to both stopping rules, the judgements were to be made subjectively by the present author.

It was decided too that, for reasons of expediency, the task analysis should be conducted at a more general level than HTA. Thus separate tasks should not be specified for all separate traffic situations on all work positions. Rather, tasks of a more general type should be described which could cover a number of situations. For example, the specific tasks involved in separating traffic might vary in detail according to the sector on which they occurred, or according to specific features of the traffic configuration. However, it was thought likely that some tasks would have sufficient in common that they could be generalised to apply to any sector or to several traffic configurations.

In two respects, therefore - the degree of rigour and the level of analysis - the technique of analysis adopted may be seen to resemble more the Overview Task Analysis (OTA) derived from HTA and described by Patrick, Spurgeon, Barwell and Sparrow (1980). Although these authors still apply the technique partly in a training context, they note that their adaptation of HTA is "used in a broader systems context rather than as a specific analysis-for-training technique." (p.4). The technique of task analysis used in the present research, however, differed in one important respect from both HTA and OTA. The specification of detailed plans was omitted from the analysis, since their main application is for training purposes. Effective plan specification is a very time-consuming part of the analysis, especially in the context of cognitive tasks which make up a large proportion of the ATCOs' job, and in a complex system with many variables to take into account. Whilst it may be essential for training design (Shepherd and Duncan, 1980) it was thought to be non-essential to this initial investigation. Insofar as the function of planning activity was relevant to ATCO intrinsic satisfactions and motivation, it would be covered in the research by obtaining ratings at the higher levels of task in the analysis, where plans are implicit in the task objective.

One particular problem that was foreseen for the task analysis was that of analysing and describing covert tasks involving mainly mental operations. Observable physical activities, whilst frequently occurring, form a small part of the range of operations performed by ATCOs. The majority of their job involves perceptual processing and decision-making, tasks which cannot be observed and therefore are not objectively verifiable. The analysis would have to depend quite heavily therefore on verbal reports from the ATCOs concerning their mental processes. However, the status of verbal reports in psychological research has been doubtful ever since the behaviourists discredited introspection (cf. Ericsson and Simon, 1980; Thomson, 1968). For example, in appraising a particular definition of tasks, Weick(1965) commented that "the value of this conception of tasks is that it places the emphasis on behavioural data rather than on verbal reports." (p.229)

Recently, the validity of verbal reports as a technique has been re-appraised, and the conditions of its appropriate use specified (Bainbridge, 1979; Ericsson and Simon, 1980). In applied psychology, verbal reports have been found to be of considerable practical use in understanding and designing systems. (Bainbridge, 1975; 1979). Such data are more likely to be useful if distortions are minimised by requiring concurrent rather than retrospective verbalisation. However, where the job requires extensive spoken communication, the use of strictly concurrent verbalisation such as by verbal protocol (Bainbridge, 1975) is inappropriate, since the job-required and research-required verbalisation tasks interfere with each other.

To some extent, hierarchical task analysis avoids the problems attached to verbal reports by focusing, not on mental processes as such, but on the objectives to be achieved by the processing. Thus, while it may be difficult to verify, for example, how an ATCO determines what levels are available for giving an aircraft further climb, the necessity for some form of activity that results in such information becoming available is verifiable in more than one way. For example, if aircraft were cleared to levels without establishing whether those levels were available, there would be many instances of aircraft being stopped off during the climb.

3.4 Repertory Grid Elicitation of attitudes towards tasks

Psychologists have developed many techniques for investigating people's perceptions of and attitudes towards aspects of their world.

Questionnaires, attitude scales and observation techniques have all been developed for this purpose. One problem with many techniques is that they assume the relevance of particular terms or ideas to the subject. Questionnaires and attitude scales in particular often reflect the attitudes or experiences of the investigator or test developer. (Shaw and Thomas, 1978). Since the present research was to investigate a novel focus of attitudes, namely tasks within jobs, it was felt that the use of only standardised questionnaires or attitude scales was inappropriate. It was thought possible that ATCOs might wish to make distinctions between, or express attitudes towards, tasks that would not be possible if existing standardised measures were used. A priori, it was possible to predict neither the extent to which ATCOs discriminated between tasks, nor the way in which they discriminated.

The Repertory Grid technique, derived from the work of George Kelly (1955), seemed to offer an approach to the problem which not only allowed for but actually made its focus the individual's particular and unique experience of his phenomenological world. Although much of the earlier research involving use of the Repertory Grid was in the clinical area (Bannister and Mair, 1968), in recent years the technique has been applied to many other settings (Easterby-Smith, 1980). Particular application in the applied psychology field include studies of the effect of cognitive complexity on job satisfaction (Standing, 1971); the influence of users' construct systems on man-machine interaction in a management information system (Peace and Easterby, 1973); evaluations of training programmes (Lifshitz, 1974; Smith, 1978); and attitudes towards safety clothing (Pirani and Reynolds, 1976).

The Repertory Grid technique grew out of personal construct theory (Kelly, 1955), which posited that people behaved rather like scientists, trying to make sense of their lives at many levels. The essence of the theory is that people look to the future and anticipate events, rather than merely reacting to stimuli. Each person does this via his personal construct system, a unique network of related 'goggles' through which he views the world. A construct is a bipolar concept which provides a means of categorising similarities and differences between objects or events. Examples of constructs are 'easy-difficult', 'satisfying-dissatisfying', or 'interesting-boring'. A construct therefore is not an inherent characteristic of things in nature, but represents a construction of reality by the person doing the construing. Thus a job is not <u>inherently</u> interesting, but may be so construed by a person comparing it with other jobs. Furthermore, by construing a job as being 'interesting', the person is formulating a set of hypotheses about it: for example, that it will be challenging, require him to think quite hard, require his attention, provide satisfaction, and that it will not be boring. It is in this way that constructions of reality anticipate events. If events disprove the hypothesis, then the job may be re-construed, or the construct system itself vary.

Kelly argued that, since the development of a personal construct system was, by definition, unique to each person depending on his or her experience, then people must differ from each other in their construing of events. The term construct <u>system</u> was used because Kelly envisaged that a person's constructs are organised in an interrelated and hierarchical structure. This implies that constructs differ in their importance to the individual, some occupying a superordinate position in the system and subsuming others. It suggests too that the application of a particular construct implies that other, related constructs are relevant. Constructs may differ too in the extent to which they may be verbalised. This being true, then any technique relying on verbalisation of constructs must be of limited value. Finally, constructs may vary in the generality of their application. For example, 'wears white shoes - has bare feet' is a construct with a limited applicability, whereas 'good - bad' may be applied to many events or situations.

Most of the points mentioned above concerning constructs and construct systems are taken into account in the measurement technique developed for the purpose, the Repertory Grid. As Bannister and Mair (1968) state, "the ideas that constructs are personal bipolar abstractions with limited ranges of conveniences, used to structure aspects of a person's world ...... are acknowledged in the procedure for eliciting constructs from the person being tested. The importance of exploring and understanding a person's system of constructs, rather than single isolated dimensions, is acknowledged by requiring the elicitation of a number of constructs and by providing statistical techniques which allow assessment of associations or links between the constructs involved." (p.28). To this statement it only needs to be added, in the context of the present research, that the same statistical techniques allow associations or links between the objects of construing, called elements in the theory, to be assessed, together with the subject's affective reactions towards them.

It was hoped, therefore, to discover the sorts of constructs used by ATCOs to construe their job content, the tasks; to discover by assessment of the links between constructs, which other constructs were implied by the application of the construct 'job satisfaction'; and to discover how the tasks in the task analysis were associated in terms of job satisfaction and motivating characteristics.

3.5 Additional Analysis of Job Characteristics and Satisfactions

Since the focus of the investigation was to be on the degree of 'fit' between task requirements and ATCO needs, it was thought that as much analysis of the existing system as possible should be carried out. Simply implementing the task analysis - repertory grid techniques on their own would have provided us with information of doubtful validity. In order that such information could be checked against some criterion, it was decided to investigate ATCOs' satisfactions and motivation at two other levels of analysis. At the most general level, ATCOs readily expressed preferences for working on some positions rather than others. It seemed appropriate that such preferences should be measured systematically to establish the level of consensus amongst ATCOs as to which work positions were most and least preferred. Secondly, at a more detailed level of analysis than simple preferences, the JDS offered a diagnostic technique that could provide information on the relative motivating potential of different work positions. Although data on the technique's reliability and validity is not available for U.K. populations, and despite the absence of population norms for the U.K., the JDS is the only existing technique in job design supported by a model of motivation, and for that reason alone it seemed essential to the investigation. Furthermore, it would provide data at a level relevant to the later stages of systems design.

As a postscript to this chapter, it should be mentioned that, in the early stages of the research, preliminary plans were drawn up for a possible computer-based simulated ATC task that would lend itself to operation at different levels of computer-assistance or automation. In this way, it was hoped that ATCO reactions to much higher levels of computer-assistance or automation could be examined directly, albeit in the artificial context of a 'game'. However, after some discussion with RSRE and members of the progress committee, the idea was rejected for the duration of the existing research agreement on the basis of the cost and man-hours that it would have involved. Its rejection meant that the research had to make its focus the match between ATCOs and task demands in the existing system. ATCO reactions to the levels of computer assistance discussed in Chapter I would have to be inferred, therefore, from their reactions to characteristics of the present job.

4. THE RESEARCH INVESTIGATION: METHODS AND RESULTS

INTRODUCTION

The following chapter describes the method and results for the whole research investigation. It begins with a report of the task analysis (Section 4.1), specifying as precisely as possible the procedure that was followed in obtaining the data with examples of data at various stages of the analysis. The final task analyses are presented in Appendix I. The next section (4.2) presents the method and results for the investigation of ATCO preferences for working on certain operational positions. Following this, Section 4.3 describes the use of the JDS to diagnose the motivating potential of different ATC positions at LATCC and Heathrow, the results being presented at the end of the section. Finally, Section 4.4 reports the most detailed level of investigation, that of attitudes towards and perceptions of tasks from the task analyses, using Repertory Grid technique. The order in which this chapter is written follows quite closely the stages of investigation at the Units. There was, however, some overlap between the rank preferences, JDS and Rep Grid phases.

4.1 TASK ANALYSES

4.1.1 Method: Subjects and Procedures

Task analyses were carried out at the two ATC Units in 1978; between February and April at LATCC, and between October and December at Heathrow. The winter months were chosen on the recommendation of the CAA, so as to avoid the consistently high traffic levels in the summer when the presence of the author in the operational setting might have been an unwelcome hindrance. In fact, after some weeks with the two Units, it was made clear that I was welcome at any time provided discretion was used when sitting-in with ATCOs.

Preliminary discussions with ATC Supervisors and operational ATCOs at LATCC suggested that the tasks of ATCOs on radar positions were the same in general terms regardless of which sector they were working on. Such differences as there were between sectors were either of a very specific nature, for example concerning the specifications of routes, or were to do with general characteristics of the sector such as the number of traffic movements. Thus it was decided that, in view of the pressure of time, one general task analysis would be carried out that could apply to any radar sector. The management of LATCC selected two suites on the South Bank which usually had more room and where the presence of an observer would cause the least upheaval or obstruction. These were TMA South and DOVER/LYDD. The task analysis for a Sector (Radar) Controller at LATCC is based therefore on analysis of these two sectors. In addition to a radar task analysis, it was thought useful to analyse a non-radar duty, and the Wing Man was chosen for this purpose. As with radar, one analysis was carried out to represent any Wings position.

The analysis was carried out normally during 'office' hours, so in the course of each working day ATCOs from three Watches were observed: those from the Morning, Afternoon, and Rotating or 'Spinning' duties. Since on any particular duty, upwards of four ATCOs would be allocated to each sector, any number of up to nine or ten ATCOs could be observed on one sector position during a working day. Thus by the end of the Radar analysis, approximately 80 ATCOs had been involved for varying lengths of time, representing all Watches. Whilst the 'selection' of ATCOs for observation was quite arbitrary and passive on the whole, some active selection occurred in the later stages of the analysis. This was to avoid the time-consuming activity of establishing rapport and providing background information each time an ATCO who was unfamiliar with the research took over a position. Thus, once a relatively large sample of ATCOs were familiar with the purposes of the research, the author tended to allocate his time to positions where 'known' ATCOs were sitting.

The arrangements at Heathrow were rather different from most points of view. Firstly, no real restrictions were imposed by management as to where the analysis could take place, since the layout of the workplace allowed for an observer on all positions. Secondly, most positions differed in terms of the tasks they involved, so that a number of separate analyses had to be carried out. In the event, nearly all the positions were analysed, the main exception being Special VFR which was atypical in that it was not concerned with the control of flights into or out of Heathrow and was thought to be an unlikely candidate for significant computer assistance in the future.

The analyses carried out were of Ground Movement Planner (GMP), Ground Movement Controller (GMC), Air Arrivals, Air Departures, No. 2 Director, and No. 1 Director and Approach (Procedural) Controller. The last two analyses mentioned were combined together in the final analysis, since they were often performed by one person in his capacity as No. 1 Director. Furthermore, they each represent the combination of the North and South split. As with LATCC, it was thought that the tasks were the same regardless of whether the ATCO was No. 1 Director North or South, or Approach North or South. Because of the lack of restrictions imposed, and since Heathrow is a much smaller Unit than LATCC, almost all the ATCOs were involved in the analyses at some point, the total number being about 70.

Several different methods were used at various stages in the task analyses. These were (1) Reference to training and operational manuals; (2) Observation of on-the-job activities, including listening to spoken communications; (3) On-the-job 'interviews'; (4) Off-the-job interviews and discussions; (5) Inference; and (6) Analysis of tape recordings of spoken communications. Of these all but the last were used extensively and found to be invaluable.

Training and operational manuals were of most use in the early and late stages of the analysis. They provided general information on the duties of ATCOs, together with some specific information related to approved or required procedures; for example for the positive identification of aircraft, or the transferring of responsibility. However, since such information was book-based, all of it had to be verified by one or more of the other methods. On-the-job observation was fundamental to the whole analysis, although, as noted in the previous chapter, it was of limited use in itself with respect to the covert activities of ATCOs. Combined with other methods, however, it was of considerable use. More use could be made of observation, too, when the analyst had become familiar with the tasks of ATCOs. At later stages in the analysis, observation of the radar display, as distinct from the ATCO, enabled the analyst to form hypotheses about what the ATCO ought to be thinking about. These hypotheses could then be verified by asking the ATCO when opportunity arose, preferably at the time.

Interviewing ATCOs on the job was necessarily an informal method, because it had to be dovetailed into the demands of the traffic situation. In the early stages of the analysis, in order that the research should not appear to be too much of a nuisance, few questions were asked of the ATCO unless it was very obviously quiet. However, as the analyst became more skilled in understanding what was going on, it was possible to ask questions more frequently, even though the ATCO was not making it obvious that he was available for questioning, and questions could be related to current situations.

A type of questioning was developed that involved asking the ATCOs 'why', 'when' and 'how' things were done. These situation-specific questions were supplemented towards the latter stages of the analysis by 'what if' questions, enabling some data to be gathered about situations and tasks that happened infrequently and had not been observed.

Of the two types of interviewing, on-the-job was found to be more useful in the early and intermediate stages than off-the-job. ATCOs found it harder to answer questions about specific situations out of context. If the questions were asked in situ, the cues were very often still available for reference, even though the particular situation might be concluded. However, once preliminary drafts of the analysis were written, off-the-job discussions became a valuable method of verifying, elaborating and modifying it. Feedback sessions were held at LATCC in training rooms, two for each Watch, in which any ATCO who was interested could come along and have an opportunity to check the validity of the analysis.

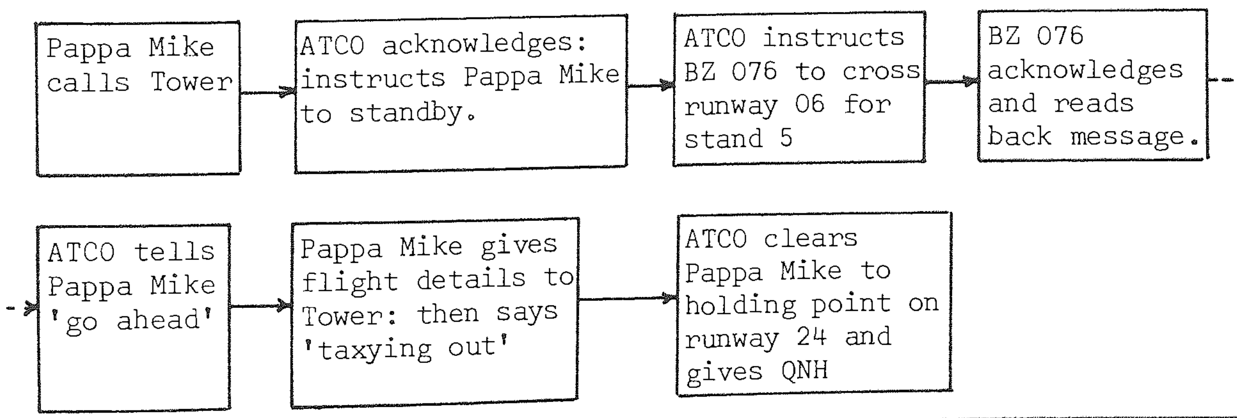
These sessions began with an introduction which explained the purposes of the research in general, the specific purposes for which the task analysis would be used, followed by a brief explanation of how the tasks were described. The group was then encouraged to comment on particular extracts from the task analysis. About 50 ATCOs attended these sessions, and they resulted in several modifications to preliminary drafts. The feedback sessions were thought to be important because one of the purposes of the task analysis was that tasks could be evaluated subsequently by ATCOs. It was clearly important therefore that ATCOs should be able to understand and agree with the analysis.

Inference had to be used a great deal, in order that covert 'tasks' could be described, although the results of inference were always subsequently verified by ATCOs. Since the purpose of each inference was to describe the objectives or goals of mental processes, rather than the processes themselves, the inferred 'tasks' could be verified with more confidence. Finally, tape recordings, although used in a pilot study at Birmingham Airport, were found to provide little additional information in isolation, and consequently were not used for the main analyses.

The final part of this section outlines the stages of development through which the analysis progressed. The first stage involved an 'upwards' analysis beginning with the observable, overt activities performed by ATCOs, together with a 'downwards' analysis which was derived from manuals and by questioning ATCOs in general terms about what their overall objectives were. At this stage, the two approaches to the analysis were relatively independent. Figures 1 - 3 illustrate three phases of development of the upwards analysis, based on the pilot study at Birmingham Airport.

Figure 1

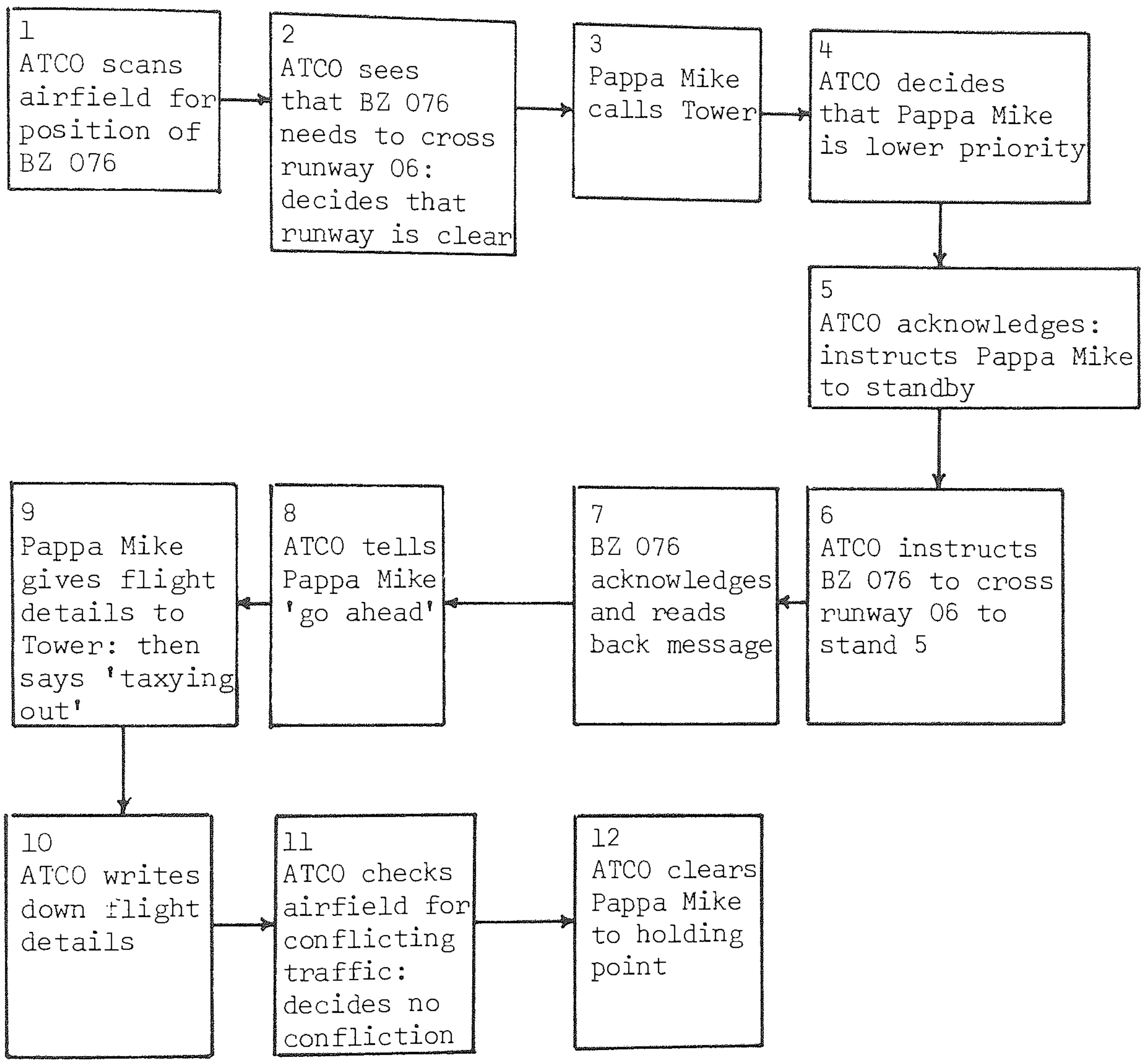
Sequential communications between Tower and two aircraft derived from tape recordings at Birmingham Airport.



The information in Figure 1 was derived from tape recordings of communications between the Tower controller and two aircraft, an inbound scheduled civil flight BZ 076 and a departing light aircraft Pappa Mike. The communications activities were then supplemented by activities that were observed at the time, and by covert activities that were either inferred or revealed by questioning of the ATCO. The elaborated diagram is shown in Figure 2.

Figure 2

Elaboration of Figure 1 including covert activities and decisions



Even with the small amount of elaboration involved in Figure 2, the sequential presentation has ceased to be of much use. Two or more of the boxes shown in the figure may have occurred simultaneously, or with considerable overlap. Furthermore, there are some boxes which indicate what the aircraft are doing rather than the ATCO. The purpose of this stage of the research was to provide an analysis of the ATCO's job, not an analysis of the whole system. Moreover, it was explained in the previous chapter that task analysis of the type used in this research describes tasks in terms of the objectives to which employee behaviour is directed. Thus the next stage in the analysis was to translate all the boxes into tasks performed by the ATCO, described in terms of the objectives to which they were directed. Figure 3 shows boxes 1 - 4 from Figure 2 redescribed in task analysis terms.

Figure 3

Redescription of boxes 1 - 4 from Figure 2 in task analysis terms

1 Identify position of BZ 076	2a Recognise that BZ 076 requires crossing clearance	2b Determine whether runway 06 is clear	3 Identify transmission from Pappa Mike	4 Decide priorities for action

The previous chapter also described how superordinate task objectives may be redefined in terms of a number of subordinate objectives which are steps achieved on the way to achieving the superordinate objective. The downwards analysis began with a statement of an overall objective for the job, 'Provide a safe, orderly and expeditious flow of traffic', and a set of subordinate objectives which together described the overall objective. Examples of subordinate tasks are 'Clear inbound traffic safely and expeditiously to their stands', and 'Provide an expeditious flow of departures'. At some stage in the analysis it became possible to match the product of the upwards analysis with that of the downwards analysis. Occasionally the one would reveal omissions in the other, so that they provided a limited check against each other.

Some parts of the jobs proved exceptionally difficult to analyse, in particular those involving perceptual processes and decision making. It was found that the most useful method of presentation of data whilst working on the difficult aspects in the early stages was in algorithmic form. The logical interrelationship of tasks and mental processes in the algorithm facilitated the spotting of omissions in the analysis, and proved an effective method of presentation for eliciting feedback from ATCOs whilst the analysis was still in progress. Figure 4 shows an algorithm from the intermediate stages of the radar task analysis at LATCC, complete with inaccuracies that were corrected only in the hierarchical presentation.

It should be noted that the algorithm describes tasks or activities still in terms specific to a particular situation, that is of a departing aircraft being cleared to a higher level by an ATCO on TMA South-West. As discussed in the previous chapter, the task analysis was to be applicable to any radar sector, and thus the algorithm had to be combined with other algorithms to produce descriptions of general tasks which were not situation specific. A comparable extract from the LATCC Sector Controller task analysis shows the transformation into a set of general descriptions (Figure 5). The tasks described in this extract are applicable to an ATCO on either TMA or an En-Route sector, dealing with either inbound or outbound aircraft.

It should be made clear, although the reader may have realised already, that task analysis is not a formalised procedure in the scientific sense of the term. There is no guarantee that another researcher, analysing the same jobs and following the procedures specified above, would have produced a closely comparable task analysis, despite the fact that more detail of the procedure has been provided here than is usual in task analysis.

Figure 4

Extract from algorithm representing decision-making processes of sector controller on TMA South-West in connection with an outbound from London Heathrow

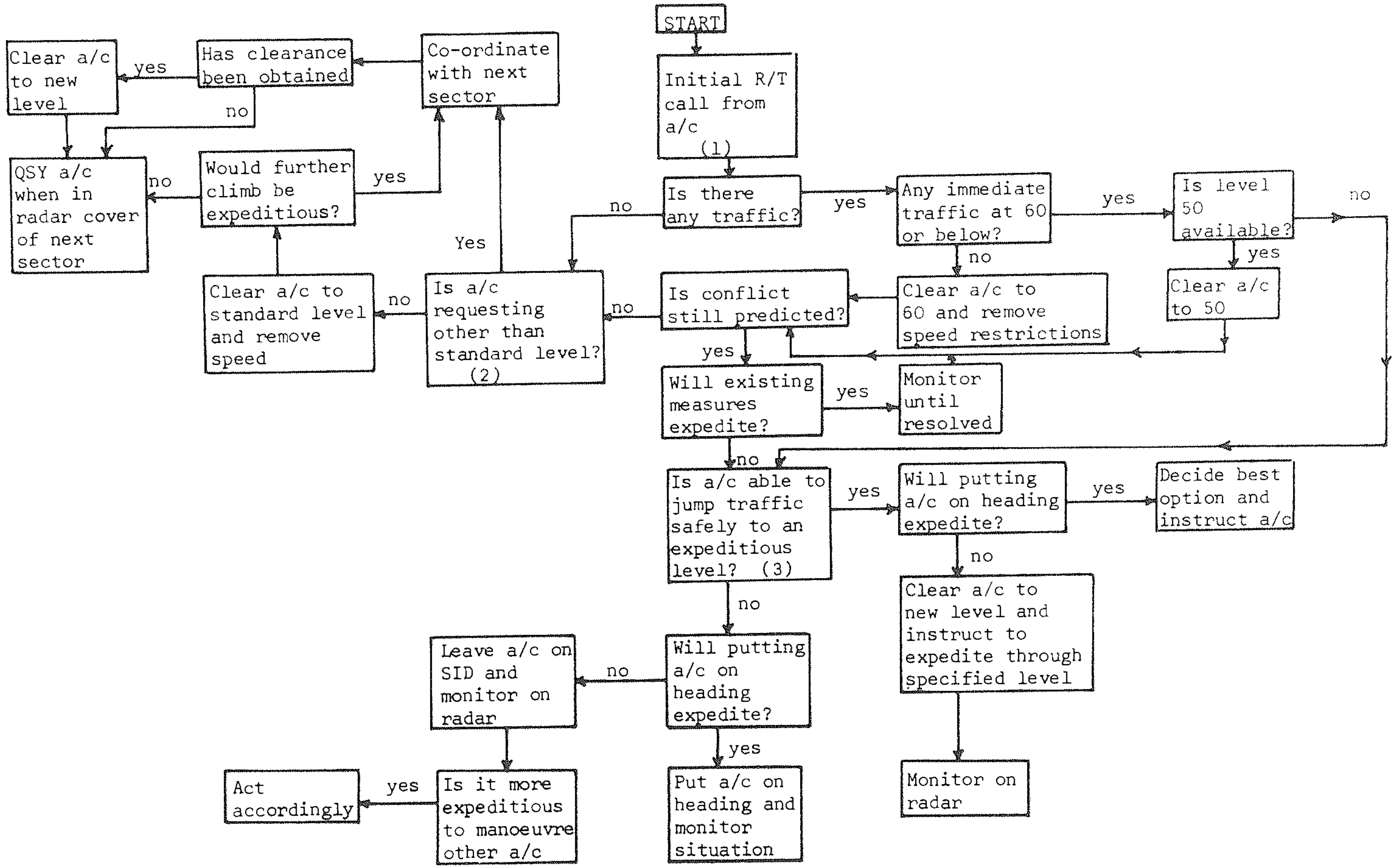
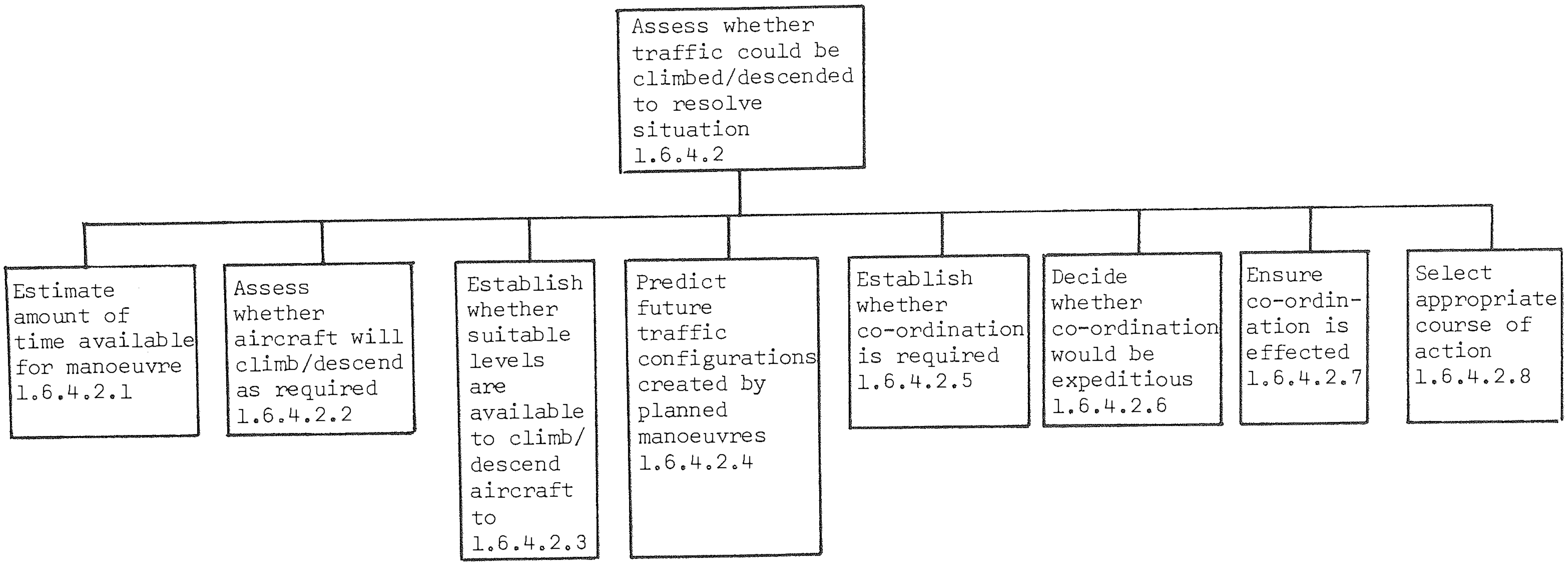


Figure 5

Extract from task analysis for Sector Controller at LATCC



4.1.2 Results

The full and final task analyses for both Heathrow and LATCC may be found in Appendix I. It can be seen that the LATCC task analyses are described in consistently more detail than those for Heathrow. The decision was taken during the analysis to provide breadth of coverage at Heathrow rather than consistent depth in order that more comparisons might be made between different positions. Moreover, redescription of some Heathrow tasks would have been mainly redundant in view of their similarity to equivalent LATCC tasks.

The final draft of the task analysis was based on revisions recommended by ATCOs and their management, although in the main these were changes of emphasis by redescription of superordinate tasks. For example, the original draft of the task analysis for LATCC Radar had as its central task the identification and resolution of conflicts. ATCOs suggested that in the main their job consisted of the prevention of conflicts, and a better description of the superordinate task would be in terms of providing solutions to the traffic situation in general. The subordinate tasks subsumed under this superordinate task remained much the same.

For each task analysis it proved possible to identify one or two tasks which are central to that particular job - 'core' tasks. These were identified on the basis of ATCOs' own comments about the main purpose of the positions, and from assessments of the frequency of task occurrence. For LATCC Radar, there are two core tasks: (a) 'Decide most suitable solution to traffic situation' (1.6) and (b) 'Ensure that traffic remains safely separated' (1.8). In practice they are almost inseparable, involving very similar or on occasion identical subordinate tasks. Task 1.6 emphasises the expedition side of the job, and task 1.8 the safety side.

For the other task analyses, the core tasks are as follows:

GMP: task 1.4 'Assess whether airfield traffic situation requires action by GMP'

task 1.6 'Decide start-up times'

GMC: task 2.5 'Decide what to do with traffic'

Air Departures: task 3.1.3 'Determine most expeditious order of departure'

Air Arrivals: task 4.1.5 'Ensure that traffic remains safely separated'

Approach: task 5.2 'Establish what level traffic is cleared to by LATCC and in what order'

No. 1 Director: task 5.7 'Ensure that traffic is directed as expeditiously as possible'

task 5.6 'Ensure that traffic remains safely separated'

No. 2 Director: task 6.5 'Ensure that traffic is directed on to final approach as expeditiously as possible'

task 6.4 'Ensure that traffic remains safely separated'

For the Wings position at radar, there is really no one task that is central to the job. The only task that involves any decision making is task 2.2 'Decide appropriate levels for departing traffic.'

4.2 PREFERRED ATC OPERATIONAL POSITIONS

4.2.1 Methods

4.2.1.1 Restriction of Data Collection to Heathrow

It was explained in the previous chapter that ATCOs readily express preferences with respect to the different positions that they are required to work on. These preferences become evident to an outsider quite quickly in a general way, due to comments made by ATCOs and to their behaviour on occasions. A story, perhaps apocryphal, illustrating an extreme case of preference is still told at Heathrow of an ATCO who, on arriving at the start of a duty and learning that he was allocated to a particular position, would go back down the stairs and head for the coffee room!

It became apparent that obtaining group data on preferences would be much more difficult at LATCC than at Heathrow. This was because of the accelerating trend at LATCC towards increasing specialisation in validations. Whereas ten years ago a reasonable number of ATCOs held validations on all the sectors on either North or South Banks, and some would hold them for sectors on both North and South Banks, today the majority of ATCOs hold validations on only two or three radar sectors, generally on one Bank. Thus it was not possible to ask ATCOs at LATCC to rank all positions in order of preference. Towards the end of the research, a statistical technique known as the Balanced Incomplete Block design was discovered which would have enabled an overall ranking to be obtained by combining partial rankings from several ATCOs. However, this aspect of the research was carried out under the supervision of the author by an MSc student who became involved in ATC research for his project. His findings are not included in this thesis. In any case, since separate task analysis data was not collected for each sector, the ranking of the different sectors at LATCC would have been less comparable with data from other parts of the investigation.

4.2.1.2 Measures

Two techniques were used to establish preferences at Heathrow, 'Simple Ranking' and 'Forced Choice Pair Comparisons'. The use of two techniques was adopted as an internal check on the reliability of the findings. 'Simple Ranking' required each ATCO to rank a complete set of positions in order of preference in response to the question: "All things being equal, which positions do you prefer usually to work on?" Rank '1' indicated the most preferred and rank '9' the least preferred position. Twenty-four ATCOs were asked to complete this questionnaire, and were instructed to complete it quickly. Most completed the task in under a minute. The set of positions comprised GMP, GMC, Air Arrivals, Air Departures, No. 1 Director North, No. 1 Director South, No. 2 Director, Approach (Procedural) Controller, and Special VFR.

The 'Forced Choice Pair Comparisons' (FCPC) questionnaire presented, separately, all possible pairs of positions from the full set (cf. Appendix IV). The positions were the same as for Simple Ranking, except that North Approach was specified rather than a combined Approach position. The inclusion of South Approach would have lengthened the questionnaire rather too much, and this for a position that very often was combined with No. 1 Director South. For reasons discussed in the section on task analysis, Special VFR was omitted from the full set of positions, so that the questionnaire covered eight positions which required 28 comparisons to be made. Each ATCO was required to indicate for each pair "Which position would you look forward more to working on generally?" An overall rank order of preference was derived for each ATCO by counting the frequency with which positions were preferred. If an ATCO had marked the middle box, indicating that no distinction could be made between a pair of positions, each position scored one half, as opposed to scoring one if a clear preference was indicated. The FCPC was administered to 37 ATCOs, different from the 24 who completed the Simple Ranking questionnaire.

4.2.1.3 Subjects

Altogether, therefore, the positions at Heathrow were ranked by 61 ATCOs, comprising 87 per cent of the ATCO II class at the Unit.

Their selection was governed only by their presence on the days that the questionnaires were given out. The return rate of completed questionnaires was 100 per cent.

4.2.1.4 Data Analysis

Since the preference data were clearly ordinal, the measure of agreement between the sets of ranks was calculated for each questionnaire by use of Kendall's coefficient of concordance $\underline{W}$. The size of $\underline{N}$ in both samples was greater than 7, thus a X^2 test was applied for significance of the results. The measure of agreement between the summarised rankings for the two questionnaires was calculated by Spearman's coefficient of rank correlation.

4.2.2 Results

The summarised rankings of Heathrow positions are shown in Table 1. Kendall's $\underline{W}$ for Simple Ranking was 0.726, and for FCPC was 0.716, both sets of results proving significant at the level $p < 0.001$. There is therefore a significant measure of agreement between the ATCOs' rankings. Although slight differences in rank order are found in the results from the two questionnaires, there is a very high level of agreement, the Spearman Brown correlation coefficient being 0.954. The raw data and calculations for $\underline{W}$ may be found in Appendix V.

Inspection of the raw data reveals that 95 per cent of the ATCOs prefer any of the first three positions (GMC, No. 1 Director North, and Air Departures) to any of the last four positions (Special VFR, GMP, Air Arrivals, and Approach). Indeed, 75 per cent of the ATCOs prefer any of the top five positions to any of the bottom four positions, and the remaining 25 per cent differ only very slightly. The consistency of these preferences suggests that the positions form two groups in the minds of most ATCOs, the more preferred group

Table 1

Overall preference for ATC positions at Heathrow Airport: Summary of results on 'Simple Ranking' and 'Forced Choice Pair Comparisons' questionnaires

QUESTIONNAIRE	Simple Ranking (n = 24) $p < 0.001$		Forced Choice Pair Comparisons (n = 37) $p < 0.001$	
POSITIONS	Sum of Individual Ranks	Overall Rank Position	Sum of Individual Ranks	Overall Rank Position
No.1 Director North	44	1	90	2
GMC	63	2	79	1
Air Departures	83	3	101	3
No.1 Director South	88.5	4	160.5	5
No.2 Director	96	5	143.5	4
Special VFR *	161	6	-	
GMP	173.5	7	241.5	6
Air Arrivals	183.5	8	245.5	7
Approach (Procedural) Controller +	187.5	9	271	8

Notes

* SVFR omitted from Forced Choice Pair Comparisons questionnaire

\+ Specified as 'North Approach' on Forced Choice Pair Comparisons questionnaire

1 = most preferred position

consisting of GMC, No. 1 Director North, Air Departures, No. 1 Director South, and No. 2 Director, and the less preferred group consisting of Special VFR, GMP, Air Arrivals and Approach. Whilst ATCOs do not agree strongly about the order of preference within each of these two groups, they agree very strongly about their preference for the first group over the second. This grouping of positions is brought out clearly by the data in Tables 2 and 3 which show the frequencies with which rankings were assigned to each position. Special VFR was omitted from this analysis to allow comparison between the other positions when the two questionnaires were combined.

Further distinctions between the positions are possible although some of them require caution since they cannot be tested for significance. Firstly, it appears that within the more preferred group of positions, No. 1 Director North and GMC are most preferred of all, being the first or second choice for two-thirds of the ATCOs. This is in marked contrast to No. 1 Director South and No. 2 Director, which are first or second choice for under a quarter of the ATCOs, but ranked in third, fourth or fifth place by nearly three-quarters of them. Air Departures seems to fall in between these two pairs of positions, being preferred to No. 1 Director South and No. 2 Director on many occasions without the consistency of preference shown by ATCOs for the top two positions. Almost equal numbers of ATCOs rank Air Departures in each of the first five places.

Amongst the less preferred group of positions, it is clear that the Approach Procedural position is the least preferred by most ATCOs, since it is ranked in last place by almost half of them, and in one of the last two places by three-quarters of them. GMP on the other hand is ranked sixth or better by just over half of the ATCOs, with Air Arrivals being ranked slightly less consistently than the other two positions.

Table 2

Preference for working on positions at Heathrow Airport: Frequencies of ranks assigned to each position combining data from 'Simple Ranking' and 'FCPC'

POSITIONS	ASSIGNED RANKS (1 = most preferred) 1	2	3	4	5	6	7	8
No.1 Director North	27	14	14	5	-	1	-	-
GMC	30	11	7	9	2	1	1	-
Air Departures	14	14	10	12	11	-	-	-
No.1 Director South	1	10	14	12	18	5	1	-
No.2 Director	6	7	12	19	13	1	1	2
GMP	-	-	1	1	7	23	20	9
Air Arrivals	-	-	-	-	7	20	16	18
Approach	-	-	-	1	2	12	19	27

Table 3

Preference for working on positions at Heathrow Airport: Cumulative Percentage Frequencies of assigned ranks.

POSITIONS	ASSIGNED RANKS (1 = most preferred) 1	2	3	4	5	6	7	8
No.1 Director North	44	67	90	98	98	100	-	-
GMC	49	67	79	93	97	98	100	
Air Departures	23	46	62	82	100	-	-	-
No.1 Director South	2	18	41	61	90	98	100	-
No.2 Director	10	21	41	72	95	97	98	100
GMP	-	-	2	3	15	52	85	100
Air Arrivals	-	-	-	-	11	44	70	100
Approach	-	-	-	2	5	25	56	100

4.3 JOB CHARACTERISTICS AND MOTIVATING POTENTIAL OF ATC POSITIONS

4.3.1 Method: Heathrow and LATCC

4.3.1.1 Measures

This part of the investigation involved the use of the Job Diagnostic Survey (cf. Appendix II), with a few amendments being made to Hackman and Oldham's original questionnaire. The most significant alteration to the JDS was made to Section Four, which normally measures job facet satisfaction with respect to the context factors of job security, pay, co-workers and supervision together with 'growth' satisfaction which is posited to be an affective outcome dependent on job content. The CAA advised the author that it would not be able to approve the use of questions about context satisfactions in the light of recent industrial relations problems. Thus the amended Section Four included only questions concerning growth satisfaction.

The other alteration of note concerned the questions in Sections One and Two relating to Task Identity. Preliminary study of the original JDS suggested that these questions were phrased in such a way that ATCOs might have considerable difficulty answering them in the context of ATC. Question 3 in Section One asks:
"To what extent does your job involve doing a 'whole' and identifiable piece of work? That is, is the job a complete piece of work that has an obvious beginning and end? Or is it only a small part of the overall piece of work, which is finished by other people or by automatic machines?"

It was thought that interpretation of 'piece of work' might be difficult, and indeed this was confirmed when a short extract from the JDS was piloted early in the investigation. Professor Hackman was consulted to establish whether he thought that some alteration would be a problem, and his view was that it was a case of playing off increased clarity for ATCOs against loss of comparability with previous JDS studies. As a result, the question was re-phrased as follows:

"To what extent does the job involve doing a <u>whole and identifiable piece of work</u>? That is, is the job a complete service that has an obvious beginning and end? Or is it only a small part of the overall service at this Unit, which is finished by other people?"

It was felt that the alteration would at least permit comparison between ATC positions, even if comparison with U.S. norms was compromised. Questions 3 and 11 from Section Two were amended on the same lines to be consistent with the first question. The only other alterations to the original were for the purpose of anglicising one or two Americanisms.

4.3.1.2 <u>Subjects</u>

At Heathrow, the JDS was completed by 57 ATCO II's. Of these, nine were volunteers who gave up some free time to attend feedback and discussion sessions at Aston University at no expense to themselves. The remaining 48 were volunteers who either attended organised lunchtime group sessions before an afternoon duty, or who were approached as individuals whilst on breaks during a duty. The sample represents approximately 80 per cent of the total ATCO II population at the Unit, and was stratified through the organisation of sessions so that all five Watches were represented.

At LATCC, 82 ATCOs, representing 27 per cent of the population at the Unit, completed the JDS. As with the Heathrow ATCOs, they were all volunteers who either came to Aston University or who attended lunchtime sessions. The sample was stratified to ensure that all Watches were represented.

4.3.1.3 Data Collection Procedures

Although the JDS was developed as a tool for diagnosing whole jobs, the main purpose for which it was intended for this research was the diagnosis of individual ATC positions. It was thought that these positions were, in many cases, sufficiently distinct as 'jobs' to enable ATCOs to rate them on the JDS.

However, the decision was taken to limit the number of positions to be rated at Heathrow for three reasons. Firstly, it was important that each position should be rated by an acceptably large sample of ATCOs, particularly in view of the relatively low scale reliabilities reported by Hackman and Oldham (1975). Secondly, it was not thought to be advisable on either methodological or practical grounds to ask ATCOs to complete more than one JDS each. This necessarily limited the number of positions that could be rated at Heathrow. Finally, it was thought unlikely that there would be significant differences between some positions on the dimensions measured by the JDS, and since there was no expectation nor indeed time to conduct exhaustive enquiries, it seemed better to rationalise the positions for the JDS. Thus, taking all these factors into account, it was decided to rate six positions at Heathrow, with a sample of eight ATCOs per position representing just over 10 per cent of the ATCO population at the Unit.

The six positions were GMP, GMC, Air Arrivals, Air Departures, Approach and No. 1 Director. These last two 'positions' were amalgamations of the North and South positions. ATCOs who rated these were asked to make an average rating for each question based on their view of both North and South positions. The blank questionnaires were each allocated to a position, the name of which was written on the front cover. This allocation was done sequentially, so that each batch of six JDS's comprised one for each of the six positions. As each person entered the room to complete the questionnaire, he or she was given whichever copy of the JDS happened to be on the top of the pile. In this way, the eight ATCOs who rated any particular position were distributed across all five Watches, and randomly in all other respects except for the fact that they were volunteers. At a later date, nine ATCOs who were attending sessions at Aston University completed the JDS for their job at Heathrow as a whole.

Similar procedures were adopted at LATCC. Since task analysis had been carried out only for generalised Radar and Wings positions, and since there were no rank preference data for comparison, it was decided to obtain JDS ratings for generalised Radar and Wings too. 62 ATCOs from the Unit representing 10 per cent of the total population attended lunchtime sessions and were allocated in equal numbers to rate either Radar or Wings. During the Aston sessions, 20 ATCOs rated the 'whole' job of an ATCO II at LATCC.

4.3.1.4 Data Analyses

Scale scores for the JDS were calculated for each respondent according to the Hackman and Oldham (1980) scoring key (cf.Appendix III),together with the additional calculation of an additive MPS for reasons discussed in Chapter Two (cf. 2.4.3). Next, scale scores for each job or position were obtained simply by averaging the individual scale scores. Finally, GNS scores for the ATCO class were obtained by averaging their individual scores.

For purposes of analysis, the JDS data may be considered in the context of a split-plot repeated measures design involving two factors, factor A being jobs or positions and factor B being JDS dimensions. The appropriate method of analysis, therefore, required an initial two-way analysis of variance (ANOVA). The focus of interest was on the AB interaction, questions being framed in terms such as: "Is there a difference between GMP and GMC on Skill Variety, Task Identity etc.?" Thus, if the AB interaction proved to be significant, tests of simple main effects were carried out for all levels of factor B, (JDS dimensions). The error term used for tests of simple main effects of factor A (jobs) was $MS_{w.cell}$, which is the pooled error term appropriate when the AB interaction is significant (Winer, 1971). The final stage of the analysis, assuming a significant F for simple main effects, was testing the difference between all possible pairs of means.

There are several procedures for making a posteriori tests for comparing differences between cell means, which vary quite widely in their power or level of conservatism. (Winer, 1971). The most widely used use the studentised range statistic. A common procedure of this type is the Newman-Keuls (cf. Winer, 1971, Chapters 3 and 7), which proceeds as follows: The set of cell means or totals is arranged in order of magnitude from least to greatest, and then divided into subsets which are consistent with the hypothesis of no differences. Within each subset, no tests are made unless its range (i.e. the greatest difference between means or totals) is significantly greater than zero. The statistic used is $\underline{q_r}$, where $\underline{r}$ is the number of steps that the two means or totals are apart in the ordered sequence.

Tests were carried out at both the 0.01 and 0.05 levels, since in some cases use of the more rigorous level produced no significant differences at all, even though the test of simple main effects had proved significant at the 0.01 level. The error term used in calculating the critical values was the pooled error term $MS_{w.cell}$.

Several assumptions underly the analysis of variance procedures. One is that the distribution of the variables in the population from which the samples are drawn is normal. However, unless there are reasons for suspecting a relatively extreme departure from normality, it is thought that the conclusions drawn from the data after using an F test will not be affected too seriously (Ferguson, 1976). Since the effect of a departure from normality is to increase type 1 error, a safeguard is to adopt a more rigorous level of confidence than usual. Throughout the JDS analysis, a confidence level of .01 was used.

A second assumption is that of homogeneity of variance. Whilst tests for homogeneity are possible (Winer, 1971) in practice it has been found that the F test is robust enough to withstand minor violations. Kerlinger (1973) goes so far as to claim that the evidence suggests that the importance of normality and homogeneity is overrated, and concludes that "it is probably safer - and usually more effective - to use parametric tests rather than nonparametric tests." (p.288)

The issue of parametric versus nonparametric statistics is controversial and seems a long way from resolution. In practice, parametric tests are often carried out on ordinal data with little or no justification provided. This is certainly true of Hackman and Oldham's research, although the JDS data cannot be classified as better than ordinal. However, from a pragmatic point of view the present research has used parametric statistics on some aspects of the JDS data, since equivalent nonparametric statistics were not available. As mentioned earlier, in order that the risk of type 1 error be minimised, more rigorous confidence levels were used at every stage in the analysis.

Additional analysis was conducted of the JDS data to provide limited checks of the reliability of the JDS on a British sample, and to examine the intercorrelations between dimensions. The former analysis required calculation of internal consistency reliabilities as described by Hackman and Oldham (1975). These reliabilities were obtained by calculating the interitem product moment correlations for all items which are scored on each scale of the JDS, transforming them to $\underline{Z}$ scores which were then averaged before conversion back to average correlation coefficients. Intercorrelations among the JDS scales were calculated for both Spearman Brown and Pearson coefficients.

4.3.2 Results: LATCC Positions

The summarised JDS results for LATCC are shown in Table 4. The two way ANOVA revealed a significant interaction between the positions and the JDS dimensions with an $\underline{F}$ value of 16.49 significant at the level $p < 0.001$ (cf. (Table 5). Tests of simple main effects were carried out (cf. Table 4) which showed that Radar rated significantly higher than Wings on all scales of the JDS, except for Feedback from Job, Feedback from Agents and Knowledge of Results on which there was no significant difference. The scales showing most difference between the two positions were Skill Variety and Growth Satisfaction, with other large differences revealed on General Satisfaction, Experienced Meaningfulness, Task Significance, Autonomy and Internal Motivation. The profiles of the two positions based on the JDS core job dimensions are shown in Figure 6.

4.3.3 Results: Heathrow Positions

The summarised JDS results for Heathrow are shown in Table 6. The two way ANOVA showed a significant Positions-Dimensions interaction, $\underline{F}$ having a value of 2.92 which is significant at the level $p < .001$ (cf. Table 7). Tests for simple main effects were carried out (cf. Table 6) which showed that there were significant ($p < .01$) differences between the positions at Heathrow on eight of the thirteen scales of the JDS. The eight scales are Skill

Table 4

JDS Means and Standard Deviations for LATCC showing F values obtained by tests of simple main effects

	Radar		Wings		F	P
	$\bar{X}$	S.D	$\bar{X}$	S.D		
Skill Variety	5.7	0.8	2.6	1.0	155.4	$<$ .001
Task Identity	3.4	1.2	2.7	1.0	8.0	$<$ .01
Task Significance	6.5	0.6	4.9	1.2	45.3	$<$ .001
Autonomy	5.5	1.0	4.0	1.1	37.6	$<$ .001
Feedback from Job	5.1	1.1	4.7	1.4	2.6	N.S
Feedback from Agents	3.2	1.5	2.7	1.0	3.8	N.S
Dealing with Others	6.4	0.6	5.3	1.2	19.5	$<$ .001
MPS - Additive	26.2	3.0	18.9	3.3		
MPS - Multiplicative	146	58.6	64	35.6		
Experienced Meaningfulness	5.8	0.6	3.9	0.9	59.1	$<$ .001
Experienced Responsibility	6.1	0.6	5.1	0.7	16.5	$<$ .001
Knowledge of Results	5.4	0.8	5.4	0.9	0.0	N.S
General Satisfaction	5.5	0.6	3.3	1.2	73.5	$<$ .001
Growth Satisfaction	5.4	0.7	2.9	1.2	103.3	$<$ .001
Internal Motivation	5.8	0.6	4.4	1.0	32.4	$<$ .001
N	31		31			

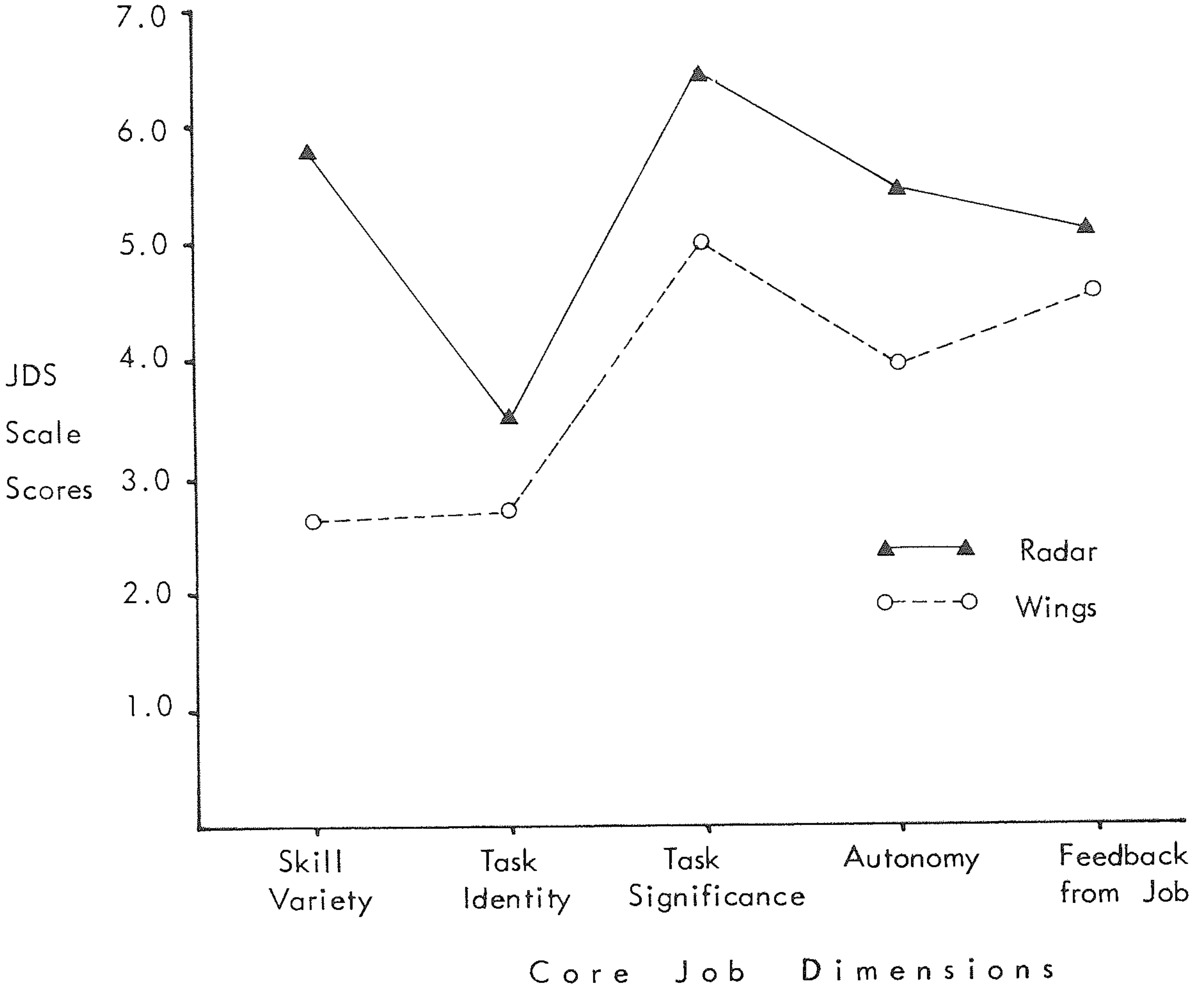
Table 5

2-Way Analysis of Variance for LATCC JDS Results

SOURCE	SS	d.f	MS	F	P
Between Positions	382.881	1	382.881	109.31	$<$.001
Subjects within Groups	210.154	60	3.503		
Between Dimensions	647.571	12	53.964	72.95	$<$.001
Interaction	146.343	12	12.195	16.49	$<$.001
B x SWG	532.591	720	0.74		

Figure 6

Comparison of Radar and Wings JDS profiles based on core job dimensions



Variety, Task Identity, Autonomy, Feedback from Job, Dealing with Others, Experienced Meaningfulness, General Satisfaction and Growth Satisfaction.

The Newman-Kuels procedure used to test the difference between all possible pairs of means revealed which positions were significantly different from each other and the dimensions or scales on which they differed. (cf. Appendix VI).

Table 6

JDS Means and Standard Deviations for Heathrow by position showing F values obtained by tests of simple main effects

	GMC		Air Departures		No.1 Director		GMP		Approach		Air Arrivals		F	P
	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D		
Skill Variety	5.7	0.91	5.0	0.79	5.9	0.58	4.0	1.53	4.3	0.71	2.8	1.02	9.04	<.001
Task Identity	4.3	1.49	4.3	1.13	4.0	0.84	3.4	1.55	3.0	1.18	2.5	1.04	3.58	<.01
Task Significance	5.3	1.43	6.3	0.60	6.5	0.78	6.2	0.82	6.2	0.78	5.5	1.22	1.55	N.S
Autonomy	6.6	0.49	5.5	1.19	4.6	1.27	5.0	1.44	3.8	1.13	4.1	0.81	7.24	<.001
Feedback from Job	5.6	1.21	5.7	1.36	5.6	1.25	5.0	1.49	5.1	1.42	2.8	1.44	8.10	<.001
Feedback from Agents	3.4	1.92	3.1	1.76	2.8	1.32	3.6	1.70	2.8	0.91	1.8	0.89	2.68	<.05
Dealing with Others	5.3	2.03	4.1	1.05	6.3	0.58	6.2	0.59	6.4	0.45	5.7	1.53	5.15	<.001
MPS - Additive	27.5	3.07	26.8	2.79	26.6	3.00	23.6	4.14	22.4	4.49	17.7	1.88		
MPS - Multiplicative	189	58.4	163	65.8	141	60.3	113	68.9	87	55.5	41	15.6		
Experienced Meaningfulness	5.8	0.65	5.9	0.60	5.9	0.55	4.5	1.31	5.1	1.08	4.0	0.54	4.38	<.001
Experienced Responsibility	6.3	0.98	5.9	0.52	6.0	0.74	5.5	1.26	5.8	1.34	5.3	0.60	0.88	N.S.
Knowledge of Results	6.2	0.52	5.9	0.63	5.1	0.92	5.5	0.97	5.7	0.50	4.6	1.36	2.20	N.S.
General Satisfaction	5.7	0.41	5.5	1.13	5.1	1.04	4.0	1.24	4.4	1.09	3.4	0.80	5.53	<.001
Growth Satisfaction	6.0	0.61	5.1	0.79	4.7	1.03	4.5	0.91	4.4	1.51	3.4	0.94	5.01	<.001
Internal Motivation	5.9	0.53	5.7	0.60	5.5	0.72	5.0	1.02	5.0	1.26	4.1	0.87	2.83	<.05

Table 7

2-Way Analysis of Variance on Heathrow JDS Results

SOURCE	S	d.f	M.S.	F	P
Between Positions	182.02	5	36.404	8.3	<.001
Subjects within Groups	184.21	42	4.386		
Between Dimensions	429.515	12	35.793	39.71	<.001
Positions x Dimensions	157.996	60	2.633	2.921	<.001
B x SWG	454.287	504	0.901		

Summarised Newman-Kuels results are presented in Tables 8 - 15, the asterisks in cells indicating differences between positions significant at the 0.01 level or 0.05 level.

Table 8

Differences between Heathrow Positions on Skill Variety

Positions	AA	GMP	APC	AD	GMC	No.1
AA		*	*	**	**	**
GMP					*	**
APC					*	*

** = significant at .01 level

* = significant at .05 level

Examining the Skill Variety dimension (Table 8), Air Arrivals is significantly lower than No. 1 Director, GMC and Air Departures. There is also reason to believe that it is lower than Approach Controller and GMP. GMP is lower than No. 1 Director on this dimension, and more cautiously it looks as though it is lower than GMC. Additionally, it seems that Approach is lower than both No. 1 Director and GMC.

Table 9

Differences between Heathrow Positions on Task Identity

Positions	AA	APC	GMP	No.1	GMC	AD
AA				*	*	*

** = significant at .01 level

* = significant at .05 level

Results on the Task Identity dimension (Table 9) are only significant at the 0.05 level, indicating that Air Arrivals rates significantly lower than Air Departures, GMC and No. 1 Director.

Table 10

Differences between Heathrow Positions on Autonomy

Positions	APC	AA	No.1	GMP	AD	GMC
APC					*	**
AA					*	**
No. 1						**
GMP						**
AD						*

** = significant at .01 level

* = significant at .05 level

It is quite clear from the results for Autonomy (Table 10) that GMC rates significantly higher than Approach, Air Arrivals, No.1 Director, GMP and less surely Air Departures. Additionally, there is evidence that Air Departures rates significantly higher than Approach and Air Arrivals.

Table 11

Differences between Heathrow Positions on Feedback from Job

Positions	AA	GMP	APC	GMC	No.1	AD
AA		**	**	**	**	**

** = significant at .01 level

* = significant at .05 level

The clear result on the Feedback from Job dimension (Table 11) is that Air Arrivals rates significantly lower than all the other rated positions.

Table 12

Differences between Heathrow Positions on Dealing with Others

Positions	AD	GMC	AA	GMP	No.1	APC
AD		*	**	**	**	**

** = significant at .01 level

* = significant at .05 level

On the Dealing with Others dimension (Table 12), Air Departures is shown to rate significantly lower than Approach, No. 1 Director, GMP and Air Arrivals, and lower than GMC at the .05 level. The results for the Experienced Meaningfulness dimension (Table 13) show Air Arrivals to be significantly lower than Air Departures, No. 1 Director and GMC.

Table 13

Differences between Heathrow Positions on Experienced Meaningfulness

Positions	AA	GMP	APC	GMC	No.1	AD
AA				**	**	**

** = significant at .01 level

* = significant at .05 level

Table 14

Differences between Heathrow Positions on General Satisfaction

Positions	AA	GMP	APC	No.1	AD	GMC
AA				*	**	**
GMP					*	*

** = significant at .01 level

* = significant at .05 level

On the General Satisfaction dimension (Table 14), it can be seen that Air Arrivals rates significantly lower than GMC, Air Departures and No. 1 Director, whilst GMP rates lower than GMC and Air Departures.

Table 15

Differences between Heathrow Positions on Growth Satisfaction

Positions	AA	APC	GMP	No.1	AD	GMC
AA					*	**
APC						*
GMP						*

** = significant at .01 level

* = significant at .05 level

Finally, on the Growth Satisfaction dimension (Table 15) GMC rates significantly higher than Air Arrivals, Approach and GMP, whilst Air Departures rates higher than Air Arrivals.

The comparative JDS profiles of the Heathrow positions are shown in Figures 7 and 8. The four Tower positions (Air Arrivals, Air Departures, GMP and GMC) are shown in Figure 7, whilst Figure 8 compares the two rated positions down in the Approach room (Approach Procedural Controller and No. 1 Director).

Figure 7

Comparison of Heathrow Tower positions on JDS profiles

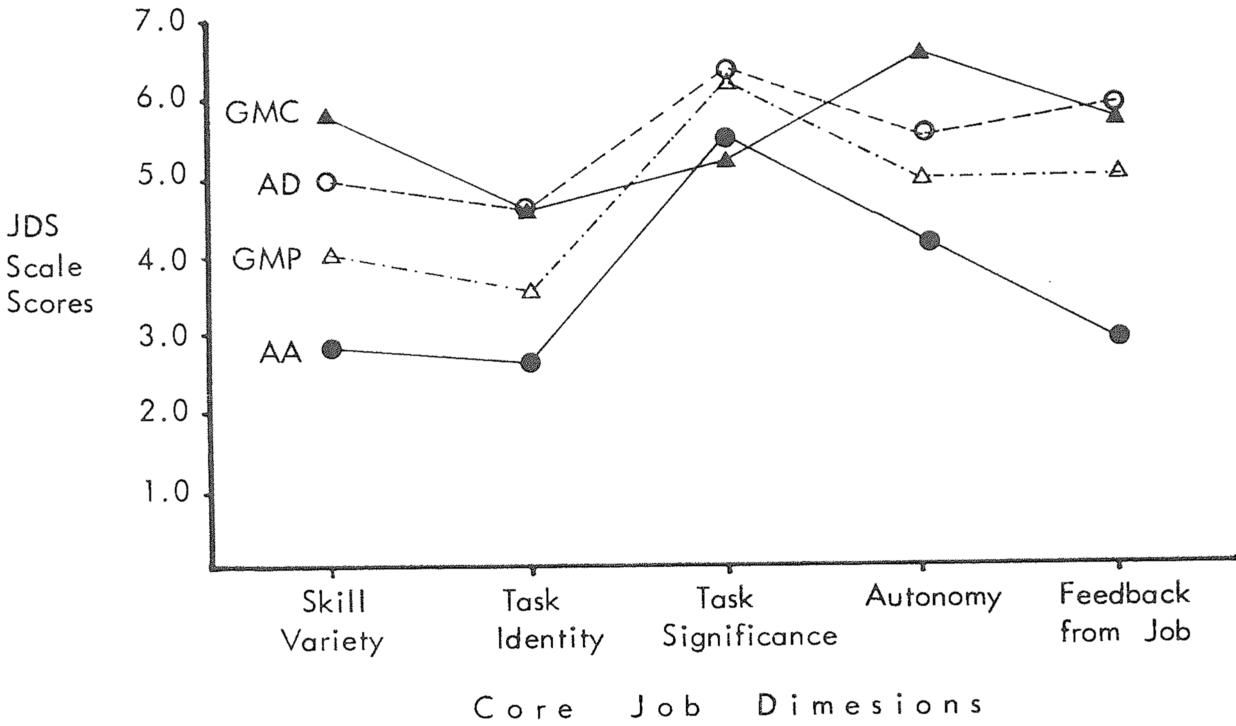
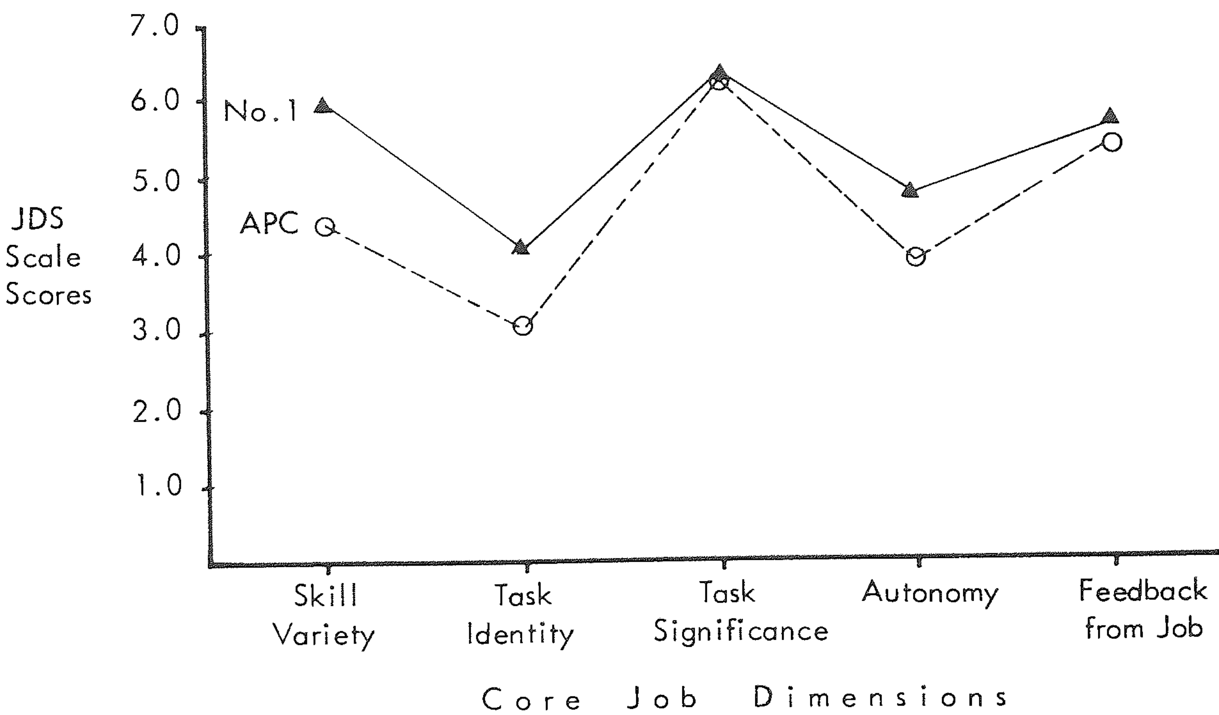


Figure 8

Comparison of Heathrow Approach positions on JDS profiles



4.3.4 Results: Ratings of Whole Job at Heathrow and LATCC and GNS Scores

Ratings of the whole job were obtained from nine ATCOs at Heathrow and 20 ATCOs at LATCC. The summarised results are presented in Table 17. For comparative purposes, U.S. normative data from the JDS are presented alongside, representing the norms for (a) all jobs (n = 876) and (b) Middle management (n = 45).

Although no statistical analysis was possible, comparison with the U.S. norms suggests that the job of ATCO in the U.K. has more motivating potential than average, comparable perhaps to a middle management job. The results suggest that the ATCOs' job content lacks mainly in Task Identity, although this comparison needs treating with even greater caution. (cf. discussion in next chapter and section 4.3.1.1). The comparative JDS profiles are shown in Figure 9.

The summarised GNS Scores for all the ATCOs who completed the JDS are shown in Table 16, and compared with selected U.S. norms. The data show that U.K. ATCOs have GNS Scores just about average for the U.S.A. and rather lower than employees coming under the Professional and Technical D.O.T. category in the U.S.

Table 16

GNS Scores for U.K. ATCO sample compared with selected U.S. norms

	U.K. ATCOs		U.S. Norms Whole Sample		Managerial		Professional or Technical	
	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D	$\overline{X}$	S.D
Total GNS	5.06	0.60	4.93	0.86	5.30	0.54	5.59	0.57
N	139		6930					

Figure 9

Comparison of ATCO Job JDS profiles at Heathrow and LATCC with USA Norms for All Jobs (n = 876 Jobs)

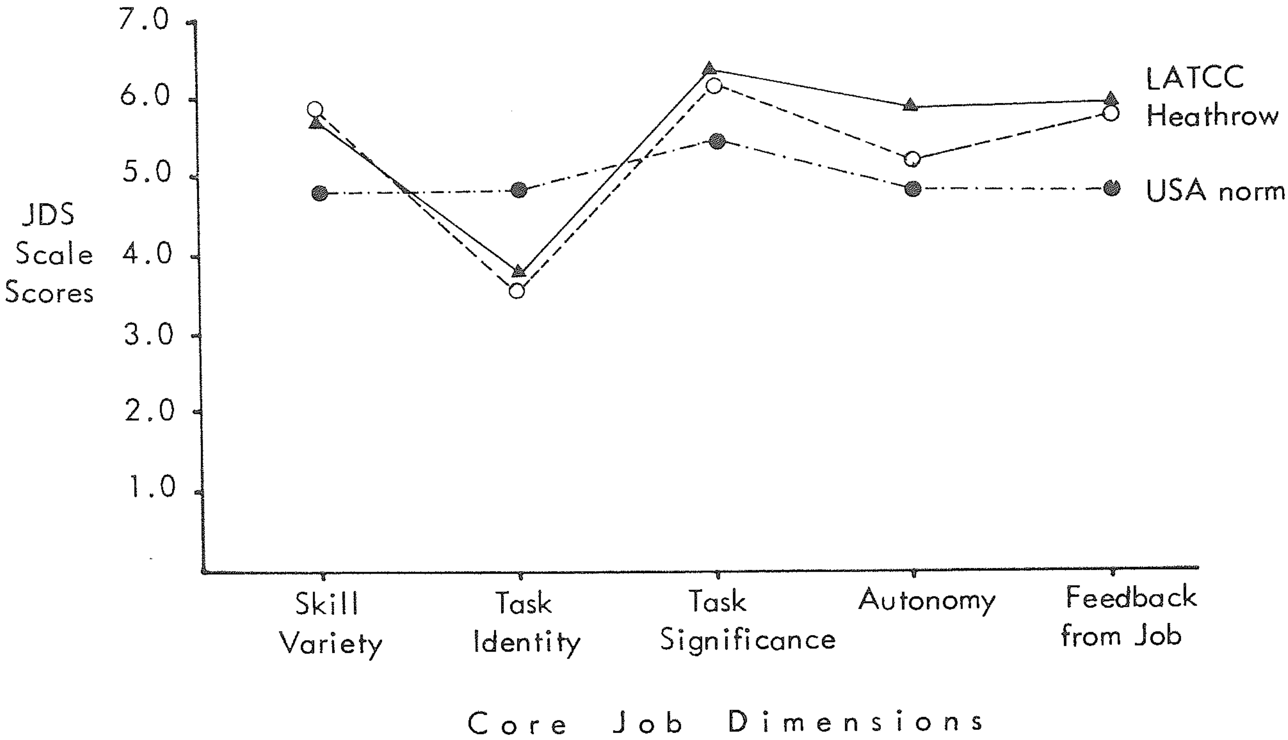


Table 17

JDS Means for LATCC and Heathrow (Whole Jobs) compared with U.S. Norms for (a) all jobs and (b) Middle Management

	LATCC	Heathrow	U.S.Norms All Jobs	U.S.Middle Management
Skill Variety	5.9	6.0	4.7	6.0
Task Identity	3.8	3.5	4.7	4.9
Task Significance	6.4	6.2	5.5	5.9
Autonomy	5.7	5.0	4.9	5.7
Feedback from Job	5.7	5.5	4.9	5.4
Feedback from Agents	2.9	4.1	4.1	4.6
Dealing with Others	6.2	6.4	5.6	6.5
MPS - Additive	27.4	26.2	N/A	N/A
MPS - Multiplicative	174	144	128	176
Experienced Meaningfulness	5.9	5.7	5.2	5.8
Experienced Responsibility	6.0	5.9	5.5	5.9
Knowledge of Results	5.2	5.9	5.0	5.0
General Satisfaction	5.6	4.6	4.7	5.2
Growth Satisfaction	5.6	5.1	4.8	5.6
Internal Motivation	5.7	5.6	5.6	5.9
N (= no. of respondents for LATCC & Heathrow (= no. of jobs for U.S. norms	20	9	876	45

4.3.5 Intercorrelations Among JDS Scales and Internal Consistency Reliabilities

Intercorrelations among the JDS scales are presented in Tables 18 and 19. The product-moment correlation coefficients shown in Table 18 at the lower left hand side of the matrix are compared with those reported by Oldham, Hackman and Stepina (1978) for computations across all 6,930 respondents. Table 19 presents Spearman rank correlation coefficients which are more supportable for the data in question.

Moderate intercorrelations are shown between the five core job dimensions, consistent with reports by Oldham et al (1978) and previous findings by Hackman and Oldham (e.g. 1975). Substantial relationships are revealed between the core job dimensions and their corresponding psychological states, although some anomalies need pointing out. Firstly, Task Identity is less closely related to Experienced Meaningfulness than either Autonomy or Feedback from Job. Secondly, Experienced Responsibility is noticeably more closely associated with both Skill Variety and Task Significance than with its posited determinant, Autonomy. Feedback from Job is associated just as closely with Experienced Meaningfulness as with Knowledge of Results.

There is a markedly stronger relationship between General Satisfaction and the core job dimensions revealed by the present study than is shown in the U.S. data. This is supported by the high correlation between MPS and General Satisfaction. The high correlation between MPS and Growth Satisfaction (+0.81) should also be noted. There is as strong a relationship directly between Skill Variety and General Satisfaction as between the mediating psychological state Experienced Meaningfulness and General Satisfaction. Internal Motivation is most closely associated with Skill Variety, MPS (Additive) and two of the three psychological states.

In common with the reports of Hackman and colleagues, the GNS measures are shown to be independent of the measures of job dimensions,

Table 18

Intercorrelations among JDS Scale Scores (n = 139)

(a) Pearson Correlation Coefficients* (Bottom left matrix = present study
Top right matrix = Oldham et al, 1978)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Skill Variety	-	.22	.42	.44	.34	.18	.39	N/A	.61	.45	.34	.15	.33	.48	.34	.15
2. Task Identity	.34	-	.19	.30	.23	.16	-.01	N/A	.46	.22	.27	.19	.20	.24	.16	.07
3. Task Significance	.56	.21	-	.32	.34	.18	.29	N/A	.51	.45	.32	.22	.29	.38	.33	.09
4. Autonomy	.54	.49	.31	-	.39	.27	.25	N/A	.79	.42	.39	.29	.42	.54	.31	.09
5. Feedback from Job	.42	.30	.22	.23	-	.38	.19	N/A	.76	.39	.36	.49	.35	.43	.32	.11
6. Feedback from Agents	.30	.14	.21	.19	.38	-	.14	N/A	.37	.29	.23	.39	.32	.36	.25	.02
7. Dealing with Others	.32	-.03	.33	.06	.16	.26	-	N/A	.29	.20	.14	.04	.13	.23	.22	.19
8. MPS - Additive	.84	.66	.63	.73	.63	.35	.24	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9. MPS - Multiplicative	.74	.61	.49	.76	.70	.35	.16	.95	-	.52	.47	.43	.46	.59	.40	.19
10. Experienced Meaningfulness	.77	.41	.61	.49	.45	.31	.24	.78	.68	-	.58	.40	.66	.65	.57	-.03
11. Experienced Responsibility	.57	.27	.58	.36	.33	.18	.23	.60	.52	.65	-	.34	.49	.51	.59	.12
12. Knowledge of Results	.10	.27	.04	.11	.46	.24	.02	.28	.32	.26	.29	-	.42	.39	.23	-.01
13. General Satisfaction	.71	.44	.49	.54	.35	.19	.20	.73	.65	.74	.61	.16	-	.69	.43	-.08
14. Growth Satisfaction	.76	.50	.54	.69	.35	.27	.25	.81	.74	.75	.59	.16	.79	-	.48	.01
15. Internal Motivation	.68	.32	.53	.43	.36	.22	.22	.67	.57	.73	.68	.25	.69	.69	-	.11
16. Total GNS	.02	-.03	-.01	-.02	.01	.06	.05	-.01	.01	-.10	-.01	-.03	-.16	-.04	-.06	-

* Correlation coefficients $\geq$ .20 are significant at .01 level
$\geq$ .25 are significant at .001 level
for data from present study

Table 19

Intercorrelations among JDS Scale Scores (n = 139)

(b) Spearman Nonparametric Correlation Coefficients *

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Skill Variety	-															
2. Task Identity	.35	-														
3. Task Significance	.53	.21	-													
4. Autonomy	.56	.48	.29	-												
5. Feedback from Job	.41	.31	.28	.25	-											
6. Feedback from Agents	.27	.18	.19	.18	.36	-										
7. Dealing with Others	.38	.02	.35	.12	.18	.29	-									
8. MPS - Additive	.83	.67	.60	.74	.62	.32	.27	-								
9. MPS - Multiplicative	.77	.61	.50	.78	.71	.34	.25	.97	-							
10. Experienced Meaningfulness	.75	.41	.57	.49	.44	.28	.27	.76	.71	-						
11. Experienced Responsibility	.58	.25	.57	.37	.31	.16	.29	.60	.55	.68	-					
12. Knowledge of Results	.06	.22	.09	.11	.44	.23	.03	.24	.29	.25	.32	-				
13. General Satisfaction	.71	.45	.43	.53	.34	.15	.26	.71	.68	.72	.59	.16	-			
14. Growth Satisfaction	.74	.52	.49	.66	.35	.28	.31	.79	.77	.70	.56	.16	.77	-		
15. Internal Motivation	.66	.31	.48	.41	.32	.18	.26	.62	.57	.71	.64	.28	.66	.63	-	
16. Total GNS	-.01	-.04	-.00	-.03	.02	.05	.13	-.00	-.02	-.09	-.00	-.01	-.15	-.01	-.04	-

* Correlation coefficients

≧ .15 are significant at .05 level

≧ .21 are significant at .01 level

≧ .27 are significant at .001 level

psychological states and outcomes. It should also be noted that the two additional job dimensions (Feedback from Agents and Dealing with Others) show generally lower relationships with other scales in the JDS, consistent with Hackman's research. A notable exception to this is that Dealing with Others is moderately associated with both Skill Variety and Task Significance, as Hackman has found.

The internal consistency reliabilities of the JDS are shown in Table 20, together with those obtained by Oldham et al (1978).

Table 20

Internal Consistency Reliabilities of the JDS Scales for present data (n = 139) and U.S. data (n = 6930)

JDS Scale	Reliabilities	
	Present Study	U.S.Data
Skill Variety	.69	.68
Task Identity	.33	.61
Task Significance	.49	.58
Autonomy	.60	.64
Feedback from Job	.64	.68
Feedback from Agents	.55	.75
Dealing with Others	.52	.62
Experienced Meaningfulness	.48	.71
Experienced Responsibility	.31	.67
Knowledge of Results	.43	.71
General Satisfaction	.48	.77
Growth Satisfaction	.66	.84
Internal Motivation	.37	.69
Would like GNS	.36	.87
Job choice GNS	.14	.71

The reliabilities in the present study range from a high of .69 to a low of .14, generally lower than the American reliabilities and in a few cases very much lower. Amongst the core job dimensions, the amended items measuring Task Identity only achieve a reliability of .33, against the .61 obtained by Oldham. Task Significance is also shown to be less reliable in the present study. The other core job dimensions however achieve comparable reliability levels to those of

Oldham. On the other JDS scales, the reliabilities for the present study are substantially lower than those obtained by Oldham, and in the case of Job Choice GNS the reliability is unacceptably low. Of 66 interitem correlations computed for Job Choice GNS, only 22 achieved significance at the .01 level. Other scales on which the reliabilities were particularly low are Experienced Responsibility (.31), Internal Motivation (.37) and Would Like GNS (.36).

Examination of specific interitem correlations reveals certain items that associate less overall with the other items on the same scale. Within the Experienced Responsibility scale, items 12 and 15 in Section Three of the JDS are relatively isolated from the others, correlations with other items ranging from .03 to .32 for item 12, and from .13 to .47 for item 15. These items require the respondent to rate the extent to which he feels that the results of the work are clearly his responsibility, for which he should receive credit or blame accordingly. On the Internal Motivation scale, items 10 and 14 from Section Three and item 9 from Section Five show low associations with other items on the scale and with each other. Item 10 (S.3) receives interitem correlations ranging from .16 to .39, item 14 (S.3) from .23 to .44, and item 9 (S.5) from .16 to .41. Finally, on the Job Choice GNS scale, item 3 (Section Seven) shows no significant association with any of the other items in the scale at the .01 level, item 1 is associated with only one other item on the scale ($r = .19$), and item 9 is associated with only two other items on the scale.

4.4 REPERTORY GRID ANALYSIS OF TASKS

4.4.1 Method: Heathrow and LATCC

4.4.1.1 Measures

The Repertory, or Rep Grid technique was used in two fundamentally different yet interconnected ways. Full Rep Grid interviews were conducted with a small sample of ATCOs to provide constructs that would form the basis of subsequent Rep Grid completion by a much larger sample. The initial Rep Grid interviewees were provided with elements - namely, tasks from the task analysis for their Unit - and the interview proceeded in order that constructs could be elicited pertaining to intrinsic job satisfaction and task demands. The details of these interviews will be provided shortly. Each interviewee was asked to select between 9 - 12 tasks from a set to make up the elements for the interview.

On completion of these initial interviews, the total set of constructs elicited during the interviews were content analysed for the purpose of selecting a sample of 'common constructs', i.e. constructs that seemed to be relevant or important to a large proportion of ATCOs. It must be emphasised that this process of selecting common constructs required the author to impose his own construct system on to the data, since it was not possible to determine whether, for example, two constructs phrased in similar language actually meant the same thing to the two ATCOs concerned.

Analysis suggested that there were six major clusters of construct across the initial grids, which encompassed most of the individually elicited constructs. These were labelled as follows: (a) Job satisfaction; (b) Decision-making; (c) Skill and experience; (d) Concentration; (e) Significance/Relevance; and (f) Autonomy. These labels, together with a large sample of the constructs they encompassed, are shown in Appendix VII.

From these initial Rep Grid interviews, a standard Rep Grid was produced by the author containing 16 tasks (elements) and 16 constructs. Of these 16 constructs, 11 were created from the summarised data arising out of the initial Rep Grids, and another five were added by the author on the basis of ideas connected with the research. However, none of the five additional constructs had been shown on the basis of the initial interviews to be related to ATCO job satisfaction, and consequently they are not included in the following analysis. The 11 'justified' constructs are shown in Table 21.

Table 21

List of Constructs included in Standard Rep Grid derived from initial Rep Grid Interviews with ATCOs

1. What I'm paid to do
2. Gives me a lot of job satisfaction
3. Demands a lot of concentration
4. Requires all my skill and experience
5. Mainly up to me whether it gets done well
6. I have a lot of autonomy in doing it
7. Unnecessarily time-consuming
8. Requires a high level of decision making on my part
9. Involves a lot of coordination and consultation with others
10. Very boring
11. Very annoying

These constructs are unipolar as opposed to bipolar; that is to say, only one pole of each is explicit. It was not clear whether bipolar constructs would be more appropriate than unipolar on a priori grounds, and indeed there were arguments in favour of both. Bipolar constructs would have provided more explicit data; however, by providing the implicit pole it was thought possible that particular constructs would have been less meaningful to some ATCOs. By omitting the implicit pole of each construct it was left to the respondent to supply his or her own, increasing the likelihood that a richer set of discriminations might be made. Reference to the initial Rep Grid interviews made it possible to ascertain whether the explicit pole of each construct was preferred or not, since this information was obtained during the interviews. The explicit poles were phrased so that they represented an 'extreme': that is, a rating that indicated an element was not accurately described by a 'preferred' explicit pole could be taken fairly reliably to mean that the element was less, not more, preferred. Finally, constructs were chosen to represent a selection of positive and negative poles to improve the reliability of ratings by the avoidance of response set effects.

Altogether 32 tasks from each Unit's task analyses were used as elements on the standard Grids, making a total of 64. These were presented in groups of 16 on each Grid. The full list of tasks appears in Appendix VIII. They were selected from the higher levels of the task analyses, representing a wide range of ATC tasks.

In addition to the Rep Grids discussed above, a few were conducted at the outset of this phase of the research using elicited situations or incidents that had provided satisfaction or dissatisfaction as the elements. These interviews were carried out partly to give the author experience in the Rep Grid technique, eliciting elements in a way that had been tried by other researchers and that was known to be quite straightforward. Since these interviews provided relevant data that were not formally obtained in any other part of the research, they are included in the results section.

4.4.1.2 Subjects

The initial Rep Grid interviews that led to the derivation of the standard Grid were conducted with 11 ATCOs who were selected by the Assistant Watch Supervisor at the time on the basis of their availability, and who were asked by him whether they would volunteer to act as interviewees. Random selection of interviewees by the author would have presented the Watches with some administrative difficulties which it was intended to avoid on principle.

The standard Grids were completed by 20 ATCOs from each Unit. These were all volunteers who gave up two days of their free time to spend it at the CAA's and Aston's expense working at Aston University on various tasks, one of which was the completion of the standard Grids. These 'working trips' were planned several weeks in advance, and were advertised at the Units through the union representatives. Only 40 ATCOs could be paid for, and it was decided that these should be divided equally between the Units and between the Watches at each Unit. Since there were more than enough volunteers from each Watch, the union representatives arranged a draw to decide the lucky winners! So far as the author could ascertain, this was conducted fairly and without bias. The selected volunteers represented not only all Watches, but all levels of age and experience, and both sexes.

4.4.1.3 Procedures

Each interviewee for the initial Rep Grids was interviewed at the Unit but in an office off the Operations Room where we would not be disturbed by colleagues or supervisors. The interview commenced with a brief explanation of its broad purpose and of the form that it would take. The interviewee was shown an array of about 30 tasks from the task analyses for the relevant Unit which were written on to separate rectangular pieces of paper and arranged on the table. He was asked to select a sample of tasks from the set to provide the elements for the Rep Grid. Two methods of task selection were used. Either the interviewee was asked to select tasks on the basis of several criteria stated by the interviewer, e.g. ' choose two tasks that you really enjoy doing: choose another two that are very important in some way. '; or the interviewee was asked merely to select _n_ tasks that represented a good cross-section of the job. The second method served as a check that the selection criteria were not influencing the elicitation of constructs later in the interview. In practice, between 9 - 12 tasks were selected for these interviews.

The Rep Grid interview then proceeded in the standard way, whereby several triads of tasks were presented to the ATCO who was instructed as follows:

"Thinking in terms of how you feel about these tasks, and the different demands they make upon you, choose two which are similar to each other and different from the third."

This stage of the interview ceased when the ATCO appeared to have exhausted the core constructs that he used to discriminate between tasks and began to repeat earlier constructs.

The procedure for completion of the standard Grids was of course rather different, since each ATCO was presented with a Rep Grid matrix containing a list of unipolar constructs down the left-hand side, and a set of columns across the page for each task on the accompanying list. To avoid fatigue and boredom, and associated sources of response error, ATCOs were only required to rate half of the full set of tasks at one go. Thus each ATCO completed two 16 x 16 Grids, each one of which took between 25 - 45 minutes to complete. ATCOs completed the Grids individually but in the context of a group session. They were required to rate across the page, that is, rating all the tasks on the first construct before proceeding to the next. In this way the 'halo' effect should have been attenuated for the task ratings. Ratings were assigned in response to the question: "How accurately does this statement describe how you feel about the task?" Point '1' on the scale represented 'Very accurately indeed', point '7' represented 'Very inaccurately indeed' whilst point '4' represented a mid-point for uncertainty. ATCOs were also given the option of rating a construct as being 'not applicable' to a particular task.

4.4.1.4 Data Analyses of Rep Grid

A major requirement was for some form of computer analysis, for reasons outlined by Easterby-Smith (1980):

"It is only necessary to use computers when the grid is large, when time constraints are limited, or when there is a need for very precise measurement." (p.11). Summaries of the methods of computer analysis can be found in Fransella and Bannister (1977) and Easterby-Smith (1980). As the latter points out, there are only two types of computer program designed specifically for grid analysis. Firstly, there is a principal components analysis package called INGRID (Slater, 1977); and secondly, a cluster analysis program called FOCUS (Shaw, 1980).

Both INGRID and FOCUS are based on similarity matrices, one for the elements and one for the constructs, the measures of similarity being conceived as distances in an n - dimensional space. However, there is some debate as to whether principal components or cluster analysis provides the better form of analysis. Rump (1974) asserts that cluster analysis in general has particular advantages over other methods; for example, the output from the program can be much more readily interpreted. Slater (1974) contests this view, holding that the choice of which method of cluster analysis to use is very difficult, since each method operates on a different basis, and that principal components analysis is just as successful in producing clear clusters.

Shaw's FOCUS program was developed in response to the need for a method of analysis that was less bewildering for the subject and the experimenter, allowing for further conversations between the two based on the summary data from the initial grid interview. This aspect of feedback to the subjects was thought to be important in the present context, since there was already strong feeling amongst ATCOs about the lack of feedback from a previous attitude study. Aside from courtesy, it was thought worthwhile too to adopt a method of analysis that would allow checking back with the ATCOs as a form of validation of the data.

FOCUS derives distance measures, or matching scores, using Minkowski's city block metric. This has certain advantages over the Euclidean metric and product moment correlation coefficients for psychological research where people's perceptions of similarity are involved (Everitt, 1974). The program uses a two-way cluster analysis which is similar to the nearest neighbour or single linkage hierarchical method, although as Shaw (1980) notes it is not strictly a hierarchical method. "The major criterion for forming clusters is that linear reorderings of the constructs and elements respectively will result in the final grid displaying a minimum total difference between all adjacent pairs of rows and columns." (p.34). Further explanation will be provided in the results section illustrated by a print-out from the program.

The Rep Grid technique is essentially an ipsative technique, and from a theoretical point of view does not lend itself easily to group analysis. Analysis for the present research was primarily of individual Grids. To facilitate comparison between tasks, the two standard Grids completed by each ATCO were analysed by FOCUS as one. Since the constructs were exactly the same for both Grids, this meant simply attaching the second Grid to the side of the first, extending the number of elements from 16 to 32. It was decided after the Rep Grids had been completed that two of the tasks in the set of 32 should be excluded from the analysis due to the limited availability of computer facilities for analysing Grids containing more than 30 elements. The list of tasks were studied carefully, and two tasks removed which appeared to be covered to a great extent by other tasks in the list. Thus the final analysis was of 30 x 11 Grids.

In addition to the individual analyses, it was decided that in principle there was no reason why some form of group analysis should not be included in the research. The FOCUS program derives measures of similarity between elements, and it could do this equally well if constructs from several people's Grids were combined as one large Grid. This could be justified more easily since the 'same' constructs (i.e. the same phrasing) were included on everybody's Grids. Since the main purpose of this part of the research was to establish differential values attached by ATCOs to tasks, in particular with respect to the extent to which tasks used valued skills and abilities, the 'group Grid' comprised a combination of the two constructs 'Gives me a lot of job satisfaction' and 'Requires all my skill and experience' from all the individual Grids for the Unit. Thus it contained 30 elements as before, and 2 x 20 (= 40) constructs. The focussed Grid would reveal which tasks were consistently preferred or valued by all the ATCOs; on which tasks the consensus view was one of disvalue; and those on which there were mixed views.

One drawback of FOCUS is that when large numbers of elements are analysed, as with the present study, some clustering of variables is obscured. This is because, when a particular variable has been linked with two other variables, one on each side of it, that variable is then omitted from further linking procedures. Thus a fourth variable which has its highest matching score with the first variable has to be shown adjacent to two other variables with which it is matched at a lower level. This explanation assumes that the matching relationship between the two variables at the centre of the discussion is not reciprocal; i.e. i_1 may be highest with j_1 but j_1 is not highest with i_1.

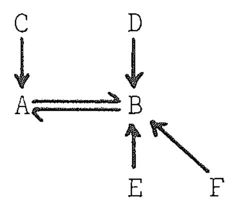
A procedure for revealing types which overcomes this problem is presented by McQuitty (1957), and is called Elementary Linkage Analysis. This procedure requires a matrix of agreement scores, such as the matching scores produced by FOCUS. The steps in linkage analysis require the identification of the highest matching score for each element. Once this has been accomplished, the highest matching score in the matrix is selected, and the relationship between the two elements written down as follows:

$$A \rightleftharpoons B$$

This relationship is reciprocal since the entry is the highest in the matrix, and is indicated by the arrow heads. These two elements represent the first two tasks of the first type. Next, all those tasks are selected which are most like the members (A and B) of the first type. Their relationship is then written down, as in Figure 10.

Figure 10

Example of types derived from matching scores



$\rightleftharpoons$ indicates reciprocal pair

$\longrightarrow$ indicates that variable at tail of arrow is highest with one at head, but not vice versa

The tasks C - F are called first cousins by McQuitty, and the next step is to select those tasks which are most like the first cousins. They are added to the type in the same way. This procedure continues until all the tasks are classified.

It was decided that Elementary Linkage Analysis would supplement the final stage of FOCUS, that is to say the representation of clusters of tasks.

4.4.2 Results: LATCC

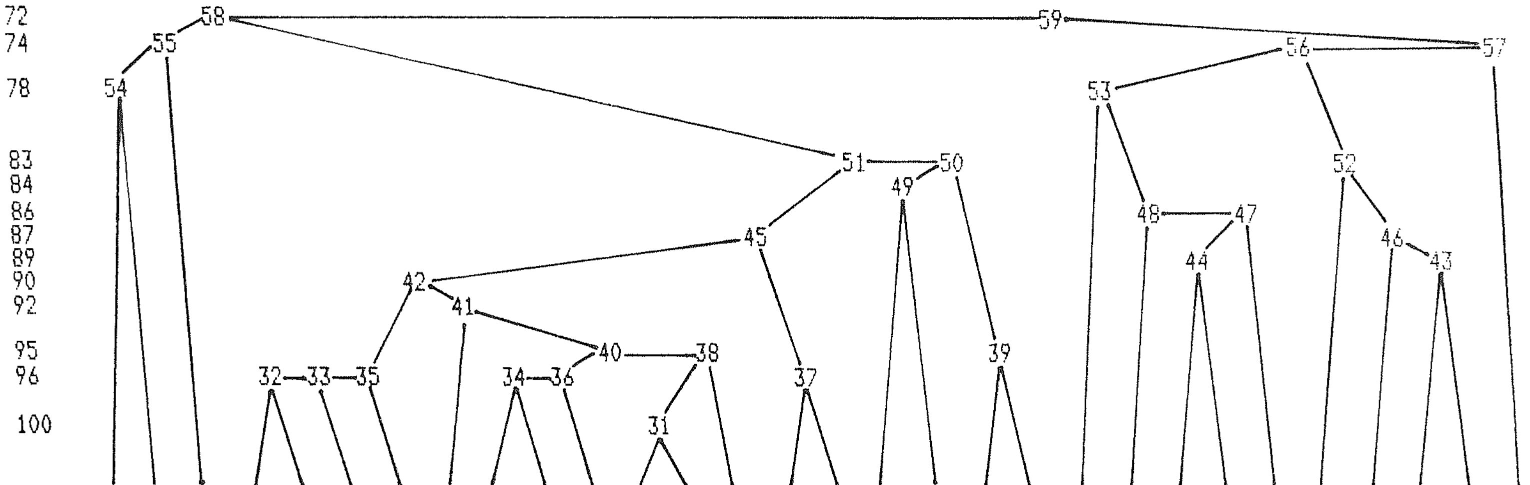
The majority of FOCUSed Grids are presented in Appendix IX. One Grid, chosen at random from the set of 20 for LATCC, will be discussed here in full to illustrate the interpretation of the output from the program, and to indicate the quality of data provided by the use of Rep Grid and FOCUS.

Figure 11 shows the FOCUSed Grid of an ATCO at LATCC. In the lower half of the figure is the matrix of raw ratings made by the ATCO when completing the Grid. Directly above the matrix are the element (i.e. task) numbers, relating to the list of tasks in Appendix VIII. Thus the task at the extreme left is number 28, and that at the extreme right is number 24. The tasks have been ordered linearly by FOCUS in accordance with its objective of achieving minimum total difference between adjacent columns of ratings. Similarly, the 11 constructs which appear at the extreme left of the matrix (numbering '1' at the top and '9' at the bottom) have been reordered to achieve minimum total difference between adjacent rows of ratings.

Above the matrix appears the Element Tree, which shows the clustering of tasks derived by the program. Also shown are the element matching scores down the left hand side of the Element Tree, increasing in closeness of match the nearer they are to the horizontal axis. Thus tasks 5 and 4 form cluster 31 with a matching score of 100; in other words, the distance between them on a scale of 0 - 100 is zero, which can be confirmed by glancing at the matrix of ratings below. The next highest match is attained by tasks 14 and 15, which form cluster 32 with a matching score of 96. However

Figure 11

FOCUSed Standard Grid for ATCO at LATCC showing clusters of tasks, matching scores for clusters, and matrix of ratings ('X' = construct not applicable)



	28	2	6	14	15	16	20	8	3	17	26	5	4	9	29	27	7	23	12	11	25	22	21	18	13	1	30	19	10	24
1	2	4	5	1	1	1	1	2	1	1	1	2	2	1	1	2	1	1	2	1	2	1	2	1	1	4	3	6	7	4
7	3	6	5	1	1	1	1	1	1	1	1	1	1	1	3	3	2	2	1	1	3	4	3	2	2	3	6	7	6	6
6	6	4	1	1	1	1	1	2	1	1	1	1	1	1	2	2	2	1	1	2	3	X	3	3	2	4	6	4	4	1
5	1	3	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	3	X	3	3	3	6	4	4	2	1
4	3	3	1	3	3	2	1	1	2	2	1	2	2	2	2	1	1	3	3	4	5	5	5	6	5	6	7	7	6	6
3	2	2	4	1	1	1	1	1	1	1	1	2	2	2	1	1	1	3	3	3	5	3	5	6	5	6	7	7	7	6
2	3	4	3	2	1	1	1	1	2	1	1	1	1	1	1	1	2	4	3	3	6	X	5	5	4	7	7	7	7	6
8	4	4	1	2	1	1	1	1	2	1	1	1	1	3	2	2	4	3	3	3	4	X	4	5	6	6	6	7	7	6
11	4	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	3	2	2	2	X	4	4	5	6	6	7	6	5
10	3	2	3	2	2	1	1	1	1	1	1	1	1	1	2	2	5	5	6	6	2	X	4	4	7	7	7	7	6	5
9	1	2	2	4	X	X	5	1	1	1	2	2	2	2	2	2	1	1	7	7	6	X	2	4	4	2	1	1	1	6

task 15 also matches task 16 at the same level, although task 16 is slightly less similar to task 14 (matching score 93). Thus the program places task 16 adjacent to task 15, and forms a new cluster 33 at the matching level of 96, i.e. the score for the single link between tasks 15 and 16. Having formed two links for task 15, the program now omits it from further analysis of matching scores. The matching score of 72 shown for the loosest cluster - that formed by joining the two large clusters 58 and 57 - represents the matching score for the two adjacent tasks from the two clusters, i.e. tasks 11 and 25. It does not, therefore, indicate the degree of similarity between the two clusters.

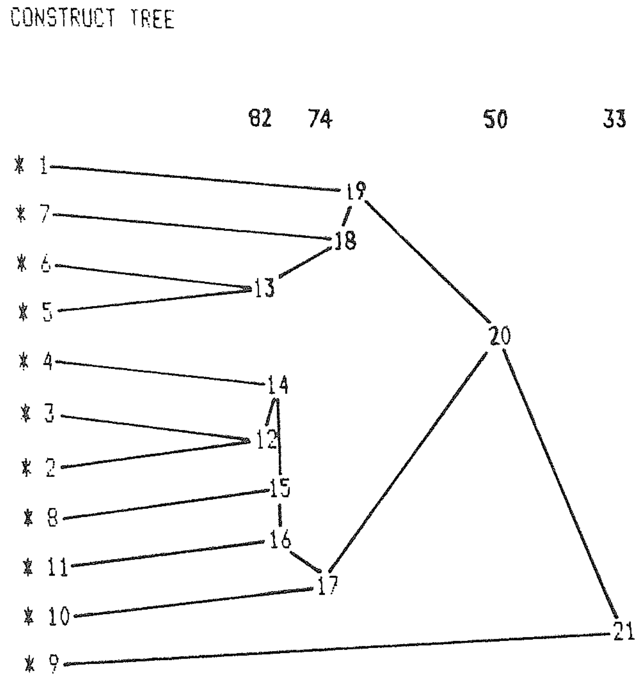
In addition to the information shown in Figure 11, FOCUS prints a Construct Tree which shows the clustering between constructs. This would normally be appended to the right hand side of the FOCUSed Grid, but due to shortage of space it is shown separately in Figure 12. This shows that the tightest cluster is formed by constructs 2 and 3 with a matching score of 82.

The results in Figure 11 show a cluster of tasks, cluster 42, which receive mostly very high ratings from the ATCO, indicating that they are valued very positively. Differences between the tasks in this cluster are indicated mainly with respect to the amount of coordination and consultation they require (construct 9), the degree of skill and experience (construct 4),and in the case of task 9, the level of decision-making it requires.

In contrast to this cluster of tasks, cluster 56 contains tasks which receive very much lower ratings, showing that the ATCO derives

Figure 12

Construct Tree from FOCUSed Grid for ATCO at LATCC (cf. Figure 11) showing clusters of constructs and matching scores.



no satisfaction from doing them (construct 2), finds many of them very boring (construct 10) and to a greater or lesser extent finds some of them annoying and unnecessarily time consuming (constructs 11 and 7). Tasks 10 and 19 in particular receive very poor ratings, since they are not considered by this ATCO to be what he is paid to do (construct 1).

The tasks in Cluster 50 receive mixed ratings. Whilst accepting that they are very much what he's paid to do, the ATCO appears to derive little satisfaction from them, with the exception of task 7. Moreover, he finds them rather boring, particularly tasks 11 and 12. These last two tasks are notable for the large amount of coordination they require. The tasks in cluster 53 receive very mediocre ratings, and are distinguished from the lowest rated cluster mainly by the fact that the ATCO accepts that they are a part of the job he ought to do. However, they give no satisfaction and require hardly any skill.

Finally, it should be noted from Figure 12 that for this ATCO, there is a very high degree of association between the use of his skills and experience, the amount of decision-making, the degree of concentration he is required to give to a task, and the amount of job satisfaction he derives from doing it.

The specification of task labels has not been included above since the presentation of results for the Group Grid which follows immediately covers the clustering of tasks in detail. The FOCUSed Grid for all the LATCC ATCOs is shown in Figure 13 and Table 22. The results of Elementary Linkage Analysis on the group data are shown in Figure 14. For additional information, Table 23 shows the frequencies of ratings allocated to each task on the Group Grid.

The results show a strong consensus of opinion with respect to the tasks in clusters 40 and 48. The tasks in cluster 40 receive very favourable ratings from most ATCOs, in particular those tasks contained in cluster 33. This latter cluster of three tasks receives a rating of '1' on between 70 - 80 per cent of the constructs in the Group Grid ('job satisfaction' and 'skill and experience' constructs), and either '1' or '2' on 95 per cent of the ratings. The tasks in clusters 35 and 38, together with tasks 15 and 16, are rated almost as favourably. They all receive ratings of '1' or '2' in 75 - 88 per cent of cases. Thus they are classed as being very satisfying

Figure 13

FOCUSed Grid for all LATCC ATCOs on 'Job Satisfaction' and 'Skill and Experience' constructs, showing task clusters and matching scores.

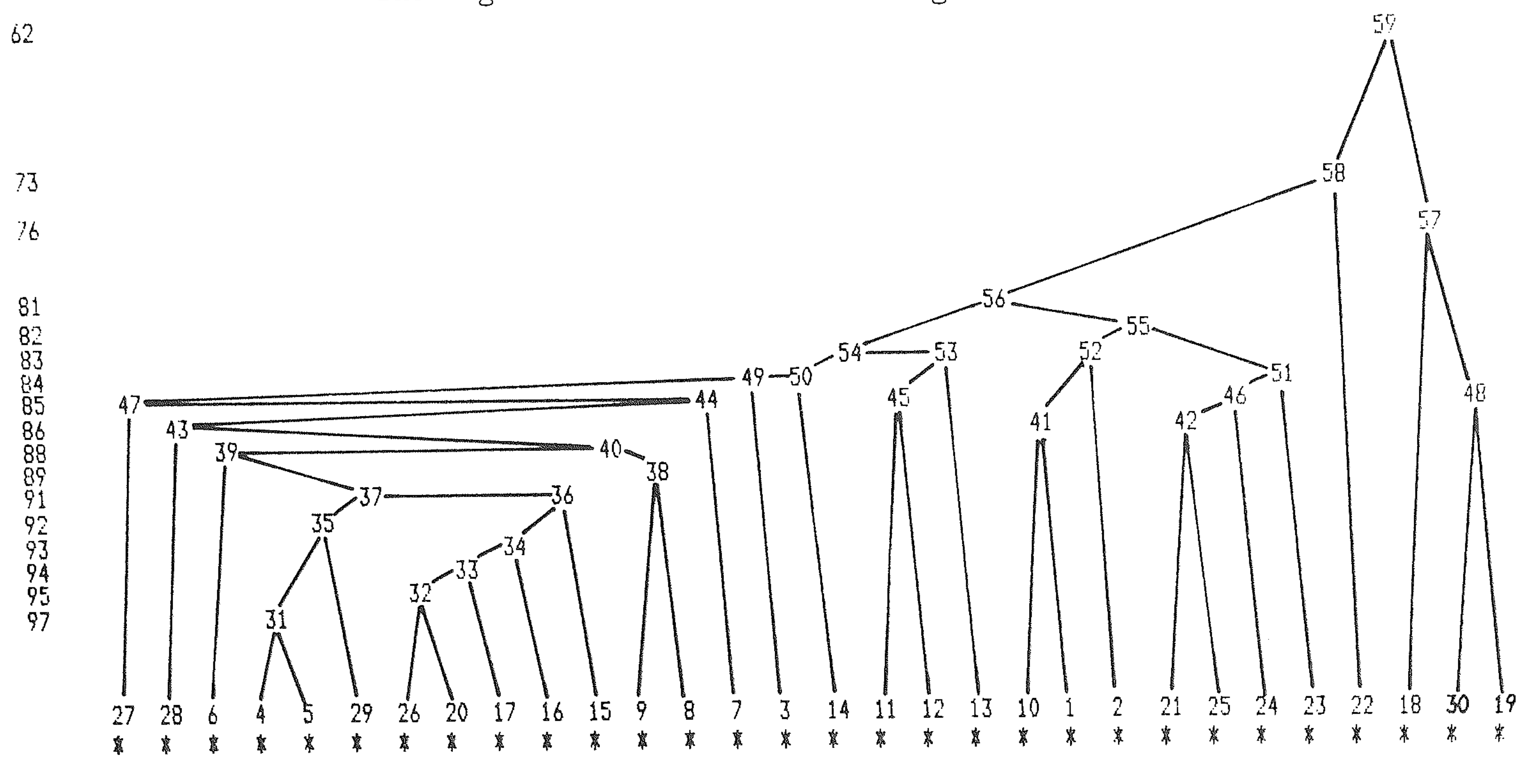


Table 22

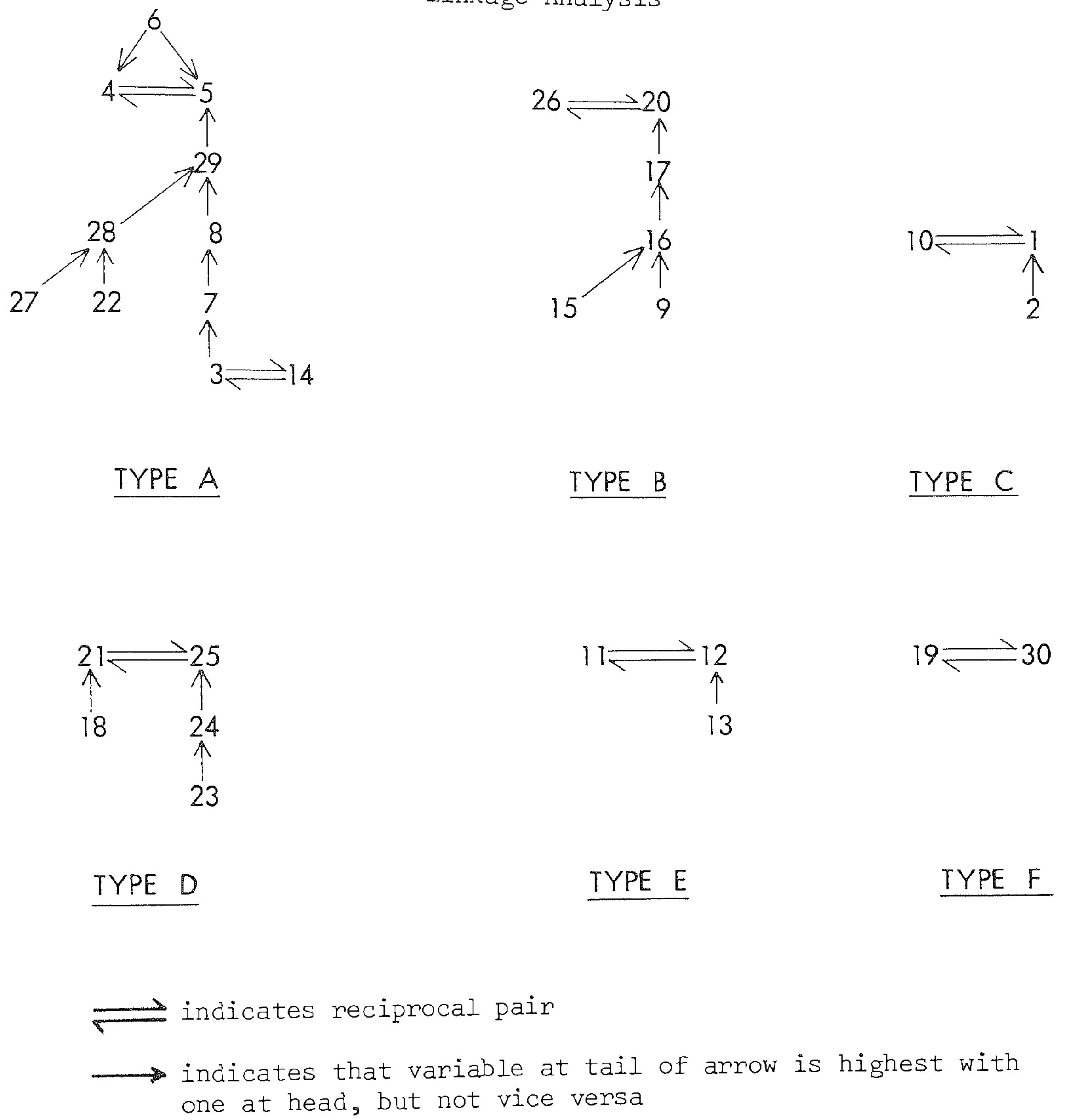
FOCUSed Grid for all LATCC ATCOs showing raw data relating to Figure 13

FOCUSED GRID

	27	28	6	4	5	29	26	20	17	16	15	9	8	7	3	14	11	12	13	10	1	2	21	25	34	23	22	18	30	19
9	5	2	1	1	1	1	1	1	2	1	1	1	2	3	2	1	1	4	5	5	6	4	4	4	1	1	2	6	7	7
5	3	2	1	1	1	2	2	1	1	2	1	1	1	1	2	4	5	5	5	6	6	4	6	4	2	2	1	6	7	7
6	2	2	1	1	1	2	3	1	1	2	2	3	2	1	3	5	5	5	7	7	5	6	6	5	5	4	2	6	7	7
34	3	2	1	2	2	2	1	1	3	3	2	4	1	4	3	5	5	5	7	6	7	5	6	6	5	5	2	7	7	7
12	3	2	3	3	3	2	1	2	2	3	2	2	2	4	3	4	5	6	5	6	7	6	6	5	6	6	4	6	5	7
36	2	2	3	4	4	1	1	1	1	2	2	2	3	5	6	4	4	4	5	7	7	7	4	5	5	5	4	6	7	7
40	1	1	2	2	2	1	1	1	1	1	3	3	4	5	5	5	5	5	7	7	4	5	5	4	4	3	1	7	7	7
13	1	1	4	2	2	2	1	1	1	2	3	2	4	4	6	3	5	5	5	6	6	6	3	3	2	2	4	4	4	7
14	1	2	2	2	2	2	1	1	1	2	2	4	4	3	3	4	6	6	6	4	4	4	3	3	2	2	4	4	4	7
29	2	3	1	1	1	3	2	2	2	2	2	3	3	3	3	2	5	4	5	6	4	4	4	4	5	3	2	4	4	5
25	2	3	3	3	3	3	1	2	1	2	3	4	3	3	4	4	5	4	4	6	5	5	6	4	4	4	4	5	5	7
32	2	3	2	3	3	3	2	1	1	3	3	2	3	2	4	4	6	4	6	5	5	5	3	5	5	4	3	3	6	7
26	3	4	2	2	2	2	1	1	2	2	3	2	2	2	3	4	4	4	4	5	4	3	3	5	7	6	4	6	6	7
4	1	3	1	2	2	2	1	1	2	2	3	2	1	1	2	3	4	3	5	6	6	3	5	5	6	3	5	6	7	7
3	1	3	3	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	4	7	7	4	5	6	6	4	×	5	7	7
11	4	3	1	1	1	1	1	1	2	2	2	2	1	2	2	2	2	2	4	6	6	5	6	4	4	5	4	5	6	7
15	4	1	3	3	2	1	1	1	1	1	2	1	1	2	4	3	3	4	5	6	6	5	5	4	4	4	4	5	3	7
16	3	2	3	2	2	2	2	2	1	1	2	2	2	3	4	3	3	3	3	5	5	5	4	5	4	4	4	5	4	7
28	2	1	1	1	1	2	2	1	1	2	3	2	2	3	3	2	4	3	3	6	5	5	4	4	3	4	1	5	5	7
27	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	4	3	3	4	2	3	1	3	5	5
39	1	1	1	1	1	1	1	1	1	1	2	1	1	1	3	2	3	2	6	4	4	4	2	3	1	1	1	3	6	7
2	2	2	4	1	1	2	1	1	1	1	1	1	1	1	2	4	3	4	4	4	4	3	2	2	4	1	5	3	7	7
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	4	4	4	4	2	2	1	1	1	2	4	7	7	7
24	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	4	3	4	4	4	4	2	2	2	2	3	7	7	7
19	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	4	4	3	4	4	4	2	1	1	1	×	1	7	7
20	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	3	4	4	5	4	4	4	3	4	1	×	3	7	7
21	1	1	1	1	1	1	1	1	1	1	1	1	2	3	2	1	2	4	5	5	5	6	4	4	3	5	4	5	7	7
22	1	1	1	2	1	2	1	1	1	1	1	1	2	3	3	2	4	5	6	6	5	7	6	4	4	4	3	5	7	6
10	5	2	1	1	1	2	1	1	1	1	2	3	3	2	3	1	2	6	4	5	5	4	5	6	5	3	3	5	7	7
33	3	3	1	1	1	2	1	2	3	2	2	2	2	3	4	4	3	4	4	4	7	6	6	6	4	4	4	6	7	7
35	2	3	3	1	1	1	1	1	2	2	2	4	1	1	1	2	3	5	4	4	7	3	5	5	4	6	5	6	7	7
8	1	2	3	1	1	1	1	1	1	1	1	2	1	3	3	1	3	2	3	4	7	6	6	3	1	2	5	7	5	7
31	1	2	2	1	1	1	1	1	1	2	3	2	1	2	3	4	3	2	3	4	7	4	4	3	3	2	5	4	4	7
7	1	2	2	2	1	1	1	1	1	2	1	2	1	2	1	1	2	1	2	3	5	5	3	3	1	3	5	4	2	4
37	2	4	2	2	2	3	1	1	1	1	1	1	1	1	3	1	4	2	3	7	7	6	4	4	4	3	4	3	7	4
38	2	3	2	2	2	2	2	2	1	1	1	2	2	2	2	2	2	3	7	7	7	6	4	6	4	3	3	7	7	7
18	5	2	1	2	2	3	1	1	1	1	1	2	2	3	2	3	4	3	4	6	6	6	6	6	6	4	1	7	7	7
17	6	5	6	2	1	1	1	1	1	1	1	2	1	4	4	3	4	4	4	6	4	6	4	5	5	4	1	5	7	7
1	4	4	4	1	1	2	1	3	2	4	7	3	1	3	4	4	4	4	4	7	7	4	4	4	4	4	7	4	7	7
30	4	3	3	2	3	4	3	3	2	3	4	5	4	4	6	6	6	6	7	7	6	6	5	4	5	4	2	4	5	6

Figure 14

Clusters or Types of Tasks revealed on LATCC Group data by Elementary Linkage Analysis



and requiring a lot of skill and experience. These tasks are listed in Table 24. It is interesting to note that task 6, although a method of controlling traffic like tasks 4 and 5, is not perceived to be quite so closely matched as the other two. It receives a rating of '1' in just under 50 per cent of the cases, and ratings of only '3' or '4' in 30 per cent of the cases.

Table 23

Ratings of tasks at LATCC according to 'Job Satisfaction' and 'Skill and Experience' constructs: Frequencies of assigned ratings (cf. Appendix VIII for task descriptions.)

	Assigned Ratings (1 = most favourable rating)						
Tasks	1	2	3	4	5	6	7
27	16	10	6	4	3	1	-
28	12	14	10	3	1	-	-
6	19	8	9	3	-	1	-
4	21	14	4	1	-	-	-
5	24	11	4	1	-	-	-
29	18	16	5	1	-	-	-
26	32	6	2	-	-	-	-
20	32	6	2	-	-	-	-
17	29	9	2	-	-	-	-
16	19	16	4	1	-	-	-
15	16	14	8	1	-	-	1
9	13	17	5	4	1	-	-
8	18	13	5	4	-	-	-
7	8	13	11	5	2	1	-
3	2	12	15	7	1	3	-
14	6	11	8	11	3	1	-
11	1	5	11	12	8	3	-
12	1	5	8	15	5	6	-
13	-	1	7	14	7	6	5
10	-	-	1	11	6	14	8
1	-	1	-	11	9	8	11
2	-	1	5	12	9	11	2
21	1	4	6	12	7	10	-
25	2	2	7	14	9	6	-
24	6	5	3	13	8	4	1
23	5	7	8	13	4	3	-
22	7	5	5	16	6	-	1
18	1	-	6	7	10	9	7
30	-	1	1	5	6	4	23
19	-	-	-	2	2	2	34

Table 24

Tasks receiving favourable ratings on 'Job Satisfaction' and 'Skill and Experience' constructs - LATCC

26.	Ensure that traffic remains safely separated (Radar)
20.	Decide most suitable solution to traffic situation (Radar)
17.	Identify possible conflictions from strips and radar (Radar)
4.	Assess whether traffic could be climbed/descended to resolve situation (Radar)
5.	Assess whether vectoring could resolve situation (Radar)
29.	Evaluate expediency of solutions for aircraft (Radar)
16.	Determine relevant features of traffic situation (Radar)
15.	Decide priorities for action (Radar)
8.	Assess whether solution is expediting (Radar)
9.	Ensure that traffic is at appropriate level, speed and heading for handover (Radar)

At the other extreme, tasks 30 and 19 (cluster 48) are clearly not at all favourably rated. Task 19, in particular, receives the lowest rating of '7' in 85 per cent of the ratings on the Group Grid, whilst task 30 scores '7' on 58 per cent of the ratings. Tasks 10 and 1 (cluster 41) also receive consistently mediocre to poor ratings. Task 10 scores '6' or '7' on 55 per cent of the ratings, whilst task 1 does so on 48 per cent. These tasks are shown in Table 25.

Table 25

Tasks receiving unfavourable ratings on 'Job Satisfaction' and 'Skill and Experience' constructs - LATCC

19.	Ensure that dead strips are removed and filed as required (Wings)
30.	Prepare strips for distribution (Wings)
10.	Remove strips from display when appropriate (Radar)
1.	Ensure that strips are obtained on all relevant traffic (Radar)

Analysis of the individual Grids (Appendix IX) shows that 85 - 90 per cent of the ATCOs surveyed rated tasks 19 and 30 as either '1' or '2' on the construct 'Very boring', and over 80 per cent rated task 19 as '1' or '2' on the constructs 'Very annoying' and 'Unnecessarily time consuming'. In addition to the above tasks, task 13 ('Ensure that strips are distributed as required') and task 10 were rated as being boring by between 50 - 60 per cent of the ATCOs.

The tasks forming clusters 51 and 53 receive very mixed ratings, showing a lack of agreement amongst the ATCOs. Although in all cases the modal rating for these tasks is '4', the mid-point of the scale, two-thirds or more of their scores are distributed between points 1, 2, 3, 5 and 6.

The results of the Elementary Linkage Analysis broadly support the clusters formed by FOCUS, with two notable exceptions. FOCUS shows tasks 18 and 22 as being relatively isolated from the main clusters. In Figure 14, however, we can see that task 22 belongs to the 'Type A' cluster, its highest matching score being with task 28. Similarly, task 18 belongs with the 'Type D' cluster, matching most closely with task 21.

4.4.3 Results: Heathrow

The clusters of tasks from the Heathrow FOCUSed Group Grid are shown in Figure 15. The raw ratings are shown in the re-ordered matrix in Table 26. Frequencies of assigned ratings are presented in Table 27. Finally, the results of Elementary Linkage Analysis on the Heathrow task matching scores appear in Figure 16.

The most favourably rated tasks at Heathrow appear within cluster 39, with the addition of task 22. This cluster is shown more clearly in Figure 16 than in Figure 15, being represented by 'Type A' in the former figure. With the exception of task 16, these tasks receive scores of '1' on at least 45 per cent of the ratings. Task 16 scores '1' on 35 per cent of the ratings, most of them relating to the 'Job Satisfaction' construct rather than the 'Skill and Experience' construct. Tasks 20 and 21 both score '1' on 63 per cent of the ratings, but whereas task 21 receives this score predominantly on the 'Job Satisfaction' construct, task 20 receives more high scores on the

Figure 15

FOCUSed Grid for all Heathrow ATCOs on 'Job Satisfaction' and 'Skill and Experience' constructs, showing task clusters and matching scores.

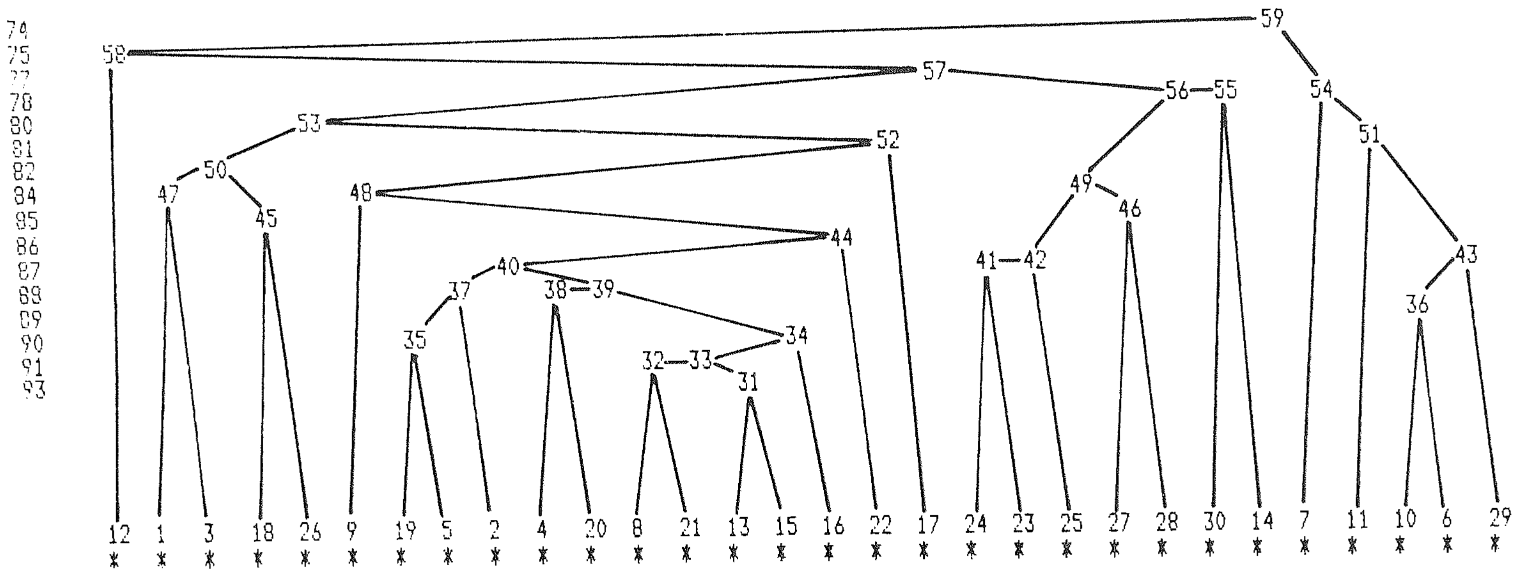


Table 26

FOCUSed Grid for Heathrow ATCOs showing raw data relating to Figure 15

	12	1	3	18	26	9	19	5	2	4	20	8	21	13	15	16	22	17	24	23	25	27	28	30	14	7	11	10	6	29
38	5	4	4	5	4	4	3	4	2	4	3	6	2	2	3	4	4	5	7	5	7	7	7	6	4	4	4	7	7	7
37	7	5	5	4	4	4	3	4	5	3	1	2	2	2	6	5	4	4	7	5	6	6	5	7	7	6	4	7	6	7
24	4	6	6	5	3	4	3	3	3	4	2	2	2	7	6	5	2	2	3	3	3	3	4	6	5	5	5	7	7	7
17	3	4	6	4	3	2	4	3	2	3	2	3	1	1	1	4	1	1	3	3	3	4	6	7	7	4	7	7	7	7
18	2	3	6	4	6	3	3	2	2	3	1	2	1	2	1	3	2	1	3	3	3	4	6	7	7	5	7	7	7	7
7	3	4	5	5	5	2	2	3	2	2	2	2	1	1	1	1	3	3	4	4	2	6	6	5	6	6	4	7	7	5
8	2	5	5	4	3	1	3	3	1	1	2	2	2	2	1	2	2	3	6	3	2	3	4	4	6	7	5	7	6	5
5	4	5	6	4	2	5	3	2	2	2	2	1	1	2	3	1	1	3	5	3	3	3	3	4	6	6	6	7	7	6
6	5	6	4	6	2	3	5	2	2	3	2	2	1	2	2	2	1	2	5	5	2	3	3	3	3	4	7	6	7	7
12	3	3	4	5	3	3	5	2	3	1	1	2	2	1	1	2	2	1	6	4	2	3	2	4	2	6	4	6	6	7
4	2	4	5	3	2	2	2	2	3	4	2	1	1	2	1	1	1	4	2	1	1	2	3	3	1	7	4	6	7	6
21	2	6	4	2	3	5	1	1	4	3	2	2	1	1	1	1	1	2	5	3	3	2	4	3	4	5	4	4	6	5
15	2	2	2	4	4	3	3	3	5	4	3	2	2	1	1	1	2	4	4	4	4	5	5	4	4	5	6	5	6	6
39	6	4	4	3	2	3	1	2	3	3	3	1	3	2	2	4	1	5	4	4	4	4	4	3	7	6	6	6	6	6
40	4	7	4	4	2	2	2	2	2	2	1	2	3	2	2	4	1	6	4	4	2	3	4	2	5	6	6	6	7	7
16	3	5	4	4	3	3	4	4	5	2	2	4	3	4	4	4	3	4	4	4	4	4	4	3	3	3	6	6	7	7
2	3	6	4	5	5	2	3	4	3	3	1	2	2	2	3	2	3	2	4	4	3	5	5	3	3	3	4	6	6	6
23	5	6	5	4	4	4	2	3	4	5	2	2	1	2	2	2	2	3	3	5	3	4	5	5	3	5	5	7	6	7
28	3	3	3	4	4	2	2	3	1	1	1	3	2	2	2	2	2	3	3	4	5	4	5	5	3	6	4	6	7	7
22	3	5	3	5	2	2	2	2	2	1	1	2	2	2	2	2	2	1	2	4	3	4	5	4	4	6	4	5	6	4
30	2	2	3	2	3	1	2	2	1	1	1	1	1	2	2	2	3	1	2	2	3	4	4	5	3	4	4	4	4	4
20	2	3	4	2	3	2	2	2	2	1	1	2	1	1	1	2	2	2	3	4	3	3	3	4	1	3	4	4	4	4
19	1	1	2	2	2	3	3	1	2	1	1	1	1	1	1	3	1	2	3	3	3	3	3	4	1	4	4	4	3	4
29	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	2	3	3	4	4	3	3	3	2	3
31	1	1	1	2	1	3	2	1	1	2	1	3	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3
32	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1	2	1	2	1	2	2	1	1	2	3	2	2	3	3
26	1	1	1	1	2	1	1	1	1	3	1	1	1	1	1	1	1	1	2	2	1	3	6	2	3	4	2	5	5	6
3	1	4	3	3	1	2	1	2	2	2	1	1	1	2	1	1	1	1	1	1	1	3	4	3	3	4	4	5	5	4
9	4	3	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1	2	2	2	3	4	4	3	4	4	3	5	4	4
10	4	3	3	2	2	1	1	1	2	1	1	1	1	2	2	2	1	2	3	2	2	2	3	2	2	6	4	5	6	5
1	4	4	3	3	3	1	2	2	2	2	1	1	1	1	1	2	2	2	3	4	2	4	4	2	3	3	4	6	6	6
27	5	5	3	3	3	2	2	3	2	1	1	1	2	1	2	2	2	1	3	3	3	2	3	5	5	2	3	6	5	5
11	6	2	2	1	4	3	2	2	2	1	2	1	1	1	1	1	1	1	4	3	3	6	4	2	3	6	4	6	4	6
13	6	3	2	2	2	3	3	2	2	2	2	1	1	1	1	2	4	2	4	2	4	4	5	3	4	5	5	4	5	6
14	6	3	4	2	2	5	2	2	3	2	1	2	2	2	2	2	5	3	3	2	4	4	5	3	4	7	6	6	7	6
34	6	6	4	2	3	2	2	2	2	1	1	3	3	2	3	3	4	2	2	3	5	4	6	2	2	7	5	7	7	4
33	6	4	3	1	1	1	1	2	2	1	1	2	1	1	2	3	1	1	1	2	2	3	3	1	4	4	6	5	4	2
35	4	2	2	1	1	3	1	2	1	1	1	1	1	1	1	1	1	1	3	2	2	3	2	1	5	4	6	6	7	5
36	3	1	3	1	1	3	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	3	4	1	5	4	7	7	7	5
25	4	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	4	4	4	4	1	5	4	4	2	4	4	3	5

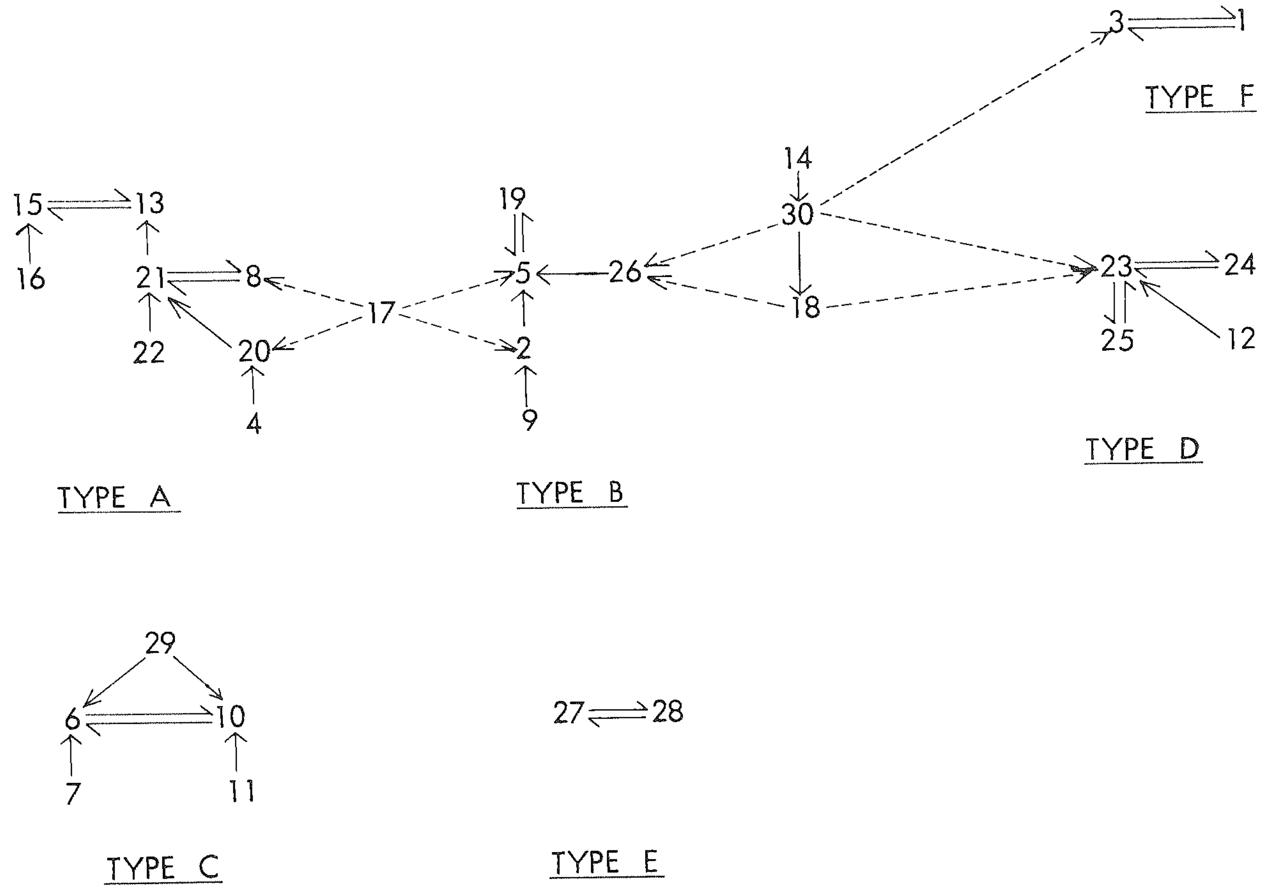
Table 27

Ratings of Heathrow tasks according to 'Job satisfaction' and 'Skill and experience' constructs: Frequencies of assigned ratings. (cf. Appendix VIII for task descriptions)

Task	Assigned Ratings (1 = most favourable)						
	1	2	3	4	5	6	7
12	6	7	8	8	4	6	1
1	6	5	8	8	6	6	1
3	4	7	9	11	5	4	-
18	7	11	5	10	6	1	-
26	7	13	11	6	2	1	-
9	9	12	12	4	3	-	-
19	11	15	10	2	2	-	-
5	10	17	9	4	-	-	-
2	10	19	6	2	3	-	-
4	18	9	8	4	1	-	-
20	25	12	3	-	-	-	-
8	18	16	4	1	-	1	-
21	25	11	4	-	-	-	-
13	20	18	-	1	-	-	1
15	22	11	4	1	-	2	-
16	14	15	4	5	2	-	-
22	18	13	4	4	1	-	-
17	14	12	6	5	2	1	-
24	2	9	13	9	3	2	2
23	3	11	10	12	4	-	-
25	3	13	14	6	2	1	1
27	1	6	14	13	2	3	1
28	1	3	9	12	9	5	1
30	4	7	10	9	5	2	3
14	3	4	11	10	5	3	4
7	-	2	7	11	6	10	4
11	-	2	4	17	5	8	4
10	-	1	2	6	7	13	11
6	-	1	4	5	4	11	15
29	-	1	3	7	8	10	11

Figure 16

Clusters of Tasks derived from Heathrow Group Grid by Elementary Linkage Analysis



indicates reciprocal pair

indicates that variable at tail of arrow is highest with one at head, but not vice versa

'Skill and Experience' construct. Similarly, task 4 receives more '1' scores on the 'Skill' construct than on 'Satisfaction'. This contrasts with the rest of the cluster, in which 'Satisfaction' scores of '1' outnumber the 'Skill' scores of '1' by at least 2:1, and in the case of task 13 by 3:1. The favourably rated tasks at Heathrow are presented in Table 28.

Table 28

Tasks receiving favourable ratings on 'Job Satisfaction' and 'Skill and Experience' constructs - Heathrow.

4.	Ensure that emergencies are dealt with (Air Arrivals)
20.	Ensure that emergencies are dealt with (Air Departures)
8.	Ensure that traffic remains safely separated (No. 1 Director)
21.	Determine most expeditious order of departures (Air Departures)
13.	Ensure that traffic is directed as expeditiously as possible (No. 1 Director)
15.	Ensure that traffic is directed on to final approach as expeditiously as possible (No. 2 Director)
16.	Establish when traffic is clear to depart (Air Departures)
22.	Decide what to do with traffic (GMC)

By contrast, the three tasks in cluster 43 are rated unfavourably, receiving scores of '6' or '7' from between 53 - 65 per cent of the ratings. Additionally, task 7 and 11 are rated more unfavourably than most, being assigned ratings of between '4' and '7' on 78 - 85 per cent of the ratings. The unfavourably rated tasks are shown in Table 29. The lowest scores on all the tasks in cluster 54 tend to be on the 'Skill' construct.

Table 29

Tasks receiving unfavourable ratings on 'Job Satisfaction' and 'Skill and Experience' constructs - Heathrow.

7.	Ensure that aircraft operational enquiries are dealt with (No. 1 Director)
11.	Establish what level traffic is cleared to by LATCC and in what order (APC/No. 1 Director)
10.	Confirm that traffic has received most recent airfield information (APC/No. 1 Director)
6.	Ensure that Tower is informed of approach sequence (No.2 Director)
29.	Ensure that strips are transferred as appropriate (any position)

Tasks 6, 10 and 29 are also rated consistently as being boring, being rated '1' or '2' on this construct by 45 - 60 per cent of the ATCOs. Moreover, over 50 per cent rated task 10 as being annoying, and 40 per cent rated task 29 the same.

Many of the remaining tasks show predominantly mediocre ratings, although scores tend to be spread across the scale. This is true for the tasks in cluster 49, although those in cluster 46 receive lower ratings than the others. Similarly, tasks 1 and 3 (cluster 47) receive ratings from almost the full range of the scale, most of them within the range '3' to '5'. The same is true of task 12, but it should be pointed out that it is consistently perceived by the ATCOs as being different from other tasks, as examination of the individual Grids shows. (cf. Appendix X). 35 per cent of ATCOs also rated it as being annoying. The tasks appearing in the cluster 'Type B' in Figure 16 are favourably rated, receiving '1' or '2' on between 50 - 75 per cent of the ratings, without being clearly amongst the highest group. Finally, it should be pointed out that Elementary Linkage Analysis of the Heathrow Group Grid reveals a rather different network of clusters to the FOCUS 'task tree'. Whilst the tightest clusters remain the same for both analyses, the clustering of the more peripheral tasks is seen to differ in several cases. This is especially true of the 'Type B' cluster from Figure 16.

4.4.4 Additional Results: Heathrow and LATCC

It was mentioned in an earlier section that at the beginning of the Rep Grid phase of the research, some interviews were carried out at LATCC using motivating and satisfying situations as the elements, rather than tasks from the task analyses. Although detailed results from these interviews will not be presented, partly because they were used to gain experience in Rep Grid technique, Table 30 presents examples of those situations which were perceived very favourably compared with those which were perceived unfavourably.

Table 30

Examples of favourably and unfavourably perceived situations from early Rep Grid interviews at LATCC

(a) FAVOURABLY PERCEIVED

1. Doing POL and CLN Wings when busy.
2. Sequencing inbounds for Manchester on DTY sector on first day back from leave.
3. On DTY, getting radar headings sorted out when sequencing for Heathrow and the TMA.
4. Doing CLN sector westbound when it goes bananas.
5. Handling the CLN sector well after a long time without doing it.
6. Late evening on DTY, when it got busy and was bandboxed.
7. Putting diversions into the computer and being the only one who knew how to do it.
8. Working DTY eastbound with very heavy transatlantic and heavy inbound to Birmingham, Castle Donnington and Manchester.

(b) UNFAVOURABLY PERCEIVED

1. Stuck on IRS (Radar) with no traffic.
2. Failed to transfer aircraft to DTY sector from POL.
3. Misinterpreted strips with aircraft leaving at Pole Hill.
4. Activated wrong flight on POL Wings.
5. Doing DTY Wings.
6. Inactivity due to no traffic whilst training.

The positive situations tend to involve being busy, working on Radar, and doing something well, often when it is quite difficult. The negative situations tend to involve being inactive, working on the Wings or making mistakes.

Finally in this results section, Table 31 shows the constructs most closely matched with Construct 2, "Gives me a lot of job satisfaction" by the ATCOs at the two Units, as revealed by analysis of the individual Construct Trees and matching scores. Construct 2 is most frequently matched highest with Construct 4, "Requires all my skill and experience", occurring on about 50 per cent of the Grids. The next highest match is with Construct 3, "Demands a lot of concentration", occurring on about one-third of the Grids. In 35 per cent of the Grids, one or the other of these two clusters was the tightest cluster of all.

Table 31

Frequency of highest matching constructs with Construct 2: "Gives me a lot of job satisfaction"

CONSTRUCTS	FREQUENCIES LATCC	HEATHROW
1	2	1
3	5	8
4	9	10
5	-	-
6	2	-
7 (reversed)	-	1
8	1	3
9	-	-
10 (reversed)	1	1
11 (reversed)	3	-

5. DISCUSSION AND RECOMMENDATIONS

5.1 THE EXISTING SYSTEM

5.1.1 Job Demands and Job Characteristics

5.1.1.1 The Overall Job

Results from LATCC and Heathrow show quite clearly that the job of an ATCO II, at least at those Units, is above average in terms of its motivating potential. Although direct comparisons with normative data are not possible until U.K. norms are available, and the JDS has been validated on U.K. employees, the scores obtained by the job of ATCO II on the JDS core job dimensions are at worst equivalent to the USA norm for all jobs, and in the case of Skill Variety and Task Significance seem to be substantially higher. At LATCC, the scores for Autonomy and Feedback from Job also seem to be markedly higher than the average. In view of the low scale reliabilities obtained for the amended Task Identity dimension, comparisons with U.S. data are not advisable.

Thus, although no attempt has been made in the past to 'design' the ATCO's job from a motivational or job characteristics point of view, it exhibits characteristics of a reasonably well-designed job. This is not to say that there is no room for job enrichment; the point is being made merely that there are no serious weaknesses in the existing job design from this point of view.

Whilst on the subject of job characteristics, it is worth examining the concept of autonomy in the context of ATC. Previous research, in fact some of the earliest research into job design, has emphasised the influence of autonomy on job attitudes, and on many occasions the concept has been defined at least partly in terms of control over one's own workpace and work methods. An often quoted example of low autonomy is the assembly line job. (e.g. Walker and Guest, 1952).

Whilst the results show that ATCOs perceive their jobs to be at worst no lower than average, they have in practice virtually no control over their workpace. ATCOs mentioned in discussion, and indeed it has been observed, that when the traffic is light they tend to increase their workload by providing extra service to aircraft, for example by coordinating with other ATCOs to arrange direct routing. However, to a large extent ATCOs are dictated to by the traffic loads, and when it becomes busy they have to respond by working harder, increasing their pace of work up to the point when they have to impose an upper limit by restricting traffic movements. Restrictions of traffic flow is anathema to ATCOs, however, and it is always a last resort.

There are two aspects to pace of work in ATC, however, which deserve emphasis. Firstly, there is a reasonable amount of variety of pace introduced by the traffic flow, especially outside the summer months and to a considerable extent it is unpredictable. Thus it is unusual for an ATCO to have to work at a constant pace throughout a session on a particular position. This is an important difference from assembly line pacing of work. Secondly, the work itself is interesting and challenging, and it is suggested that the effect of an externally controlled workpace is moderated by the sort of work that is required. In assembly line work the task is often very routine and repetitious, and low autonomy would be expected to compound the effects of this on attitudes. In ATC, the task of controlling traffic is far from tedious on many positions, and having an unpredictable and externally determined pace of work is unlikely to detract from the enjoyment. The problems might arise, of course, in circumstances where the ATCO is fully stretched for long periods of time. This will be discussed in a later section.

Insofar as low control over workpace has a negative effect, it probably takes the form of an inverted 'U' relationship between workload and satisfaction in ATC. At very low levels of workload, when the traffic is light, ATCOs complain about the boredom of being compelled to remain at their radar position and yet unable to make themselves more busy. Their work is wholly dependent on traffic. At the upper end, as mentioned above, there is the possibility of too much stress.

With respect to control over work methods, the position is rather less clear-cut. There are a considerable number of rules and procedures which constrain how and when ATCOs perform certain tasks. As traffic movements have increased, and ATC has become more complex, the number of rules has increased substantially. There is limited and unsubstantiated evidence from some of the older ATCOs that, because of this trend, they perceive the amount of autonomy to have fallen over the past decade in a way that has had slightly negative effects. It seems, therefore, that control over work methods might be of more significance in the ATCOs job than control over workpace.

The very high rating on the Task Significance scale properly reflects the importance of the ATCOs' work, not only to the CAA as the employing organisation,but to the airlines, and to the general public as passengers and as residents close to airports. Errors or other forms of substandard performance on many aspects of the ATCOs' work could lead to outcomes such as unacceptable noise levels for residents near to airports, increased fuel consumption by aircraft, increased discomfort for passengers on an aircraft, and of course ultimately there is the possibility of a disaster with its huge accompanying 'costs' both human and financial.

Because of its significance, the job demands a high degree of reliability and professional conduct from the ATCOs. The level of skill and ability required is not of the highest intellectually. However, the nature and context of the job often imposes severe time constraint on the application of skill in task performance. It is the time constraint combined with the significance of the task that elevates the job demands to a higher level. The required skills seem to be above average, heavily biased towards perceptual, cognitive and verbal skills. The assimilation and interpretation of relatively complex stimuli from several sources, and the ability to switch from one problem to another very quickly are vital. Effective performance requires a lengthy training and a particular type of skill which develops with experience. In addition to the formal learning of a vast body of rules and information during training, ATCOs build up a considerable body of knowledge through on-the-job experience, much of it relating to the performance of individual aircraft and pilots with individual airlines, and the effect of different weather conditions.

5.1.1.2 Differences between Individual Positions

Differences in job content and job demands between positions are clearly shown by the task analysis and JDS data. At LATCC, the difference between working on Radar and working on the Wings is enormous and very obvious even to an outsider, and this is reflected in the results. The Wing positions consist mainly of a few clerical and manual tasks, such as tearing the paper flight progress strips from the teleprinter, checking the details on the strips, inserting them into holders, and taking them to the relevant Radar position. The nature of the work is reflected in the low Skill Variety score.

The Wing position also includes a computer input device which can be used to obtain strips, or details of flight plans. There is a tendency for the older ATCOs not to use the input device, leaving that task to the ATCA. Indeed, when there is not much happening, the ATCO on the Wings can often be observed leaving most of the duties to the ATCA. The only task which must be carried out by an ATCO is that of allocating cruising levels to traffic departing from airports within the TMA. This task requires some moderate ATC skill, knowledge and experience for its effective performance, but quite often the levels allocated by the Wing Man are subsequently changed by the Radar controller. The outcomes of the work are not so important on Wings, as shown by the Task Significance score. If mistakes are made, they tend to be a minor irritation for the Radar controller rather than critical to the system. Finally, because the Wing Man requires much less skill, training and experience in order to do a competent job, the position is used as a training position for junior ATCOs prior to being sent for radar training.

Working on radar, however, demands the highest level of skill and training that an ATCO can have. The importance of this part of the job is unquestionable, since it involves the active and constant separation of traffic in frequently congested airways or airspace. It is working on radar at LATCC that makes the ATCO earn his salary. The observable tasks are the verbal communications with pilots and other ATCOs, the arranging of strips on display in front of him and the frequent making of notes on the strips as the profile or plan of an aircraft changes, or the occasional alteration of the electronic displays by manipulation of switches or controls. The most demanding tasks, however, are covert and involve mental processing: assessing whether pairs of aircraft are going to conflict with each other at some future time; deciding what control manoeuvre to adopt to resolve the situation safely and, if there is time, expeditiously; monitoring the results of those decisions and assessing whether further action is required; making judgements about the competence of pilots and the degree of caution that is required in controlling their aircraft; noting the effects of winds, air pressure and temperature on the performance of aircraft at different levels.

The above average Skill Variety score for radar reflects both the level and range of skills that are required. Although constrained by procedures and legal requirements, the Radar controller has considerable discretion with respect to how and when he manoeuvres each aircraft under his control. The feedback he gets from doing the work is moderate without being exceptional. Loss of separation, on the occasions that it happens, is fairly obvious, but it is less obvious on many occasions whether a particularly good job has been done or not.

If the traffic load allows it, the ATCO on radar will often increase the demands on himself by trying to provide a more expeditious service to the aircraft. The regulations that are laid down in the manual refer mainly to safety standards. However, rigid adherence to safety can result in flight profiles that are expensive to the airlines, involving frequent levelling-off during climb, or lengthy re-routing, and slower flight times. The ATCO, in order that the pilot or the airline operator will benefit, and sometimes to give himself something to do, will often go beyond the minimum requirements by giving an aircraft continuous climb or by coordinating with another sector for direct routing or further climb. The effect may be that the ATCO has to watch the situation more carefully, thus increasing his workload and it is <u>potentially</u> less safe. This point will be returned to in later discussion.

At Heathrow, clear differences are revealed between the various positions. The division of the overall task at Heathrow into separate positions has resulted mainly in serial rather than parallel processing of aircraft, with a much more marked effect on the difference between positions than at LATCC. At LATCC, the skills required in controlling and separating aircraft are very similar, no matter what stage of the flight or segment of airspace the aircraft happens to be in. The demands may change from sector to sector, such as time pressures or average traffic levels, but the tasks and skills do not.

At Heathrow, this is not a generalisation that can be made. Whilst the task and skill differences between No. 1 Director and No. 2 Director may not be very marked, they are the only two positions to which this comment applies. (For the purpose of this discussion, No. 1 Directors North and South count as one position since they were divided for parallel processing of aircraft, in the same way that LATCC is divided up into North and South Banks. Generally speaking, aircraft do not move from No. 1 Director North to No. 1 Director South). At different stages in its flight plan under Heathrow's control, an aircraft has many different requirements and its relationship with other aircraft in the system differs greatly. Thus, when GMP was separated from GMC some years ago, the central task for GMP became one of dealing with stationary aircraft, a rare event in ATC! This task, deciding or establishing at what time each aircraft should either start its engines or be airborne, is clearly quite different from tasks involving moving aircraft. Similarly, the separation of Ground Movement Control from air control means that GMC is faced only with aircraft or vehicles moving along a two-dimensional plane and at modest speeds, with the ability to apply their brakes and stop if necessary. This, too, is a rare feature of ATC.

Taking each position in turn, there is no doubt from the JDS results that Air Arrivals is the position with least motivating potential. It is significantly lower than all other positions on the Feedback from Job dimension; lower than No. 1 Director, Air Departures and GMC on the Skill Variety dimension; and possibly lower than GMP and Approach on Skill Variety. There is little discretion as to how and when tasks are done, and no feedback to speak of from other people.

The central task for Air Arrivals is to monitor the final approach and landing of each incoming aircraft. There are rarely more than two or three aircraft on the frequency at one time, and the sequence of tasks is very rigid. When the traffic situation is routine, little information processing is required. Instructions to aircraft are simple and repetitive, as are the transmissions from the aircraft. Little skill or attention is required to ensure that the approach continues safely, and expeditiousness of the spacing between aircraft has been carried out by No. 2 Director. Occasionally Air Arrivals may have to organise overshoot procedures: if an aircraft has got too close to preceding traffic; if there is an obstruction on the landing runway; if the visibility is too poor to allow the pilot to see the runway at the last minute; or if there is a problem with the aircraft, such as the undercarriage warning light indicating a fault. Occasionally, too, he may have to set up the emergency services for an aircraft in trouble on landing. In the main, however, Air Arrivals is the nearest there is in the existing system to a passive monitor.

Also in the Tower, GMP is shown to be low in motivating potential and in general not very demanding. The work is frequently repetitive, involving only routine tasks. However, GMP is the first link in the Heathrow departure chain, and the flow of departures has become increasingly important. High levels of traffic movements at the airport, almost constant flow restrictions imposed by foreign ATC agencies in European airspace, and soaring fuel costs have combined to increase the importance of establishing a smooth flow of departures with minimal delays once an aircraft has started its engines. If GMP is not attending closely to the traffic situation at the airfield and gives clearance to start engines to more aircraft than the system can handle effectively, then delays can result at the holding point, the taxiways become congested, and aircraft can miss their departure slot times. This happens from time to time according to ATCOs at

Heathrow, and will be discussed again in a later section. It is not surprising, however, that GMP receives one of the highest ratings for Task Significance.

The other two positions in the Tower, GMC and Air Departures, have much greater motivating potential, yet they could not be more different from the point of view of the work they involve. Air Departures can usually be seen with his head down over the display of strips in front of him, quietly trying to work out from the information available to him about aircraft type, performance, departure routes, slot times and other restrictions what the optimum order of departures would be to maximise departure flow and minimise delays. The central task involves fairly moderate mathematical skills for calculating separations between pairs of aircraft, but with considerable time pressure to solve the problem before minimum spacings are exceeded and slot times missed. Every so often an aircraft calls the controller to say that it is with him on the frequency and waiting for further instructions. Again, every so often, the ATCO transmits to an aircraft to give instructions for the various discrete stages of departure. If there was only Air Departures in the Tower, an air of calm and quiet would prevail. The outcomes of the work are very conspicuous, with a rapid flow of departures being a visible sign of success. The skill is taken away from the job in certain conditions: when the traffic is light, or when there is work in progress near the holding point or congestion of traffic, both of which may mean that the order of departures is 'first come, first away'.

GMC, on the other hand, is the noisiest position in the Tower, because when it is busy the ATCO is making and receiving transmissions continuously. The complexity of decision making is not high, since all the conflicts occur in two dimensions. However, the task demands are for rapid decision making and rapid switching of attention between any number of different aircraft and vehicles which must be observed through a 360^{o} arc. More than any other position, GMC could do with eyes in the back of his head, and the mental processing has to build a picture of traffic movements that cannot be continuously observed. The best analogy is of an ATC circus ring-master, with everything revolving physically around you, and nothing moving without your approval. It is a very autonomous position, with few rules. The trick is to avoid blocking certain critical conflict points on the airfield so that traffic can keep flowing. If GMC does forget a potential conflict behind his back, the chances are that the pilots will see each other and apply the brakes or call GMC. Thus although the workload is very high, there are more safe-guards and little chance of a catastrophic outcome in the event of a mistake.

Downstairs in the Approach room, the main distinction is between No. 1 Director and Approach Procedural Controller (APC). The latter position acts as a support and relief position to No. 1 Director, and there are many occasions when No. 1 Director works on his own, especially on the South side. This subordinate relationship with No. 1 Director shows itself in the low score that APC receives on Autonomy. The contribution of APC to the overall service is quite small, and as much as anything he relieves No. 1 Director of the phone calls from LATCC TMA informing him of the order of traffic into the stacks and the flight levels at which they will be. There are times when APC will take on some limited decision making, maintaining separation between traffic that is holding in the stack and descending it through the stack as appropriate until it can be handed over for further direction by No. 1 Director. These occasions are not very frequent, however, and in general the demands on APC are reflected by the mediocre Skill Variety and high Dealing with Others scores.

No. 1 Director has the job that is most like that of the Radar controller at LATCC. However, mostly the aircraft under his control are descending for final approach into Heathrow, and the risk of conflicts is less than at LATCC since there are fewer potential conflicts either built into the system or brought about by control decisions. The central task for No. 1 Director, as indeed it is for No. 2 Director, is to expedite the flow of traffic into Heathrow so that delays are minimised. The lower Autonomy score may reflect the extra constraints imposed on decision making by having to coordinate with the other No. 1 Director. It is the practice on some Watches for No. 1 Director North to be the dominant member of the two due to his higher average traffic load, so that No. 1 Director South has, to a greater extent, to fit in with what his colleague is doing.

Finally, although no JDS data is available for No. 2 Director, it should be pointed out that the effectiveness with which he can do his job is dependent very much on the quality of performance of their tasks by the No. 1 Directors. Furthermore, the difficulty of the central task decreases very rapidly as traffic levels decrease. In moderate to light traffic, the task becomes little more than choosing the appropriate headings to turn aircraft on to the Instrument Landing System.

5.1.1.3 Job Specialisation

The effect of job simplification and specialisation over the past decade or two has been greater at Heathrow than at LATCC. At LATCC, increased sectorisation has done little to de-skill the individual control positions, as the upward trend of traffic movements has more than compensated for the greater specialisation, and the fundamental tasks have remained the same. At Heathrow, however, the effect of dividing tasks up into the different positions has been to produce one set of positions with relatively high motivating potential and another with markedly lower motivating potential. The six positions rated on the JDS can be grouped in pairs, each pair representing an identifiable superordinate function. Thus No. 1 Director and APC form a pair, as do the two Air controllers and the two Ground controllers. Within each pair, there is a high and low scoring position from a job characteristics point of view.

Increased specialisation has created problems of coordination, as indicated briefly in Chapter 1. A number of standardised procedures, or standing agreements, have been introduced at LATCC to enable ATCOs who are working at high pressure to transfer aircraft to another ATCO without the need for coordination between them, provided that the aircraft are adhering to certain specified rules. The problem is different at Heathrow. In the Tower, GMP, GMC and Air Departures carry out the functions that would be performed by one person at a small provincial airport. The various stages of departure - engine start up, push-back, taxi, hold and take off - form part of an integrated plan. If one man performs all these functions, the status of different aircraft in the departure chain is integrated in his head as a mental picture. If he foresees the possibility of either congestion or unnecessary gaps in the flow of traffic, he should be able to avoid the problem by immediate action. Aircraft may be denied clearance to start their engines, or an aircraft flying a particular route can be speeded up to fill the gap.

If these functions are split, as at Heathrow, the mental picture has to be externalised by the three ATCOs so that each of them is aware of any problems another may have. This requires coordination between them, and a continual checking of the airfield to see what the situation is. However, in practice GMC is often too busy to coordinate effectively with GMP, and if, for example, an aircraft is passed to him with a tight slot time he may fail to notice unless GMP tells him. This places an even greater importance on GMP's role to make sure that aircraft are cleared for start-up at the right times and in the right numbers.

5.1.2 ATCO Reactions to Job and Task Characteristics

The results from the Rep Grid and the JDS show unequivocally that ATCOs react more positively towards the tasks and positions that demand more from them in the way of concentration, skill and ability, and that are higher in motivating potential.

The Rep Grid results show clearly that decision making, problem-solving and the interpretation of complex radar display data are perceived by ATCOs as being the very essence of their job, especially when associated with the control of air traffic. The great majority of tasks forming the most positively rated clusters were defined in Section 4.1.2 as tasks central to the positions on which they occur. Comparison of the task clusters with the JDS and Rank Preference results shows that in general, the most preferred and most motivating positions are those which have as their 'core task' at least one of those tasks appearing in the highest scoring cluster. It is not sufficient that a position contains one or more positively rated tasks for it to be preferred; it must have as its core task one that is positively rated.

Thus Air Arrivals is one of the less preferred positions, and is rated very low on its MPS, despite its having three tasks (tasks 2, 4 and 17) appearing in the positive clusters at Heathrow. The reason is that these tasks occur very infrequently, and are insufficient compensation for the lack of satisfaction and challenge derived from the core tasks (tasks 1 and 2) on Air Arrivals which require monitoring the arrival of aircraft. GMC, No. 1 Director and Air Departures, on the other hand, involve the performance of core tasks that are very satisfying, and these are the positions that are preferred by most ATCOs. The Rep Grid data, therefore, both confirm and add to the results from the Rank Preference and JDS data.

The satisfaction that a task gives appears to be related very closely to the amount of skill that ATCOs perceive it to involve. Thus the safe separation of traffic receives the highest ratings at LATCC, where it is one of the most skilful tasks, but rather less consistently high ratings at Heathrow where separation is more proceduralised. Moreover, it gives more satisfaction on No. 1 Director, where there is still potential conflict between aircraft, than on No. 2 Director where there is much less potential for conflict.

It is interesting to note the mediocre ratings obtained by the main tasks on GMP in view of the earlier discussion of the criticality of the position in the departure system at Heathrow, and in particular the poor rating of task 25, 'Assess whether airfield traffic situation requires action'. Several ATCOs in discussion at Aston and also at the Unit were of the opinion that this particular task was not performed well enough by ATCOs on too many occasions, and moreover it tended to be neglected in some circumstances. The reasons given were that, because of the undemanding and frequently boring nature of the work on GMP, ATCOs switched off mentally. 'The brain goes into neutral' was one description used. Observation of ATCOs on this position confirmed, not merely that their brains went into neutral but, that their attention was easily distracted by non-job-related matters.

Fortunately ATCOs make every effort to avoid themselves becoming distracted on positions where aircraft safety is involved. More disturbing however, was the comment from two ATCOs that, because Air Arrivals can be so boring, they have been known to pass 'clearance to land' to an aircraft that has just landed. The combination of boredom with the control of airborne aircraft is fortunately rare but deserves emphasis.

The point has been made strongly that decision making is much liked by ATCOs. Not all decision making tasks are very satisfying to most ATCOs, however. There are some more routine decision making tasks which, whilst satisfying, are not rated in the top clusters. For example, task 9 at LATCC: 'Ensure that traffic is at appropriate level, speed and heading for handover'; and the decision making task on the Wing Man position, 'Decide appropriate levels for departing traffic' (task 14). This latter task is a strategic control task, and it is not connected directly with the active control of traffic.

Other routine tasks which give satisfaction to some, but fail to make the most favoured clusters, include the identification of all aircraft making their first call on the frequency. This task is more demanding at LATCC than at Heathrow, for technical ATC reasons, and this difference is reflected in the ratings for the task at the two Units. The routine tasks of transmitting instructions to aircraft (tasks 7 and 23) are rated moderately favourably but no more than that.

Several tasks receive ratings that suggest they are either very boring or dissatisfying. The least favourably rated tasks concern the transfer of routine information and the manipulation of strips. Tasks involving the preparation and distribution of strips and the removal of 'dead' strips receive the worst ratings at LATCC, all these tasks being part of the Wing Man's job. These are the truly menial parts of the ATCO's job, and many ATCOs, particularly those with many years' experience behind them, find them a source of considerable dissatisfaction. It is hardly surprising, given the content of the Wing Man's job, that it is so unpopular with many ATCOs.

The situation at Heathrow is different, because the preparation and removal of strips is the job of assistants, not ATCOs. The manipulation of strips at Heathrow is a task that appears to take up little time and effort. Nevertheless, task 29 (transferring strips) is a source of annoyance for many ATCOs. On the other hand, many of the tasks receiving the worst ratings at Heathrow involve the transfer of spoken, not written, information. These include giving routine airfield information to every inbound aircraft, receiving details on inbound traffic from LATCC TMA, and informing Air Arrivals of the approach sequence.

A common source of dissatisfaction amongst some ATCOs is tasks which are perceived as hindering or interrupting the effective performance of other tasks directed towards the provision of an expeditious service. A good example of this is task 12 at Heathrow, providing CDA assistance. This is a task that was added to the job quite recently by the management in an effort to save fuel for airline operators and to reduce noise for local residents. Whilst these are objectives that ATCOs adhere to in general, this particular task is perceived as taking up too much of No. 1 Director's time without adding to the effectiveness of the traffic flow. There are other possible reasons for its unfavourable or indifferent rating from many: the increased approach speeds of aircraft following CDA procedures reduces decision making time; and also some ATCOs claim that pilots who have checked their performance after landing say that ATCOs are not very good at one of the main subordinate tasks on CDA procedures, namely estimating the distance to run before the runway.

Other tasks which can dissatisfy or annoy also come under the heading of hindrances to the service or irritations under pressure. For example, being required to call for a strip on an aircraft that is already calling on the frequency is an irritation on radar at LATCC, especially when it is busy. At Heathrow, checking the airborne and landing times of aircraft are a requirement not of ATC but of the airport authority and airline operators. In the preliminary Rep Grid interviews they received invariably poor ratings, and ATCOs considered that they were not part of their proper job.

The intercorrelations among JDS scale scores show that, for the group of ATCOs to whom the JDS was administered, satisfaction with the work and with the opportunities for psychological growth and development is most closely associated with the amount of Skill Variety that the work is perceived to have, and with the Motivating Potential Score of the job or position. Although causal relationships cannot be ascribed on the available evidence, it must be emphasised that the level of association is very high indeed. However, some aspects of the JDS results must be treated with caution and the reader is referred to the following section for further discussion.

To summarise the existing system and ATCO reactions to it, it has been shown that the job of an ATCO at both Units encompasses work of widely differing demands which elicits a wide range of reactions from high motivation and satisfaction to boredom and dissatisfaction. The fact that ATCOs react to the overall job content with enthusiasm, many of them even after several years doing essentially the same work, depends in no small measure on the application of job rotation in the Units. Thus, despite the fact that some positions are disliked, the frequency with which the favoured positions are worked on compensates fully for this, at least at the moment.

The results only partially confirm Smith's comments (Smith,1973) with respect to the sorts of tasks that give most satisfaction. The methodology, of course, was very different in the two studies, Smith relying on task descriptions by the ATCOs themselves with the Critical

Incident Technique. More importantly, the methodology used in the present investigation allowed for much more detailed analysis of the affective reactions to tasks. Thus, whilst the present results confirm that 'working with radar', to use Smith's terminology, is very satisfying, they go further by pointing to the particular subordinate tasks associated with working with radar that give most satisfaction. These results do not, however, suggest that 'radio communications' and 'advising pilots' are consistently as satisfying as Smith's results suggest.

As a final comment, one wonders whether the job as it stands even now is motivating enough to satisfy the new generation of ATCOs. At the beginning of the thesis it was mentioned that ATC has a very flat career structure, so few ATCOs can expect promotion above the operational level. To this information it should be added that increasingly ATCOs are being selected straight from, or soon after, school at the age of 18 - 20. Formerly a large proportion of the ATCO force was made up of 'second career' ATCOs who had left the Services in their thirties. Many of these are reaching retiring age. The extra years of operational life, combined with the increasing trend towards specialisation of training and job simplification, may begin to take their toll in the form of increasing loss of intrinsic satisfaction in the decade to come. In this respect it is interesting to note that the LATCC and Heathrow ATCO union, a branch of the IPCS, has just taken part in its first strike with a large measure of support from its membership in furtherance of a pay claim. Loss of interest in job content and increased concern with extrinsic rewards are well known to go hand in hand with each other.

5.1.3 Research Methodology: Rep Grid, Task Analysis and JDS

5.1.3.1 Job Diagnostic Survey

One of the very earliest tasks in this research was the search for a technique that would provide appropriate and reliable data about jobs that could be applied to the research problems. The JDS was at the time, and still is, the only instrument of its kind with any history of validation. To have carried out this research programme by using only techniques or a methodology developed within and for this research would have been to either take up a disproportionate amount of time validating the techniques, or to proceed regardless and finish up with data of unknown validity. Despite the limitations expressed about the JDS in Chapter 3, it was hoped that the JDS would provide a baseline of relatively reliable and valid data that the Rep Grid data could be related to.

In the event, the JDS has proved to be something of a curate's egg in this research; some parts of it have been very useful, but others have proved to be unreliable. The internal consistency reliabilities reveal that the amended Task Identity dimension is composed of items that are too heterogeneous to be acceptable. Obviously this will require further more careful research to find items that are both reliable and acceptable to ATCOs. Moreover, most of the scales apart from the job dimensions show reliabilities considerably lower than has been found in America.

Amongst the psychological states, Experienced Responsibility has an internal reliability of only 0.31. Examination of the individual interitem correlations showed that items 12 and 15 in Section 3 of the JDS associated weakly with the other items. These two items emphasise the question of the extent to which the respondent feels that the results of his work are clearly his responsibility, for which he should take the credit or blame. It seems very possible that these items have touched on a controversial issue in ATC, namely that of legal responsibility for accidents and other incidents. If you ask an ATCO whether he cares about the work or whether he feels personally responsible for his work, as the other items on this scale do, he will probably answer strongly in the affirmative. However, raise the possibility of accepting responsibility for mistakes, and a streak of caution and suspicion will emerge. If nothing else, the outcomes of his work are strongly influenced by what the pilot does; and if one's livelihood is at stake, as it would be in the event of an incident, then it is sensible not to automatically accept responsibility without establishing all aspects of what happened.

Despite the low internal reliability of this scale, the JDS results show that Experienced Responsibility is considerably higher on all positions than the scores for Autonomy would lead one to expect from the Job Characteristics model. This anomaly perhaps highlights a weakness in the posited relationship between the two variables, and the nature of the model itself. Experienced responsibility, especially when defined in terms of 'caring about the work being done right' and 'feeling personally responsible for the work', is not just a function of autonomy in ATC, and perhaps this is true of other occupations too. The product of an ATCO's work, which at one level is the safe flow of civil air traffic, is something for which he almost certainly feels responsible and cares about, even on positions such as Air Arrivals and Approach where there is only moderate autonomy at best. This is not responsibility such that for example, the ATCO feels that if the aircraft lands safely he deserves credit, but the sort of responsibility that a parent might feel for its child's behaviour even when it is out of the parent's direct control. In other words, the mere fact of being an ATCO, and all that that implies, instills caring and responsibility in the person that carries over into whatever he does, no matter how much autonomy he may or may not have.

The low internal consistency reliability of the Internal Motivation scale may be explainable simply in terms of cultural differences between U.K. and U.S. populations. In particular, item 10 in Section 3 and item 9 from Section 5 of the JDS ask the respondent to state how much he agrees with the statement that he feels 'bad and unhappy' when he discovers that he has done something poorly. This overt expression of feeling may be more typical of U.S. people than U.K. people.

The GNS scale, particularly the Job Choice aspect of it in Section 7, is a more serious problem altogether. The lack of association between the different items in Section 7 is such that the assumption that they are measuring an identifiable and persistent individual trait must be questioned very severely. Whilst particular comments might be made about certain items showing the least association, the safest conclusion would appear to be that until further research has been done the GNS scale should not be interpreted for the ATCO population. The nature of these findings however, suggest that the JDS needs to be re-validated on a U.K. population before it can be used with confidence. The job characteristics show moderate internal reliability, but most of the other scales are probably too low to be acceptable.

The results of this investigation shed some light on the failure of the Dealing with Others dimension to show a strong or consistent relationship with the outcomes in the U.S. research on the job characteristics model. Derived from the 'interaction' task attributes of Turner and Lawrence (1965), Dealing with Others is based on assumptions about the role of social interaction in the elicitation of feelings of satisfaction at work. However, in the context of ATC, a high score on Dealing with Others may be due partly to a high level of coordination and consultation with others, which can imply low autonomy. The JDS results for the APC position at Heathrow suggest this. Moreover, it may be due partly to a high degree of routine and time-consuming information transfer, again as seen on the APC position. Thus there are several reasons why one might expect Dealing with Others to imply negative reactions, as well as the positive reactions originally foreseen by Hackman and Lawler (1971).

As a final comment on the JDS, the level of association between the core job dimensions supports the use of the additive rather than the multiplicative MPS score.

5.1.3.2 Rep Grid and Task Analysis

The use of task analysis data in conjunction with Rep Grid technique provided the most original contribution of the research, and was intended in addition to provide the most useful contribution to the pursuit of the research objectives. In retrospect, the author considers that this part of the investigation has provided very valuable and acceptably valid data, but that the approach has much unrealised potential. The following points illustrate how, in the future, more useful data might be obtained for systems design.

Firstly, if standard Grids are to be used again, they should contain explicitly bipolar constructs. Earlier in the research the argument was advanced that unipolar constructs would allow the respondent to make each construct more personally meaningful by rating elements according to his own implicit contrasting pole. However, the absence of an explicit contrasting pole caused two problems: (a) There was ambiguity about the interpretation of ratings of '4' and higher; for example, did a '7' on the 'job satisfaction' construct imply an absence of satisfaction or the presence of dissatisfaction? The distinction may be important for systems design. (b) There was obviously some confusion for some ATCOs about the use of 'Does not apply' as distinct from '7' on the scale. Comparison of the two 16 x 11 Grids completed by each ATCO showed that, in a couple of cases, ATCOs had rated all elements on one Grid as '7' on a particular construct and on the other as 'Does not apply'. This only happened where the explicit pole was a negative statement. Use of bipolar constructs would have overcome both these problems. Either semantic opposites could be used on all the Grids, or each respondent could be asked to write his or her own contrasting pole on to the Grid in the appropriate place. This last approach adheres closer to the principles of Construct Theory.

The tasks, as elements, would allow for more precise discriminations if they were more specific. The tasks in this investigation, as explained earlier, were mostly generalised tasks that were applicable to most positions or situations. This was true more of the LATCC than the Heathrow tasks. Because of this, it seems very likely that some tasks were so vague in definition that some of the differences in attitude expressed by ATCOs may have been due to differences in definition, not real differences in attitude. Research is currently in progress to produce more specific task descriptions and incorporate them in Rep Grids.

5.2 IMPLICATIONS FOR SYSTEMS AND JOB DESIGN IN ATC

5.2.1 The Research Objectives in Perspective

The starting point for this research was the RSRE research and development programme relating to the architecture of ATC systems, with particular reference to systems which would contain computers having some decision making capability. The overriding objective was to provide guidelines or recommendations for the appropriate allocation of tasks or functions between ATCOs and computer. The other objectives, predicting the reactions of ATCOs to various levels of computer assistance and assessing the likely 'costs' of negative reactions to system and organisational effectiveness, were stages that would eventually facilitate the achievement of the prime objective.

The research was influenced from the outset by several factors which affected both the method and therefore data collected, and which will affect the contents of this final chapter. Central to the approach of the research, as discussed earlier, was the lack of a specific system or systems for the author to investigate that would provide direct evidence concerning ATCO reactions to computer assistance. There is one system development programme which may feature computer-aided decision making in a strategic ATC context for Oceanic Control in Scotland, but the opportunity to study it arose too late, and its future is still uncertain. Thus the data collected have been based on reactions to the current ATC system, and the following recommendations must of necessity be based on informed speculation and generalisation.

Another influence on the research was the pressure to go beyond 'basic applied' research and produce results that would provide a basis for future policy making. There were times, therefore, during the research that decisions were taken on pragmatic grounds primarily, with academic considerations having to take second place. With hindsight, a proper piloting of the JDS for example, or even a fresh approach to the analysis of job characteristics, would have produced more useful data in the long run. To some extent, therefore, this entire research programme ought to be viewed as a preliminary investigation, since a good deal of work remains to be carried out before truly effective incorporation of affective factors into systems design can occur in ATC.

Whilst the starting point for the research was the context of basic systems research at RSRE, the following recommendations extend to matters of job as well as systems design, since in practice the two processes overlap and policy decisions affecting systems design may require consideration of job design possibilities.

5.2.2 Costs of Negative Reactions

In general terms, the costs to the system and employing organisation of negative affective reactions were discussed in the review of the literature in Chapter 2. This section will interpret findings from the present and previous research in the context of ATC.

The effects of job dissatisfaction, low motivation and boredom will depend to some extent on their strength, their novelty, and the general context in which they occur. Of great relevance to the ATC context is the motivating and satisfying nature of the job content at present. People are entering ATC with the expectation of both an interesting and a challenging job ahead of them. To use Graen's distinction (Graen, 1969) the job is thus perceived by ATCOs as being high on 'attraction', or anticipated satisfaction. If the job were to change such that it became more routine and less satisfying, there would be an intervening period during which, assuming the same people carried on doing the work, there would be a body of ATCOs whose expectations of the job would be fundamentally changed. These ATCOs could be expected to experience considerable dissatisfaction with the new job, greater than if those same people had been selected and trained for the new job from the outset. Indeed, the research by Wanous and Lawler (1972) and Barth (1976) suggests that anticipated satisfaction is more relevant to employees such as ATCOs than current satisfaction. Moreover, since the job at present is above average in motivating potential and derived satisfaction, there is the potential for a very substantial drop in both motivation and satisfaction should the job change for the worse. Consequently, there is potential for a substantial increase in costs to the CAA.

Although the research did not investigate directly the importance of job content for ATCOs' satisfaction compared with job context factors and extra-work variables, the consistency and strength of association between job and task characteristics on the one hand and ATCO satisfaction on the other suggests that ATCOs would be very sensitive to changes to job characteristics brought about by the implementation of a new system. It is not surprising, given that most ATCOs remain in secondary education until after 'A' levels, and given that they then enter a period of technical education and training geared to ATC for 2 - 3 years, that they respond positively to the use of their skills and negatively to their disuse.

What would be the consequences of a significant increase in the strength and persistency of negative reactions towards the job content? Firstly, assume that the education level, length and type of training, level of remuneration and organisation structure remained substantially the same. Given that, then the CAA would be faced with a body of intelligent, articulate employees who had found that their jobs were no longer intrinsically motivating or satisfying, who had little prospect of promotion out of the situation, whose training prepared them for no other work, and who had financial commitments based on a salary that was substantially higher than they could earn as employees outside ATC without a lengthy period of higher education and/or re-training.

Regardless of the level of unemployment and economic buoyancy of the country at the time, it seems unlikely in these circumstances that the CAA would see a change to a high wastage rate amongst ATCOs, although there might well be a rise in wastage amongst young cadets as they became aware of the job demands. The most likely consequences would be contained within the day-to-day operation of the system and the CAA. There would more likely be a rise in absenteeism through genuine or contrived sickness, both mental and physical. This is of course a cost to the individual's well-being as well as to the CAA (Warr and Wall, 1975).

There is one scenario in which sickness rates might increase very substantially. That is if the new job required ATCOs to act primarily as manual back-up, a belt-and-braces arrangement, in the event of system failure. This might prevent the ATCOs even from being able to 'switch off' and divert their attention elsewhere, whilst denying them the opportunity to exercise their skills and remain alert in the course of their normal work. It should be emphasised that sickness to an ATCO under existing arrangements is a double problem, because not only must the ATCO suffer the sickness itself but he faces the possibility of loss of validation on positions where he has been unable to work for a specified number of days, and ultimately he can face the loss of his licence altogether if the sickness is severe enough, or requires the use of certain drugs.

As intrinsic satisfaction falls, there is likely to be a greater reliance on and expectation from extrinsic rewards and outcomes. This may show itself in an increased willingness to press for higher levels of remuneration, especially as the workforce becomes dominated by first-career ATCOs whose attitudes and behaviour are uninfluenced by a lengthy period in one of the Services. The IPCS section committees in ATC are becoming increasingly dominated by younger ATCOs whose attitude towards industrial action is noticeably different from many of the older ATCOs, and who are much less willing to sit back quietly. Thus the CAA could face financial costs through increased staff costs and through refusal to operate the system, not to mention the impact that industrial action might have on the public image of the CAA.

Finally, there is the question of performance effects. It was made clear during the course of the literature review that there is no strong or consistent relationship between job satisfaction and performance that can be supported by the literature. Yet, subjective comments from ATCOs during the course of this research suggested that there was a possible relationship between low motivation and boredom on the one hand and performance decrements on the other. ATCOs at the moment are extremely conscientious, professional, and concerned about the service that they provide. It is no exaggeration to say that the present system works so well largely due to the efforts of ATCOs to surmount its shortcomings. If ATCOs ever worked to rule, the effect on the expedition of the service at LATCC and Heathrow would be very substantial. Yet, despite this present attitude towards the job, ATCOs believe that there are some circumstances even now in which decrements or errors are made more likely, despite their wish to maintain standards. This aspect of negative reactions requires further investigation, focusing on boredom rather than dissatisfaction.

The extent of possible costs of this nature, however, depends on the degree of influence that the ATCO has over system effectiveness. For example, if the ATCO were to be responsible for achievement of a task objective similar to that of GMP for assessing the airfield situation, which is both crucial to the system and yet is performed poorly due to the lack of challenge of that and other tasks on the position, obviously the ATCO could influence system performance both substantially and frequently. On the other hand, if he was concerned solely with minor tasks which if they were performed poorly could be absorbed by slack elsewhere in the system, then his influence would be of less importance.

5.2.3 ATCO Reactions to Computer Assistance

In order to be able to predict the reactions of ATCOs to different degrees of automation, it is necessary to consider the context in which it is likely to be introduced. The ICAO theoretical criteria for automation in ATC mentioned in the opening chapter specify that automation is justified (a) when any particular ATC functions or processes are becoming too burdensome or time-consuming to be carried out efficiently by human operators alone; or (b) when it becomes certain that substantive improvement with regard to regularity and expedition of operations cannot adequately be maintained without automation while maintaining the required level of safety.

Both these criteria imply circumstances involving appreciably higher traffic levels and/or traffic complexity. Moreover, it seems likely that there will be increased pressure from either airline operators, government or both parties to increase the expedition of traffic flow so that fuel consumption may be minimised.

The effect of these circumstances on the ATCOs will be to increase their average workload and also the proportion of their working time spent at or near maximum workload. Their peak workload cannot increase since that point is already reached very occasionally with existing traffic levels. The consequence of higher traffic levels will be to make delays to aircraft more frequent, and ATCOs will have to provide a less expeditious service in order that safety can be maintained.

If these circumstances were to prevail, there is no doubt that ATCOs' intrinsic job satisfaction would begin to fall since the provision of an expeditious, as well as a safe, service is critical to their satisfaction from the job. In addition, the increased pressure of traffic demands may begin to take its toll on the health and wellbeing of some ATCOs. Thus it seems very likely that ATCOs would be amenable to some change to their existing system that enabled them to provide a better service and feel that they had done a competent job whilst not being over-stretched. However, this does not mean that ATCOs would automatically welcome a more automated system. Several ATCOs mentioned in discussion that they considered increased automation to be less useful than, for example, increasing the amount of controlled airspace that was available. Thus the willingness to accept a more automated system might depend on the extent to which ATCOs perceived it to be a valid solution to the problem. This is a point to which the discussion will return later.

It is important to emphasise, too, that positive reactions to a new system on its introduction are no guarantee that negative reactions to the system or the jobs within it will not arise later on. If the new system reduces the motivating potential of jobs at the Units, it may not be apparent to the ATCOs until they have operated it for some considerable time. A system that was welcomed initially, therefore, may be the cause of low satisfaction and motivation at a later date, bringing with it hidden long term costs to the CAA. The remainder of this discussion will be concerned with possible long-term reactions to systems and jobs.

The discussion will distinguish between the terms 'automation' and 'computer-assistance'. The term '<u>automation</u>' implies a very high degree of mechanisation, re-allocating most functions to the computer and leaving the human operator to perform a secondary or supportive role. Since the CAAS trials referred to in Chapter 1, RSRE have adapted the concept of '<u>computer-assistance</u>' to refer to a human-computer system in which the human operator is the dominant half of the relationship, and the computer acts as a support to him by enhancing his ability to perform certain functions. Thus, although it is common for people to talk about 'automation' in the context of <u>any</u> re-allocation of function from person to computer, it will only be used in this discussion when fundamental changes to the human-computer relationship, and to the balance between active (e.g. conflict prediction) and passive (e.g. monitoring) tasks in the person's job, are implied.

To proceed with the discussion, consider first of all the effect on ATCO affective reactions to the introduction of a highly automated system. There seems little doubt that there would be widespread negative reactions to such a system. The large-scale allocation of decision-making, or control, tasks to the computer would remove the very heart of the job from the ATCO, replacing his former role with that of system monitor. The evidence from Air Arrivals, for example, suggests strongly that requiring the ATCO to passively monitor some activity results not merely in an absence of satisfaction, but more importantly can lead to performance decrements through inattention. Similar effects due to undemanding work can be seen from the GMP evidence.

The question must be asked, what sort of role would the ATCO play in such a system? If it was purely acting as technical support to the computer, then clearly there would be no point in selecting ATCOs to do the job at all. More likely is that the ATCO would be monitoring the system in his capacity as a trained ATCO, perhaps acting as a belt-and-braces support to the automated system. This might involve taking over at short notice in the event of system failure, or dealing with certain situations that the computer was not able to handle effectively; aircraft emergencies, for example. There might be additional tasks to perform such as responding to non-routine enquiries from pilots.

The sort of tasks described above are either too infrequent, or too low a skill level, to allow the ATCO to derive satisfaction from the overall job. The ATCO would probably feel of secondary importance to the computer, and be unable to feel any great pride in his work. The requirement to take over in the event of system failure presents a host of other problems outside the scope of this thesis, although ultimately related to job satisfaction: maintenance of skill levels, for example, under conditions of infrequent practice.

The situation is less clear cut if one considers automation of individual positions, as distinct from the overall job. ATCOs' reactions to automation of discrete parts of the job would depend very much on which parts were automated, and on the overall balance that could be achieved between challenging and routine tasks. The results show very clearly that ATCOs derive considerable intrinsic satisfaction from their overall job at present, despite the fact that they find some positions generally boring or dissatisfying. This is due to the balance achieved in the job by job rotation, and the fact that there are sufficient motivating and challenging tasks distributed between the individual positions.

Automation of the less popular positions ought to cause fewer problems with the ATCOs than automation of the favoured positions, and a similar point could be made about the tasks. If the 'core' tasks on positions such as GMC and Radar were automated, there would very likely be strong negative reactions unless the job as a whole could be made more motivating by the introduction of new tasks that used the ATCOs' skills, or by altering the organisation of work to allow sufficient time on the interesting parts of the job. There might actually be positive reactions if some of the least satisfying positions or tasks could be automated. On the basis of the evidence from this research, it is probable that a well-designed system for flight data transfer and display would be positively received at both Units, provided that it reduced the laborious aspects of the present system without introducing new difficulties. Similarly, automatic transfer of some of the routine information might well be received positively, such as the communications between TMA and Approach regarding the order of traffic into the stacks, or between No. 2 Director and Air Arrivals.

There are some routine decision making tasks, too, which ought not to cause strong negative reactions if they were automated. Two sorts of tasks are referred to in this category: (a) the relatively straightforward decision making on the less popular positions such as the Wings at LATCC, or GMP, Air Arrivals and APC at Heathrow; and (b) the routine clearances given to aircraft on Radar when no conflicts are involved.

If computer-assistance were to be provided with the decision making tasks in the most satisfying clusters, the reactions of ATCOs would depend very much on the extent to which the improvement in service to aircraft, to which they would react very favourably, was offset by any loss in skill level, variety or autonomy. The ICR concept at RSRE, for example, provided computer assistance to radar controllers with the prediction of conflicts, leaving the ATCO to decide how to resolve them. The evidence obtained from this research with the Rep Grid does not allow for firm conclusions to be drawn with respect to this example, however, since the standard Grids did not include subordinate tasks at a sufficiently low level from the task analysis. It can be said, however, that ATCO reactions to ICR should be more favourable than towards CAAS, since the former allocates a greater variety of tasks to the ATCO, tasks that are more demanding and that will be performed on a regular basis.

5.2.4 Recommendations for System and Job Design

It was described in Chapter 1 how specialists in the field of ATC systems research, national and international controlling bodies in civil aviation seemed to agree on two points:

(a) there is no question of total automation of ATC in the foreseeable future; but

(b) the job of the ATCO will be substantially affected by technological change during the next 20 years and beyond.

Clearly, therefore, the ATCO is going to continue as part of the ATC system for some time to come. With this in mind, it is essential that the designers of new ATC systems and the CAA take into account the intrinsic motivation and satisfaction of ATCOs. Failure to do so will very likely cause the CAA organisational problems as described in section 5.2.2, and may result in sub-optimal system performance.

It is not the view of this author that management should attach overriding importance to job satisfaction. Whilst there are strong ethical, social and economic arguments in favour of improving job satisfaction specifically and the quality of working life generally, there are often other considerations which may have to take priority. In ATC, there is very obviously the need for safe separation of traffic above all else. Nevertheless, job satisfaction and motivation cannot be viewed in isolation from system performance and organisational effectiveness, since they may influence both. The question for the CAA is not one of whether or not to consider ATCO wants and satisfactions, but of the extent to which they should be considered. That is the true implication of sociotechnical systems design. The degree to which the CAA seeks to maximise job satisfaction depends on its ethical standpoint as well as economic and social criteria. The following recommendations primarily are directed at helping the CAA to select, and systems designers to design, effective systems.

A general recommendation is that every effort should be made to ensure that ATCOs' jobs are designed in such a way that they would achieve a high motivating potential score. That is, they should require ATCOs to use on a regular basis their skills and knowledge acquired through training and experience; the autonomy to make decisions and use judgement in making them should remain with the ATCO; and the job should make a clear and significant contribution to the ATC service. Moreover, ATCOs should be set clear task objectives of at least moderate difficulty and be provided with feedback on their progress towards those objectives. If these criteria are met, and assuming that the sort of people selected for the job of ATCO remains much the same, then ATCOs should derive considerable intrinsic satisfaction from the job.

For the systems designer, these criteria imply the allocation of a well balanced range of tasks to the human controller. An acceptable balance requires the ATCO to perform on a regular basis at least one superordinate task that is demanding of a variety of his skills, although the inclusion of some additional routine tasks should be acceptable provided that they do not interfere significantly with the pursuit of the main task goal. The more directly related subsidiary tasks are to the main task objective, the more acceptable they are likely to be.

Examples of tasks from the current ATC system that are reacted to very positively are shown in Table 32. Following each task is a reference to the appropriate page from the task analysis which will enable the reader to check what variety and type of subordinate task objectives are entailed in striving towards the superordinate task objectives shown in the table. As a general rule, <u>systems designers should proceed with very great caution if their initial conceptions involve automation of any of these tasks</u>. They should be aware that automation of any of these tasks may result in a substantial loss of intrinsic satisfaction from the job unless equivalent tasks are introduced to replace them. If this is not possible, then the CAA in conjunction with the systems design team should attempt to organise the job of the ATCO in such a way that loss of motivating potential in one part of the job is compensated for in some other way: for example, by changes to job rotation or to the length of working time spent on particular positions.

Table 32

Tasks central to intrinsic motivation and satisfaction of ATCOs in current system (numbers in brackets refer to task analyses in Appendix I)

1.	Ensure that traffic remains safely separated (SC14, task 1.8)
2.	Decide most suitable solution to traffic situation (SC7, task 1.6)
3.	Identify possible conflictions from strips and radar (SC8, task 1.6.2.1: SC.14, tasks 1.8.1, 1.8.4)
4.	Assess whether traffic could be climbed/descended to resolve situation (SC10, task 1.6.4.2)
5.	Assess whether vectoring could resolve situation (SC11, task 1.6.4.3)
6.	Evaluate expediency of solution for aircraft (SC7, task 1.6.7)
7.	Determine relevant features of traffic situation (SC8, task 1.6.2)
8.	Decide priorities for action (SC7, task 1.6.3)
9.	Assess whether solution is expediting (SC1, task 1.9)
10.	Ensure that traffic remains safely separated (No. 1 Director, task 5.6)
11.	Determine most expeditious order of departures (AD3, task 3.1.3)
12.	Ensure that traffic is directed as expeditiously as possible (No. 1 Director 2, task 5.7)
13.	Ensure that traffic is directed on to final approach as expeditiously as possible (No. 2 Director 2, task 6.5)
14.	Decide what to do with traffic (GMC 2, task 2.5)

The most favourably rated tasks in the current system appear to involve at least one of the following: (a) at least a moderate level of decision making; (b) estimation and calculation, e.g. of relative speeds, rate of climb, optimum sequencing of groups of aircraft; (c) combination of several sources and types of information to establish a more complete body of related information; (d) judgement and assessment, e.g. of future traffic configurations, of complex or ambiguous radar information, of viability of particular solutions to traffic problem. As a general rule, ATCOs at the moment prefer such tasks to be directly related to the tactical control of air traffic. It is a matter of some priority that future research should attempt to identify underlying skills to these tasks, so that it would be possible to make more accurate assessments of the motivating potential of new tasks during systems design.

One point deserves special emphasis. A considerable proportion of ATCOs' intrinsic satisfaction is derived from going beyond the requirements of safety alone. Thus at LATCC, ATCOs will, when they consider that the situation allows it, opt for a solution that relies for its safety on their performance, rather than a solution that is inherently safe. As explained earlier, this is because the former solution tends to require more skill and is more demanding, it provides a more expeditious service to the aircraft which pilots appreciate, and it may either alleviate boredom in light traffic or reduce the possibility of excess workload and delays in heavier traffic. There is, therefore, at the moment a direct conflict between the requirements for a system that is inherently very safe on the one hand, and that is expeditious on the other, and this is made explicit by the tendency for the latter requirements to encompass tasks that are more demanding and therefore potentially more motivating in some circumstances. It will be a challenging task for systems designers to produce a design that increases the safety level without at the same time reducing substantially the challenge in the ATCOs' job.

One possible solution to this problem in light traffic would be a computer based conflict alert system. This would provide visual and auditory warnings to ATCOs that a conflict required action fairly immediately. The qualifier 'light traffic' was added for two reasons. Firstly, it is in light traffic that ATCOs tend to select a solution that needs close monitoring, since their workload allows for an increase. However, it is also in light traffic that their attention can divert through inactivity or an inappropriately timed telephone call. Secondly, in light traffic a back up system would be largely supportive to the ATCO whereas in heavy traffic there may be too many occasions when the computer system activates warnings, with the effect of annoying the ATCO who is already aware of the potential conflict. This second point would depend very much on the criteria which triggered off the conflict alert warnings.

Another recommendation that can be made perhaps needs no emphasising by now. Future systems should not allocate 'passive' monitoring tasks - i.e. tasks that are not as a matter of course followed by active decision making tasks - to ATCOs. The evidence from Air Arrivals suggests that at the very least such tasks fail to give any satisfaction, and at worst they may make a system inherently unsafe. In addition, future systems should not allocate to the ATCO routine or menial tasks as a significant proportion of his job. ATCOs would react to such a job, as they do already to the Wings, very negatively.

It is a reflection of the 'state of the art' and of much of the research that is done that it is possible to be more specific about what to avoid in systems design than what to include or change. Nevertheless, the consistently negative reactions to some tasks in the current system suggest that they might be a target for change in the future, although it is unlikely that such change would facilitate the handling of much higher traffic movements. It ought, however, to remove or reduce some of the frustrations for the ATCO. These tasks are shown in Table 33.

The final part of this section, and indeed of the thesis, raises an issue that is relevant to sociotechnical systems design and to the criticisms of existing approaches discussed in Chapter 3. Whilst it is true that there are considerable difficulties involved in participative sociotechnical systems design in ATC, for reasons discussed earlier, it is the author's view that much could be done by the CAA to increase the involvement of ATCOs in systems design. There is so much knowledge and expertise to be found exclusively amongst operational ATCOs that not to utilise it to the utmost seems absurd. Yet, the systems research team at RSRE are restricted to two ex-operational ATCOs with whom they can discuss the implications of

Table 33

Tasks that could be automated in the future. (figures in brackets refer to task analysis in Appendix I)

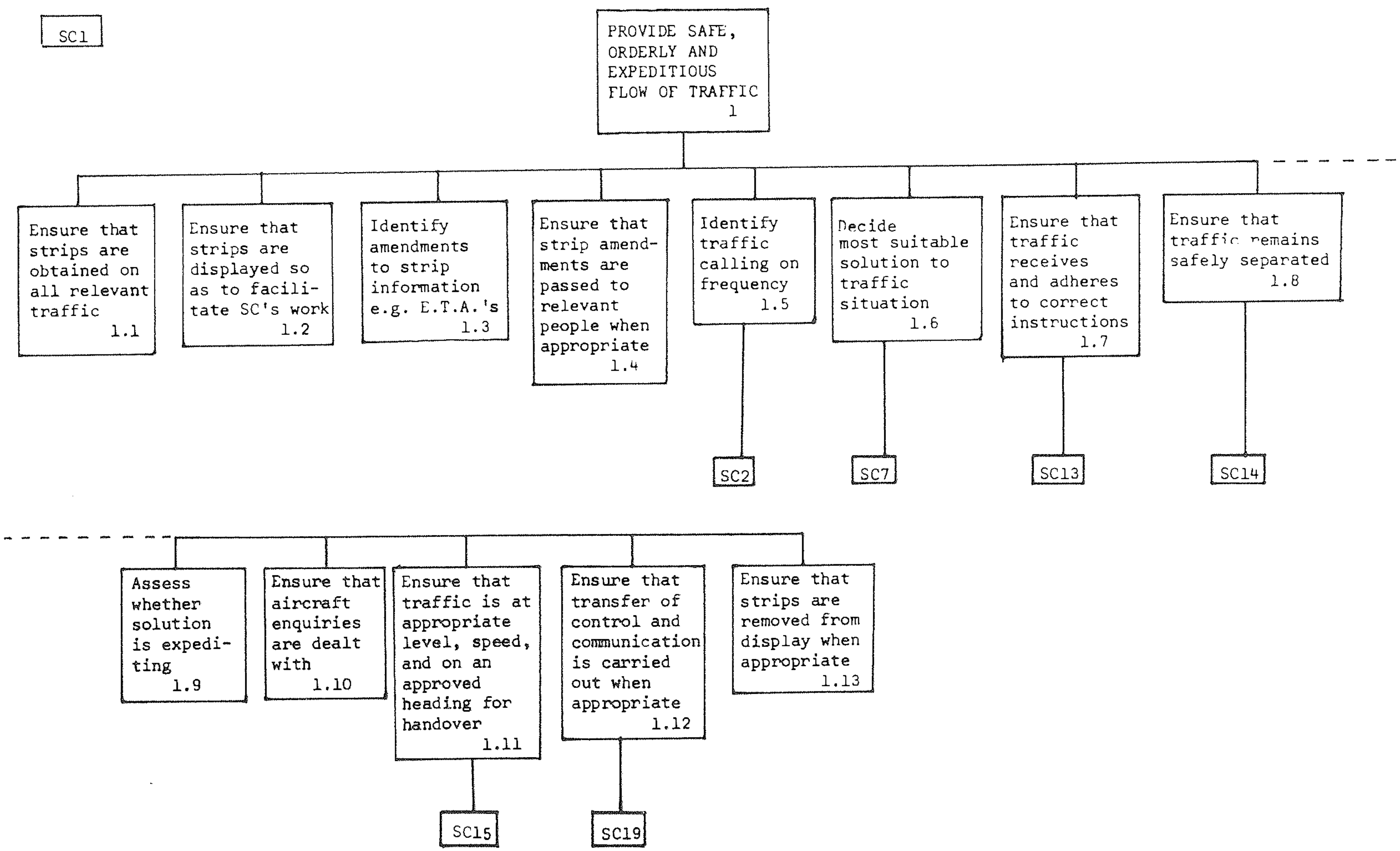
1.	Ensure that dead strips are removed and filed as required (ASC1, tasks 2.11 and 2.12)
2.	Prepare strips for distribution (ASC4, task 2.3)
3.	Confirm that traffic has received most recent airfield information (No. 1 Director 1, task 5.5)
4.	Ensure that Tower is informed of approach sequence (No.2 Director 1, task 6.6)
5.	Ensure that strips are transferred as appropriate (any Heathrow position)

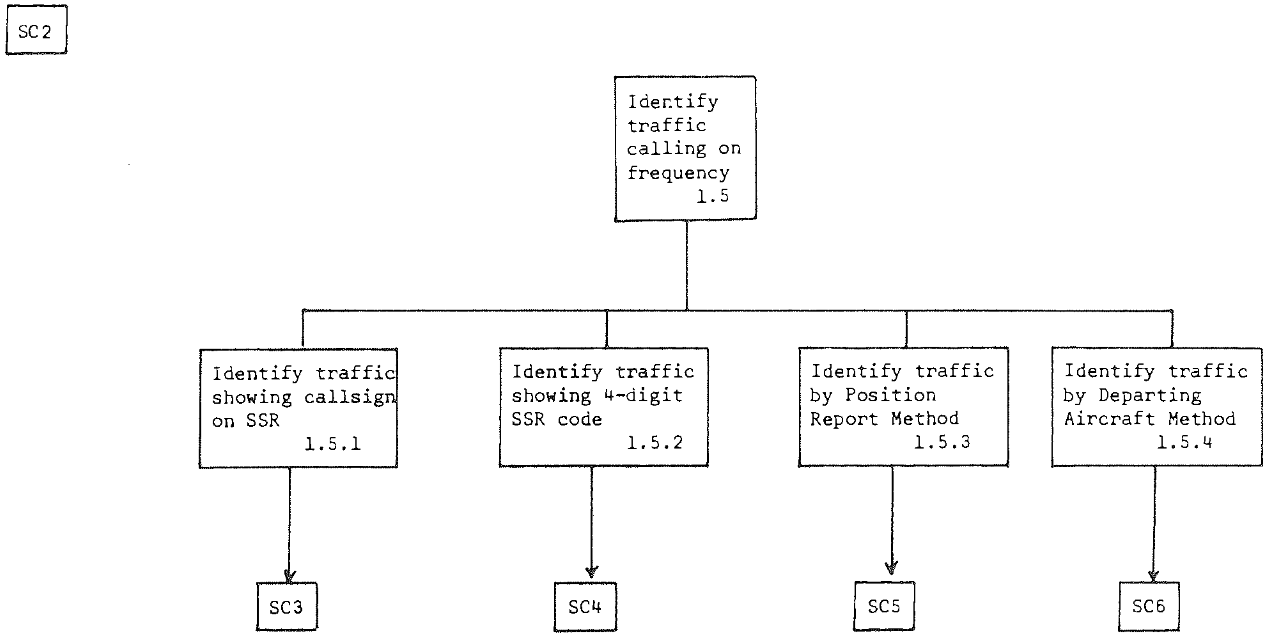
their ideas for the operational environment, neither of whom has worked operationally for some years. This is not a criticism of them, nor their contribution, nor indeed RSRE itself, but of the almost total lack of formalised interaction between systems designers in ATC and operational ATCOs.

What is needed is a change of approach to systems research and design in ATC, beginning with a thorough investigation of the needs of ATCOs in the existing system. What are the major difficulties for ATCOs at present, what tasks are most time-consuming or performed least effectively? Would ATCOs appreciate help with the easy but time-consuming tasks, or with the difficult, challenging tasks? These appear to be fundamental questions which need answering in addition to those already being examined. They are questions which need to be answered before a systems design project gets under way, and the only way they can be answered is by involving ATCOs in a systematic, rigorous way.

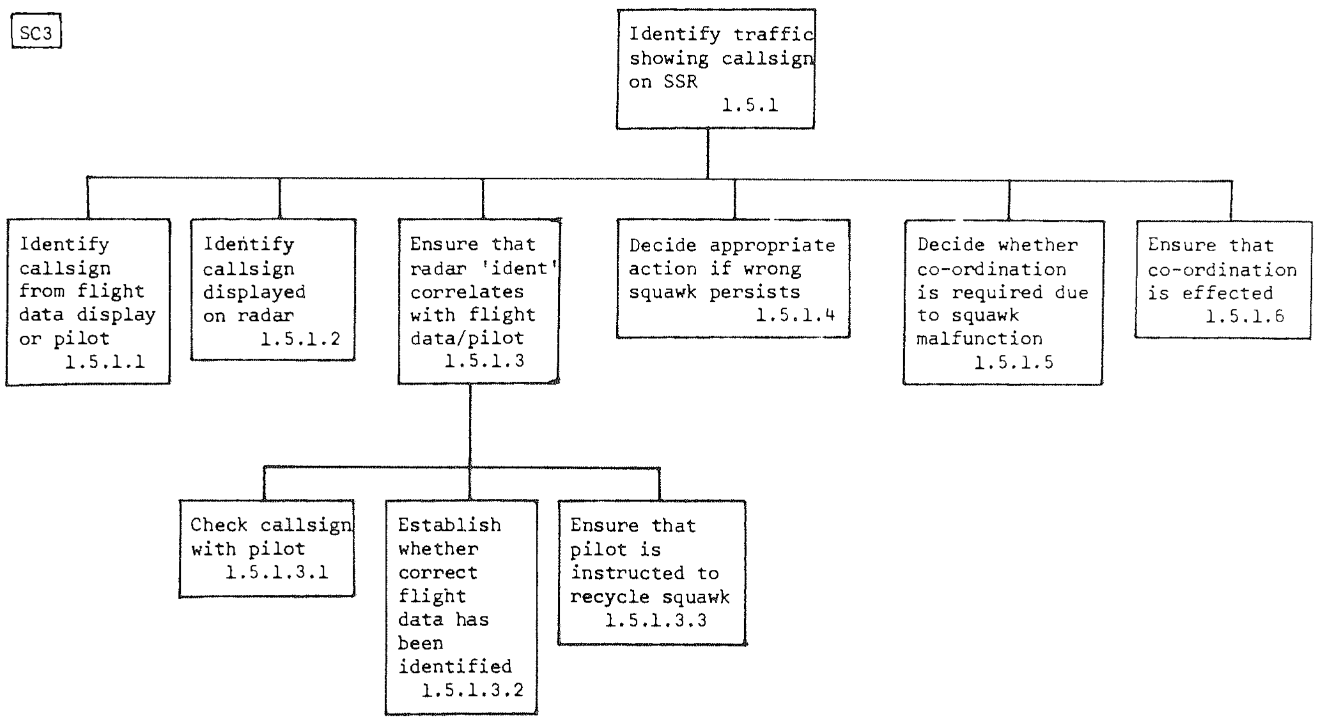
APPENDIX I : Task Analyses - LATCC and Heathrow

RADAR (SECTOR CONTROLLER): LATCC

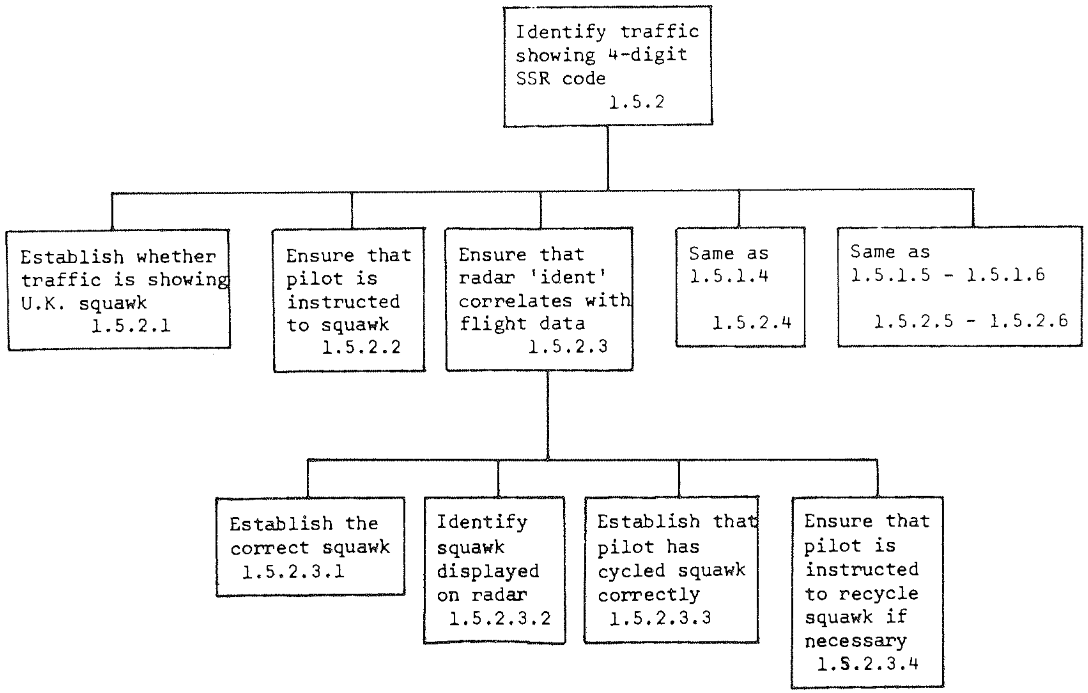

SC1
PROVIDE SAFE, ORDERLY AND EXPEDITIOUS FLOW OF TRAFFIC 1
Ensure that strips are obtained on all relevant traffic 1.1
Ensure that strips are displayed so as to facilitate SC's work 1.2
Identify amendments to strip information e.g. E.T.A.'s 1.3
Ensure that strip amendments are passed to relevant people when appropriate 1.4
Identify traffic calling on frequency 1.5
Decide most suitable solution to traffic situation 1.6
Ensure that traffic receives and adheres to correct instructions 1.7
Ensure that traffic remains safely separated 1.8
SC2
SC7
SC13
SC14
Assess whether solution is expediting 1.9
Ensure that aircraft enquiries are dealt with 1.10
Ensure that traffic is at appropriate level, speed, and on an approved heading for handover 1.11
Ensure that transfer of control and communication is carried out when appropriate 1.12
Ensure that strips are removed from display when appropriate 1.13
SC15
SC19


SC2
Identify traffic calling on frequency 1.5
Identify traffic showing callsign on SSR 1.5.1
Identify traffic showing 4-digit SSR code 1.5.2
Identify traffic by Position Report Method 1.5.3
Identify traffic by Departing Aircraft Method 1.5.4
SC3
SC4
SC5
SC6

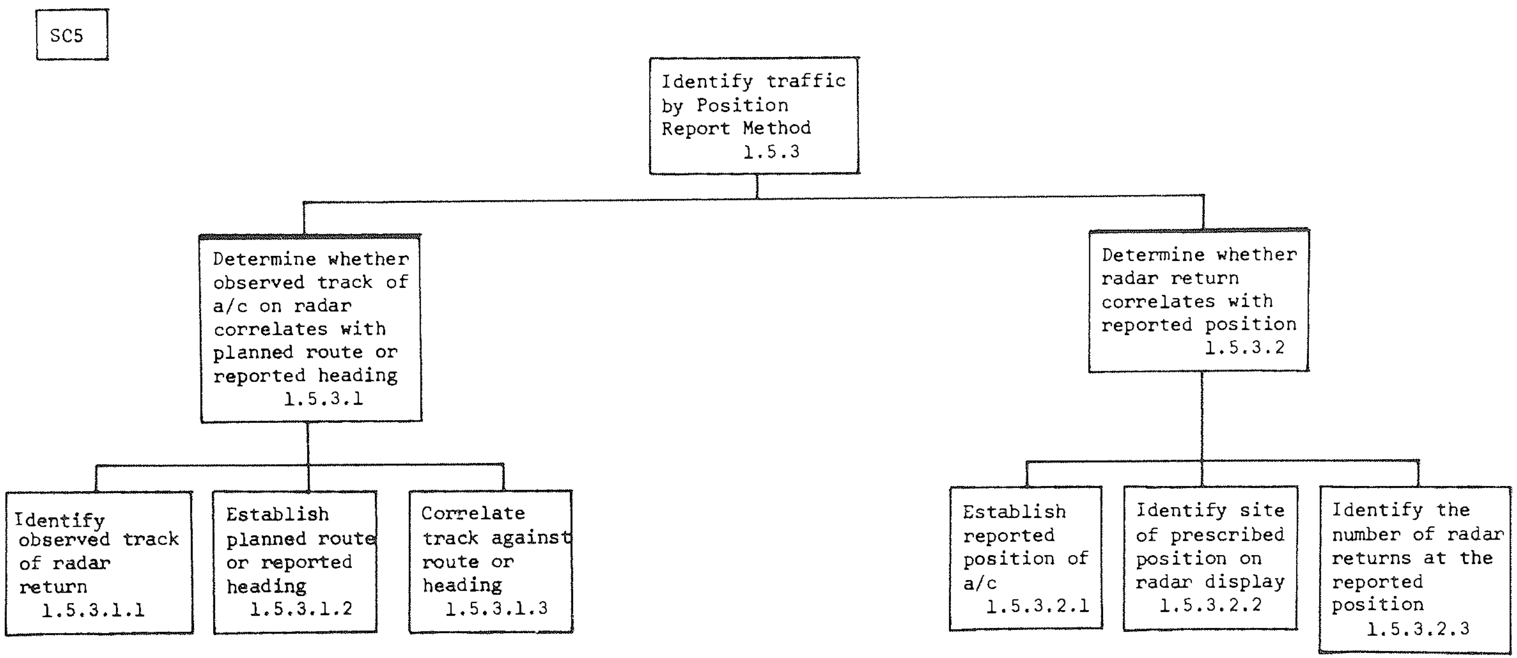
SC3

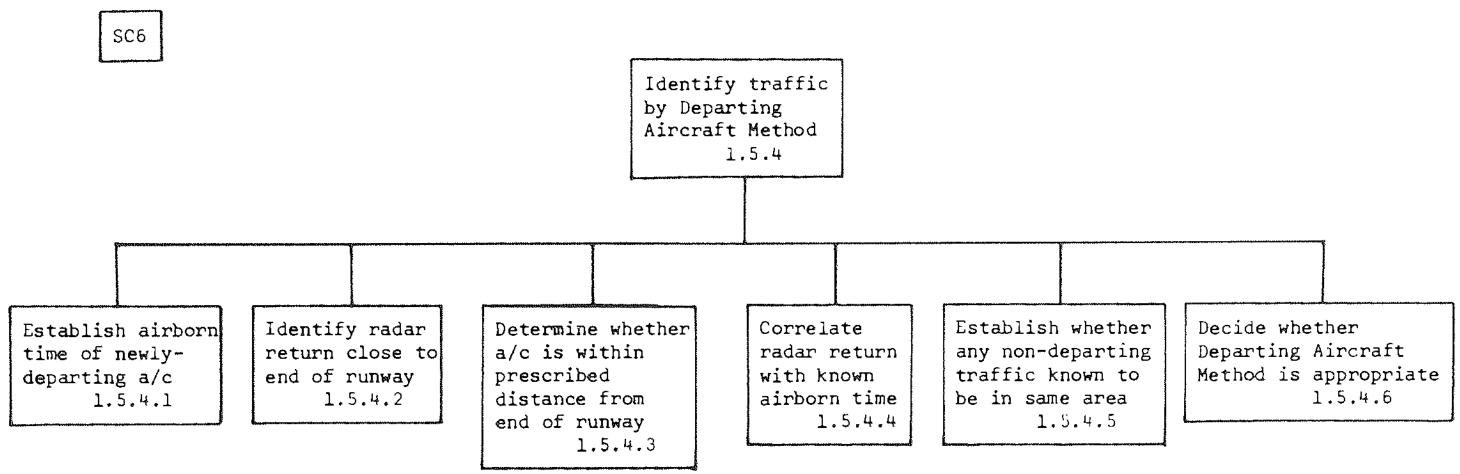

Identify traffic showing callsign on SSR 1.5.1
Identify callsign from flight data display or pilot 1.5.1.1
Identify callsign displayed on radar 1.5.1.2
Ensure that radar 'ident' correlates with flight data/pilot 1.5.1.3
Decide appropriate action if wrong squawk persists 1.5.1.4
Decide whether co-ordination is required due to squawk malfunction 1.5.1.5
Ensure that co-ordination is effected 1.5.1.6
Check callsign with pilot 1.5.1.3.1
Establish whether correct flight data has been identified 1.5.1.3.2
Ensure that pilot is instructed to recycle squawk 1.5.1.3.3

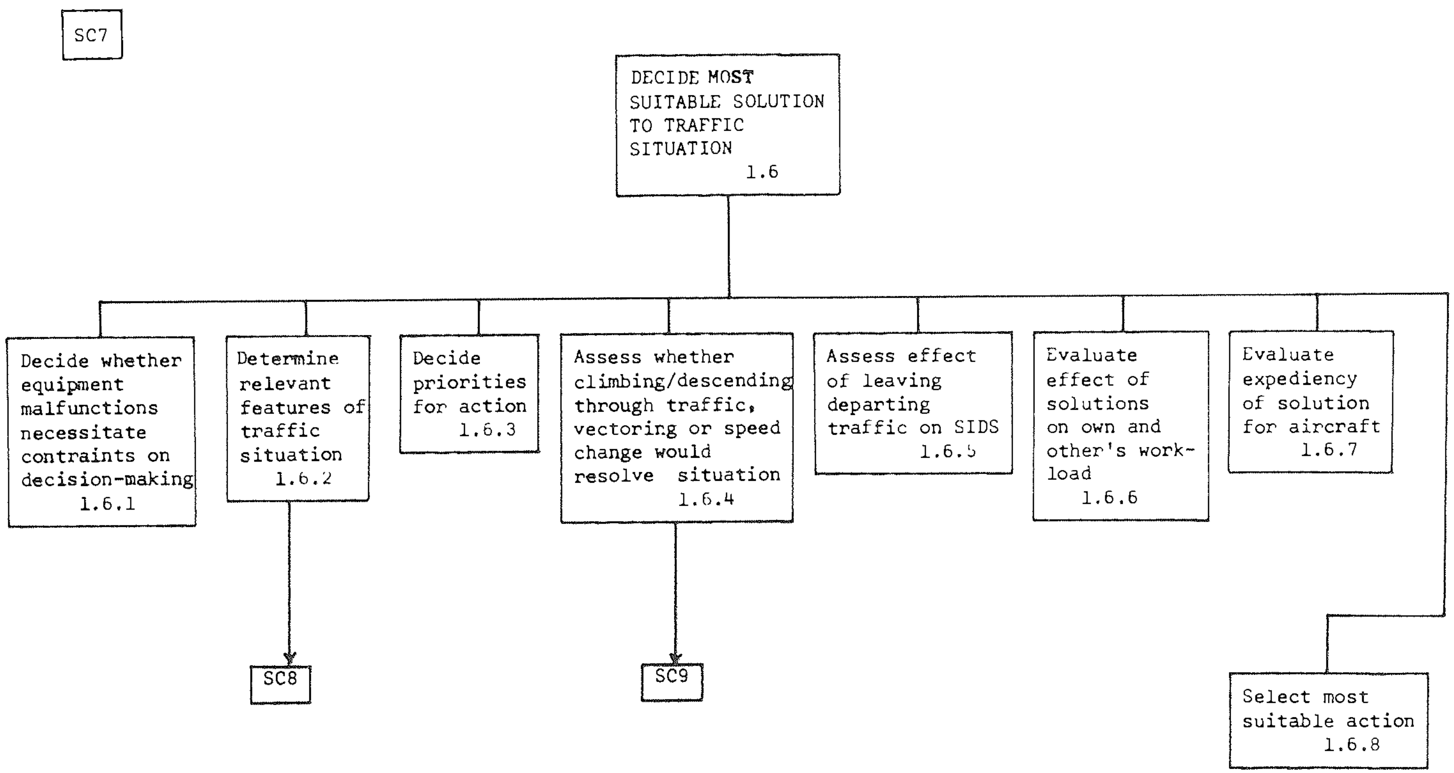
SC4

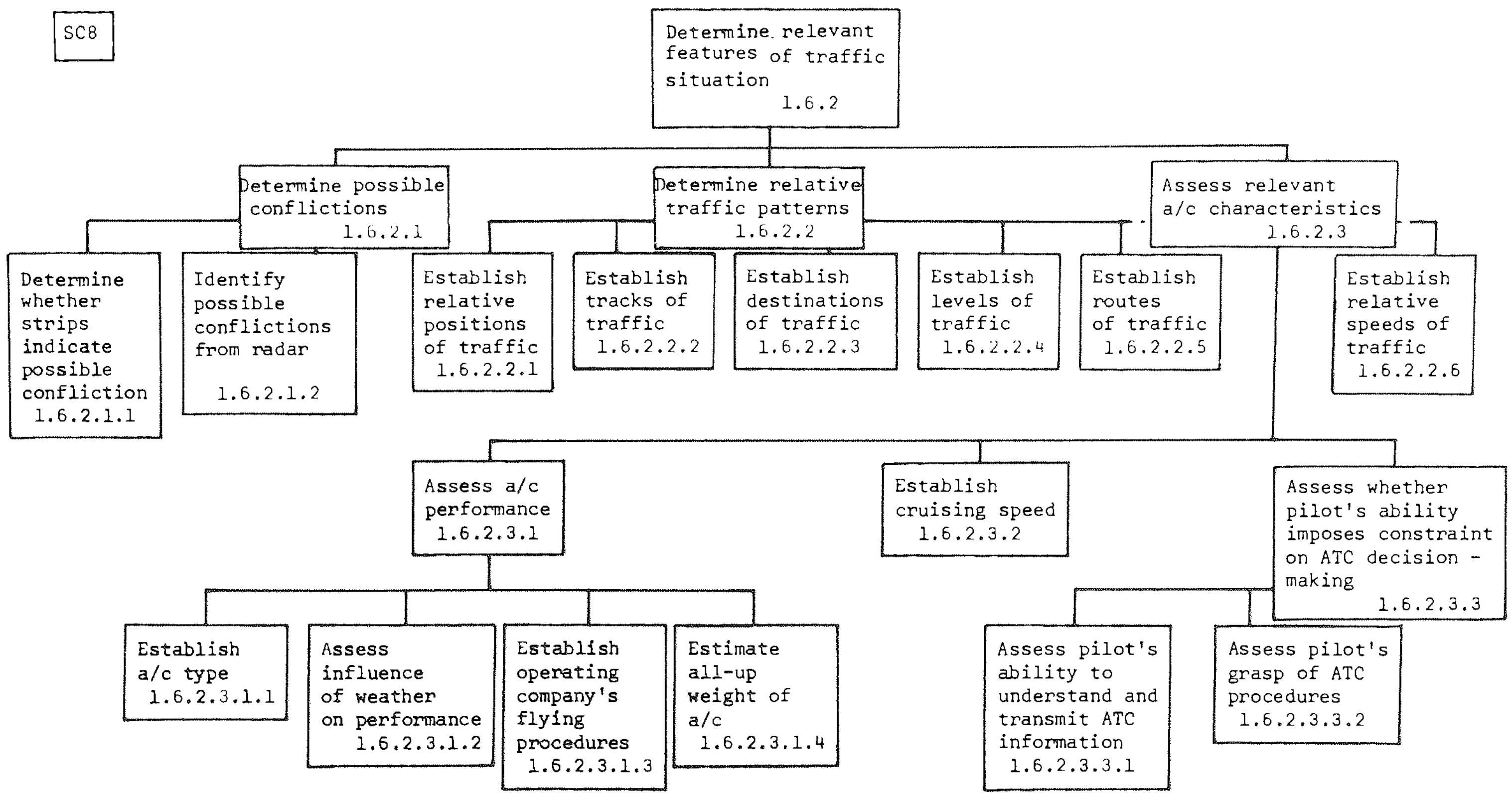


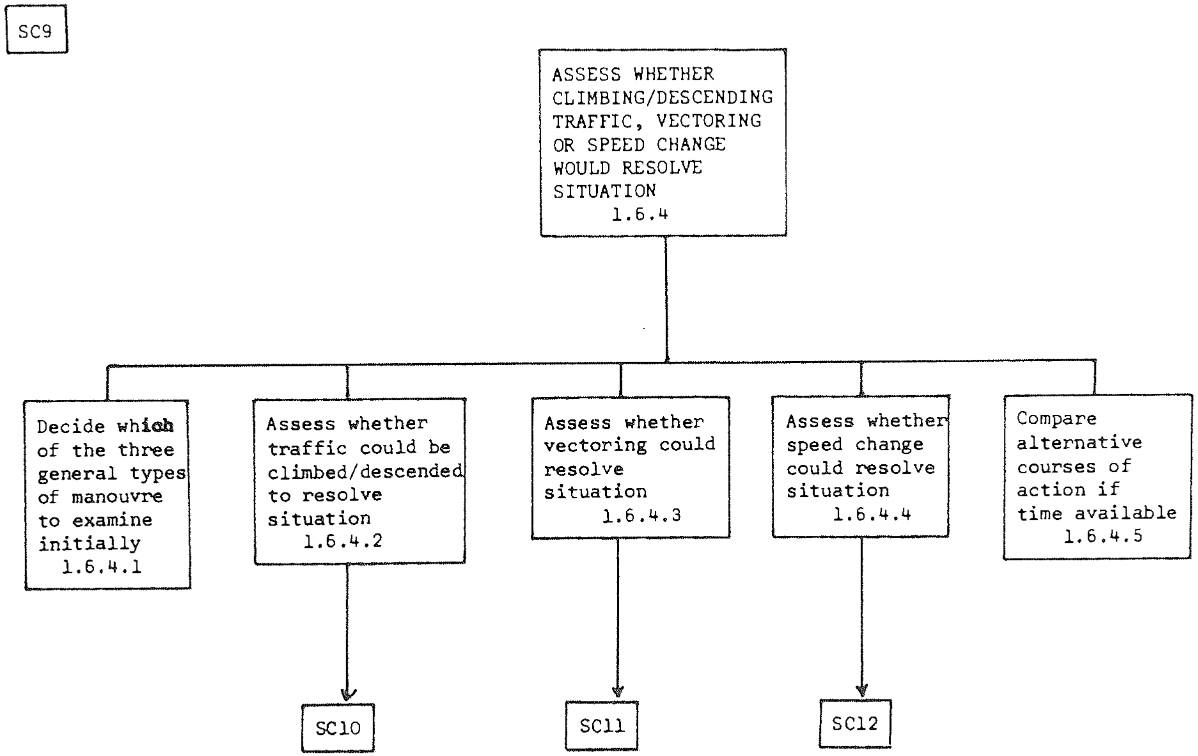
Identify traffic showing 4-digit SSR code 1.5.2
Establish whether traffic is showing U.K. squawk 1.5.2.1
Ensure that pilot is instructed to squawk 1.5.2.2
Ensure that radar 'ident' correlates with flight data 1.5.2.3
Same as 1.5.1.4 1.5.2.4
Same as 1.5.1.5 - 1.5.1.6 1.5.2.5 - 1.5.2.6
Establish the correct squawk 1.5.2.3.1
Identify squawk displayed on radar 1.5.2.3.2
Establish that pilot has cycled squawk correctly 1.5.2.3.3
Ensure that pilot is instructed to recycle squawk if necessary 1.5.2.3.4


SC5
Identify traffic by Position Report Method 1.5.3
Determine whether observed track of a/c on radar correlates with planned route or reported heading 1.5.3.1
Determine whether radar return correlates with reported position 1.5.3.2
Identify observed track of radar return 1.5.3.1.1
Establish planned route or reported heading 1.5.3.1.2
Correlate track against route or heading 1.5.3.1.3
Establish reported position of a/c 1.5.3.2.1
Identify site of prescribed position on radar display 1.5.3.2.2
Identify the number of radar returns at the reported position 1.5.3.2.3

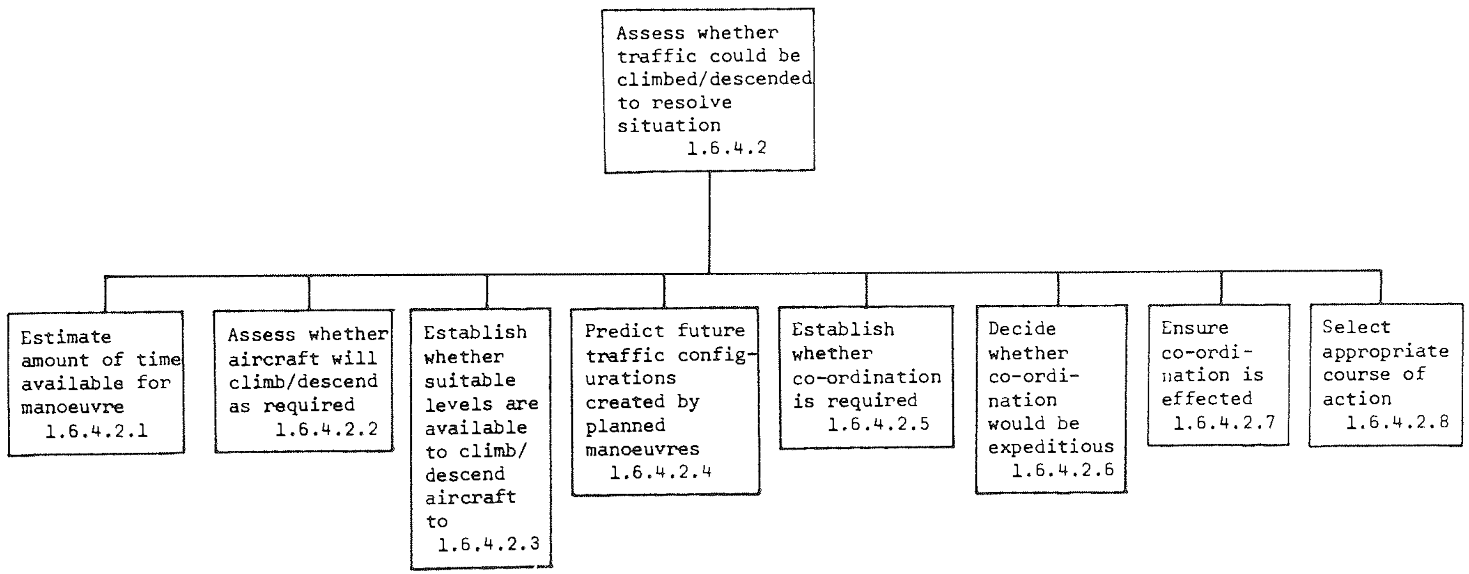

SC6
Identify traffic by Departing Aircraft Method 1.5.4
Establish airborn time of newly-departing a/c 1.5.4.1
Identify radar return close to end of runway 1.5.4.2
Determine whether a/c is within prescribed distance from end of runway 1.5.4.3
Correlate radar return with known airborn time 1.5.4.4
Establish whether any non-departing traffic known to be in same area 1.5.4.5
Decide whether Departing Aircraft Method is appropriate 1.5.4.6


SC7
DECIDE MOST SUITABLE SOLUTION TO TRAFFIC SITUATION 1.6
Decide whether equipment malfunctions necessitate contraints on decision-making 1.6.1
Determine relevant features of traffic situation 1.6.2
SC8
Decide priorities for action 1.6.3
Assess whether climbing/descending through traffic, vectoring or speed change would resolve situation 1.6.4
SC9
Assess effect of leaving departing traffic on SIDS 1.6.5
Evaluate effect of solutions on own and other's work-load 1.6.6
Evaluate expediency of solution for aircraft 1.6.7
Select most suitable action 1.6.8


SC8
Determine relevant features of traffic situation 1.6.2
Determine possible conflictions 1.6.2.1
Determine whether strips indicate possible confliction 1.6.2.1.1
Identify possible conflictions from radar 1.6.2.1.2
Determine relative traffic patterns 1.6.2.2
Establish relative positions of traffic 1.6.2.2.1
Establish tracks of traffic 1.6.2.2.2
Establish destinations of traffic 1.6.2.2.3
Establish levels of traffic 1.6.2.2.4
Establish routes of traffic 1.6.2.2.5
Establish relative speeds of traffic 1.6.2.2.6
Assess relevant a/c characteristics 1.6.2.3
Assess a/c performance 1.6.2.3.1
Establish a/c type 1.6.2.3.1.1
Assess influence of weather on performance 1.6.2.3.1.2
Establish operating company's flying procedures 1.6.2.3.1.3
Estimate all-up weight of a/c 1.6.2.3.1.4
Establish cruising speed 1.6.2.3.2
Assess whether pilot's ability imposes constraint on ATC decision - making 1.6.2.3.3
Assess pilot's ability to understand and transmit ATC information 1.6.2.3.3.1
Assess pilot's grasp of ATC procedures 1.6.2.3.3.2

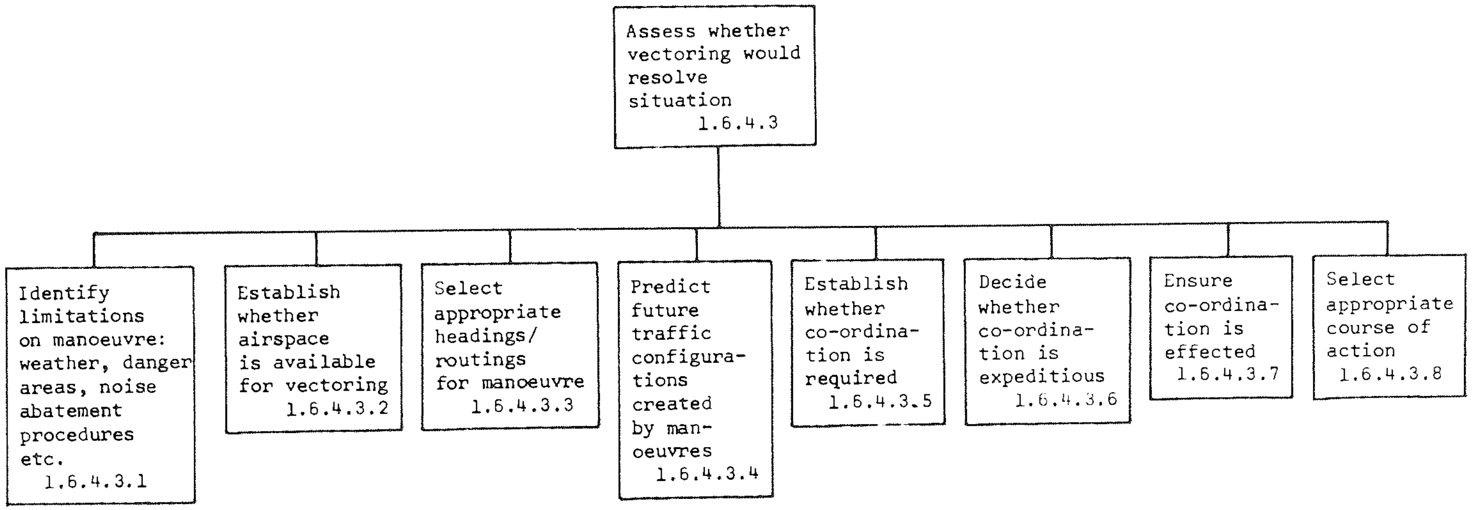

SC9
ASSESS WHETHER CLIMBING/DESCENDING TRAFFIC, VECTORING OR SPEED CHANGE WOULD RESOLVE SITUATION 1.6.4
Decide which of the three general types of manouvre to examine initially 1.6.4.1
Assess whether traffic could be climbed/descended to resolve situation 1.6.4.2
Assess whether vectoring could resolve situation 1.6.4.3
Assess whether speed change could resolve situation 1.6.4.4
Compare alternative courses of action if time available 1.6.4.5
SC10
SC11
SC12

SC10

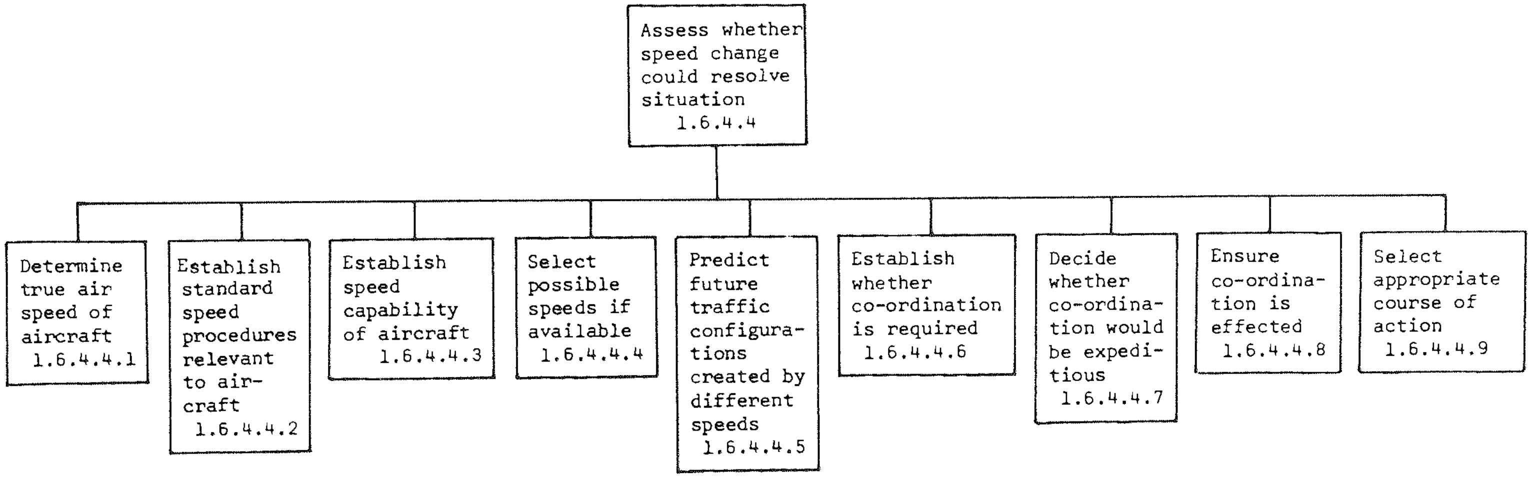


Assess whether traffic could be climbed/descended to resolve situation 1.6.4.2
Estimate amount of time available for manoeuvre 1.6.4.2.1
Assess whether aircraft will climb/descend as required 1.6.4.2.2
Establish whether suitable levels are available to climb/descend aircraft to 1.6.4.2.3
Predict future traffic configurations created by planned manoeuvres 1.6.4.2.4
Establish whether co-ordination is required 1.6.4.2.5
Decide whether co-ordination would be expeditious 1.6.4.2.6
Ensure co-ordination is effected 1.6.4.2.7
Select appropriate course of action 1.6.4.2.8

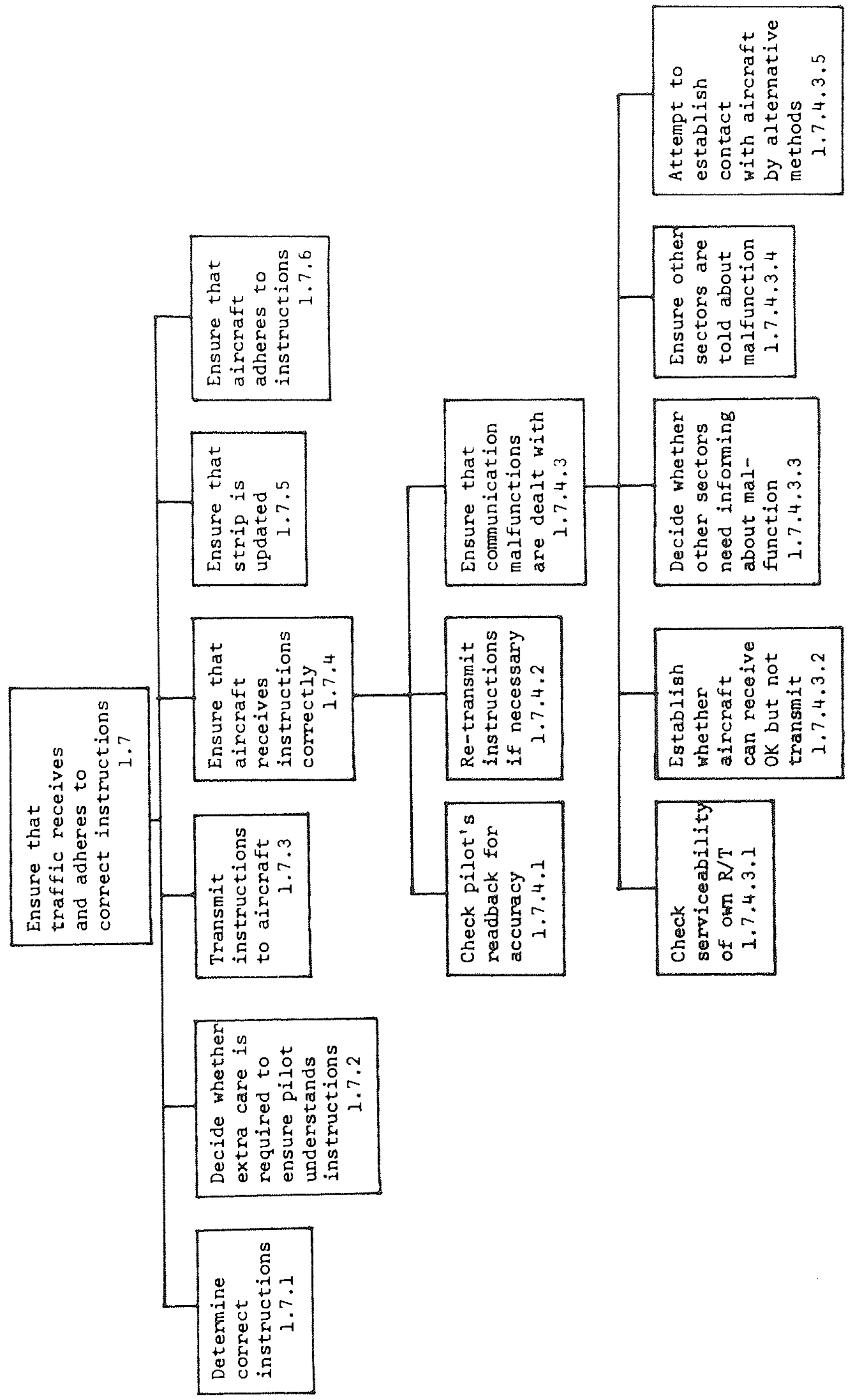
SC11


Assess whether vectoring would resolve situation 1.6.4.3
Identify limitations on manoeuvre: weather, danger areas, noise abatement procedures etc. 1.6.4.3.1
Establish whether airspace is available for vectoring 1.6.4.3.2
Select appropriate headings/ routings for manoeuvre 1.6.4.3.3
Predict future traffic configurations created by manoeuvres 1.6.4.3.4
Establish whether co-ordination is required 1.6.4.3.5
Decide whether co-ordination is expeditious 1.6.4.3.6
Ensure co-ordination is effected 1.6.4.3.7
Select appropriate course of action 1.6.4.3.8

SC12

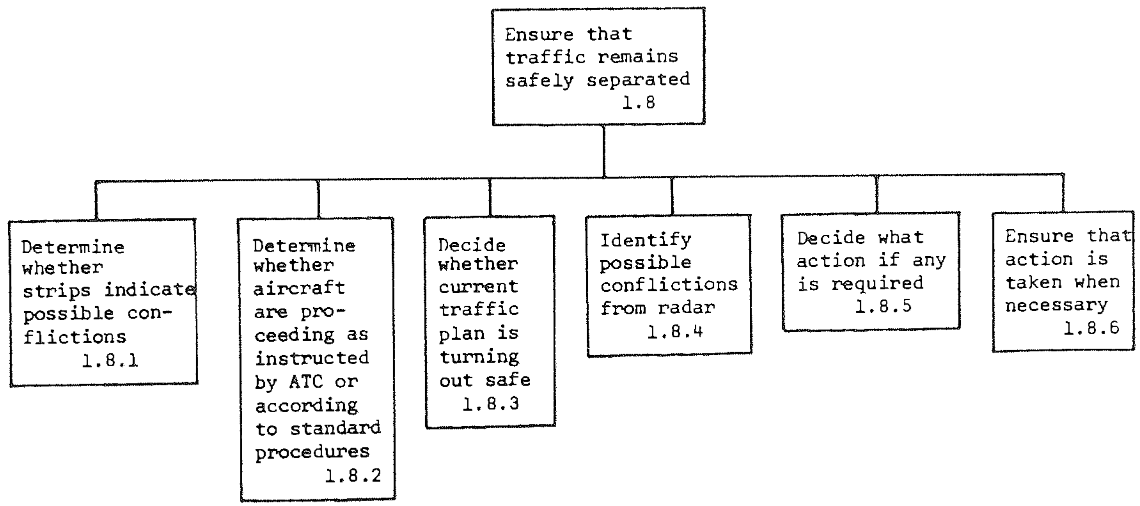

Assess whether speed change could resolve situation 1.6.4.4
Determine true air speed of aircraft 1.6.4.4.1
Establish standard speed procedures relevant to air-craft 1.6.4.4.2
Establish speed capability of aircraft 1.6.4.4.3
Select possible speeds if available 1.6.4.4.4
Predict future traffic configura-tions created by different speeds 1.6.4.4.5
Establish whether co-ordination is required 1.6.4.4.6
Decide whether co-ordina-tion would be expedi-tious 1.6.4.4.7
Ensure co-ordina-tion is effected 1.6.4.4.8
Select appropriate course of action 1.6.4.4.9

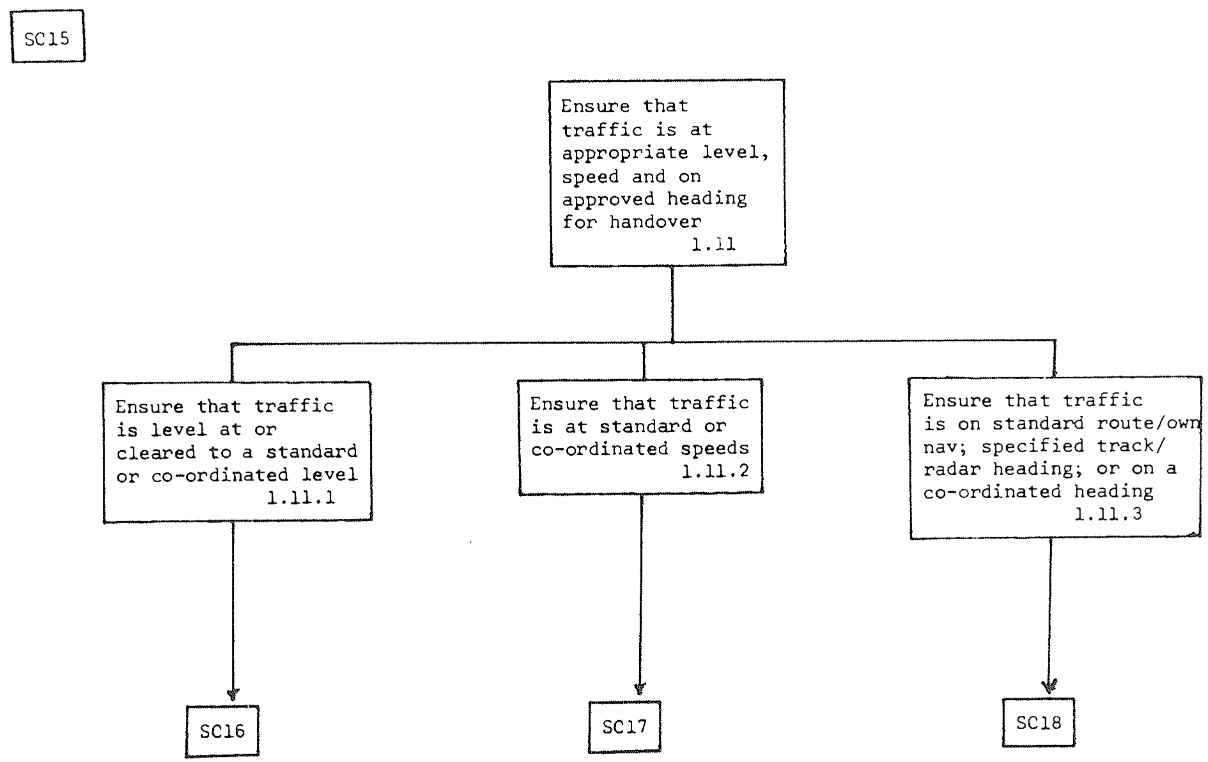
SC13



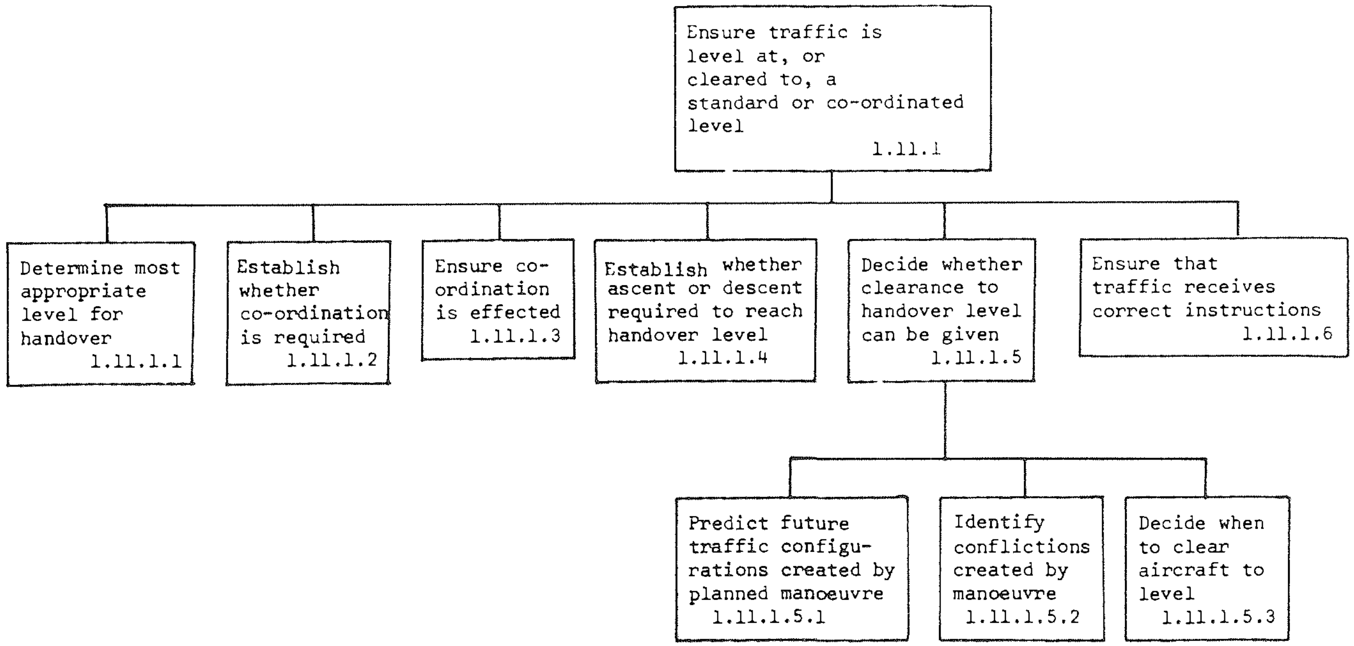
Ensure that traffic receives and adheres to correct instructions 1.7
Determine correct instructions 1.7.1
Decide whether extra care is required to ensure pilot understands instructions 1.7.2
Transmit instructions to aircraft 1.7.3
Ensure that aircraft receives instructions correctly 1.7.4
Ensure that strip is updated 1.7.5
Ensure that aircraft adheres to instructions 1.7.6
Check pilot's readback for accuracy 1.7.4.1
Re-transmit instructions if necessary 1.7.4.2
Ensure that communication malfunctions are dealt with 1.7.4.3
Check serviceability of own R/T 1.7.4.3.1
Establish whether aircraft can receive OK but not transmit 1.7.4.3.2
Decide whether other sectors need informing about mal-function 1.7.4.3.3
Ensure other sectors are told about malfunction 1.7.4.3.4
Attempt to establish contact with aircraft by alternative methods 1.7.4.3.5

SC14


Ensure that traffic remains safely separated 1.8
Determine whether strips indicate possible conflictions 1.8.1
Determine whether aircraft are proceeding as instructed by ATC or according to standard procedures 1.8.2
Decide whether current traffic plan is turning out safe 1.8.3
Identify possible conflictions from radar 1.8.4
Decide what action if any is required 1.8.5
Ensure that action is taken when necessary 1.8.6

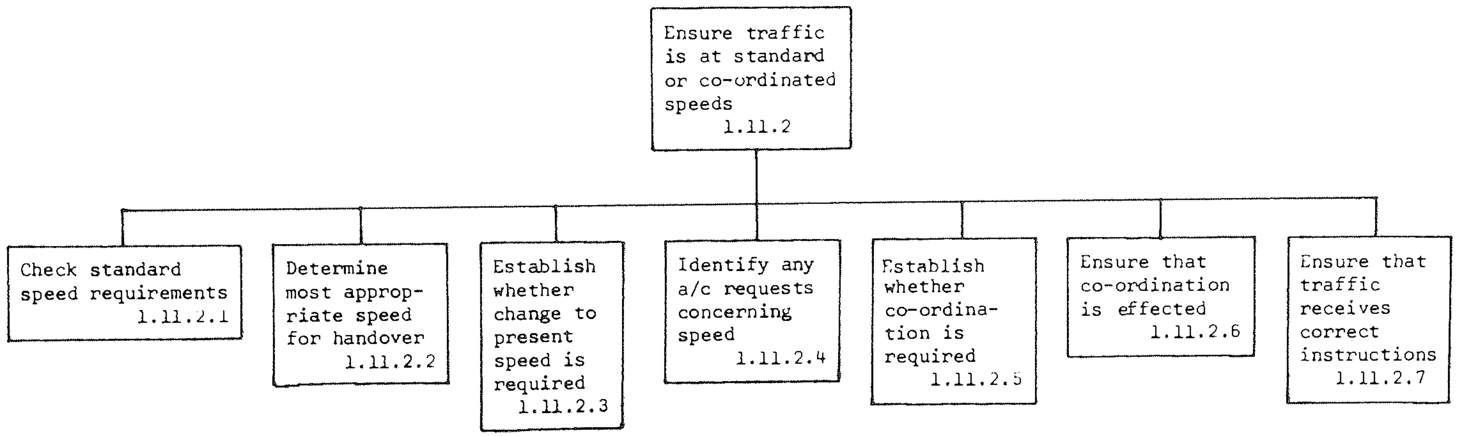

SC15
Ensure that traffic is at appropriate level, speed and on approved heading for handover 1.11
Ensure that traffic is level at or cleared to a standard or co-ordinated level 1.11.1
Ensure that traffic is at standard or co-ordinated speeds 1.11.2
Ensure that traffic is on standard route/own nav; specified track/ radar heading; or on a co-ordinated heading 1.11.3
SC16
SC17
SC18

SC16



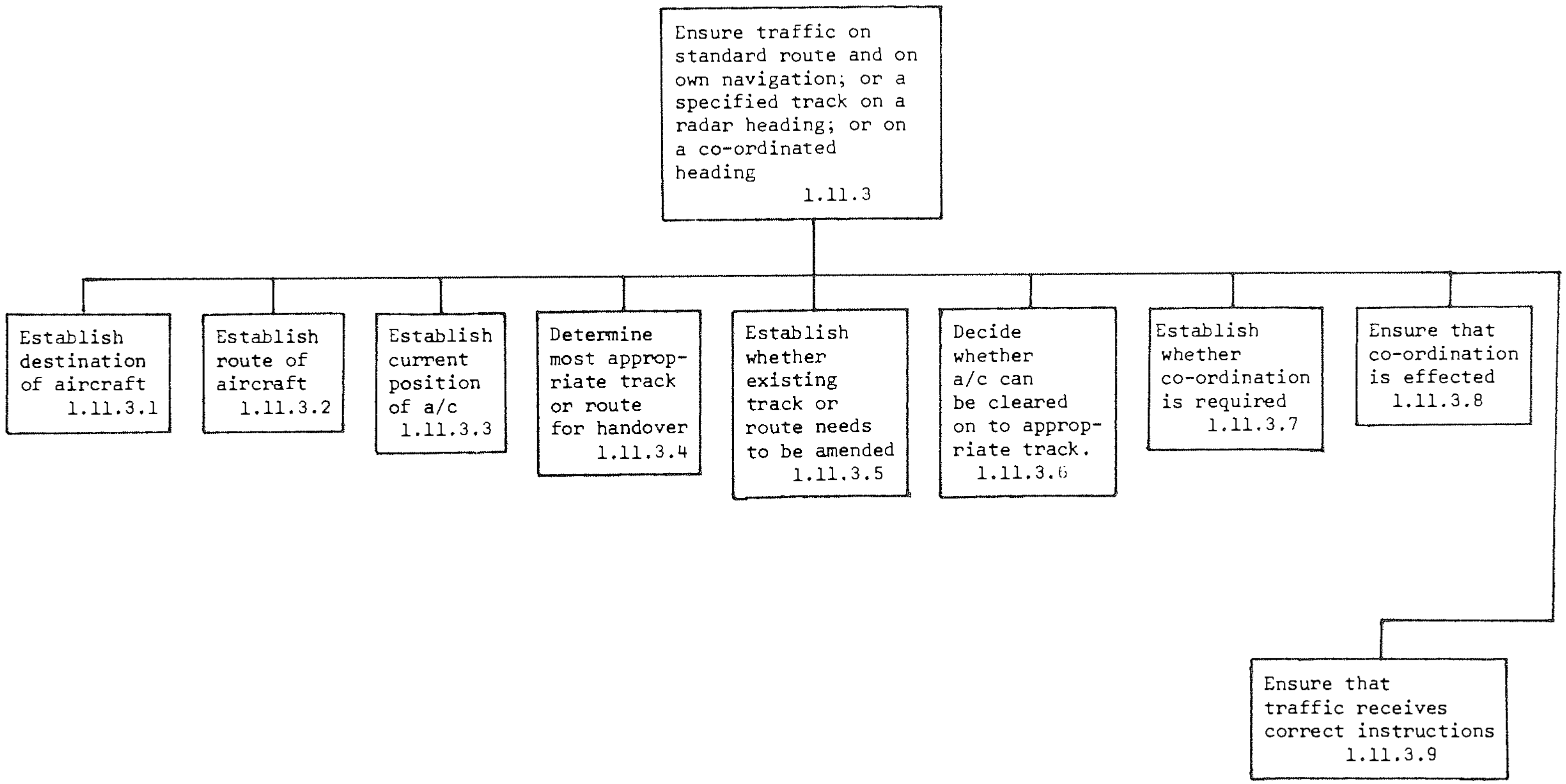
Ensure traffic is level at, or cleared to, a standard or co-ordinated level 1.11.1
Determine most appropriate level for handover 1.11.1.1
Establish whether co-ordination is required 1.11.1.2
Ensure co-ordination is effected 1.11.1.3
Establish whether ascent or descent required to reach handover level 1.11.1.4
Decide whether clearance to handover level can be given 1.11.1.5
Ensure that traffic receives correct instructions 1.11.1.6
Predict future traffic configurations created by planned manoeuvre 1.11.1.5.1
Identify conflictions created by manoeuvre 1.11.1.5.2
Decide when to clear aircraft to level 1.11.1.5.3

SC17

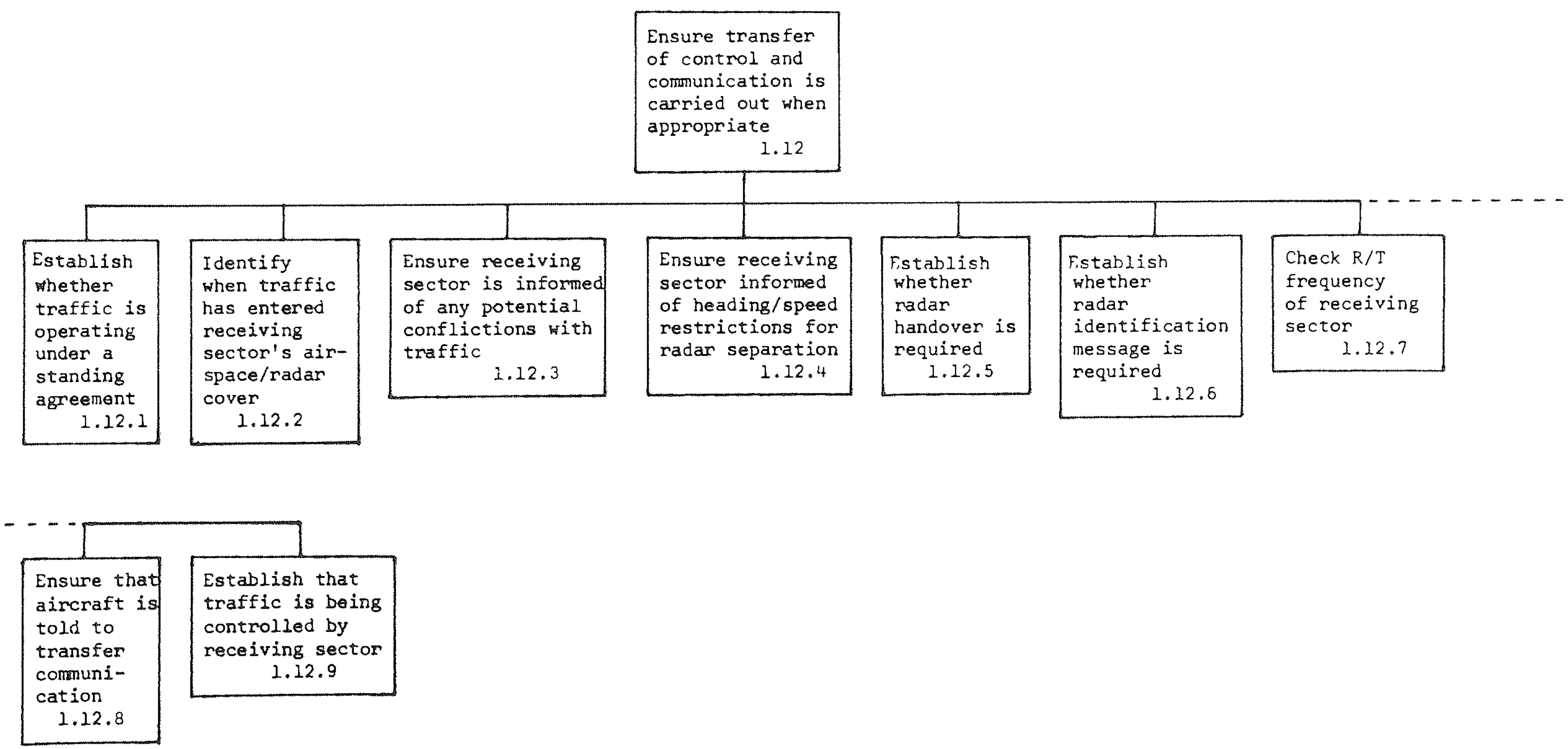


Ensure traffic is at standard or co-ordinated speeds 1.11.2
Check standard speed requirements 1.11.2.1
Determine most approp-riate speed for handover 1.11.2.2
Establish whether change to present speed is required 1.11.2.3
Identify any a/c requests concerning speed 1.11.2.4
Establish whether co-ordina-tion is required 1.11.2.5
Ensure that co-ordination is effected 1.11.2.6
Ensure that traffic receives correct instructions 1.11.2.7

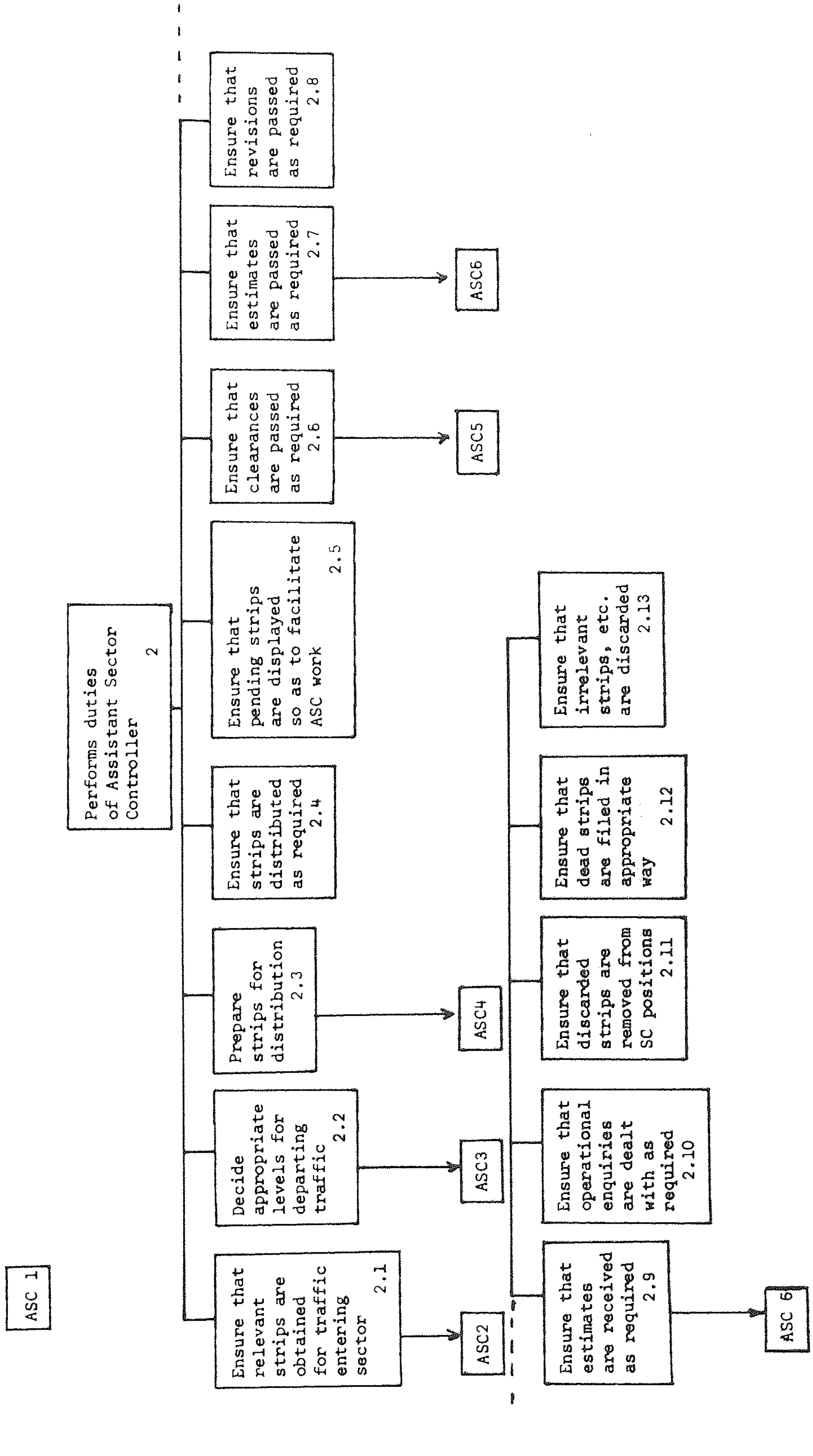
SC18


Ensure traffic on standard route and on own navigation; or a specified track on a radar heading; or on a co-ordinated heading 1.11.3
Establish destination of aircraft 1.11.3.1
Establish route of aircraft 1.11.3.2
Establish current position of a/c 1.11.3.3
Determine most approp-riate track or route for handover 1.11.3.4
Establish whether existing track or route needs to be amended 1.11.3.5
Decide whether a/c can be cleared on to approp-riate track. 1.11.3.6
Establish whether co-ordination is required 1.11.3.7
Ensure that co-ordination is effected 1.11.3.8
Ensure that traffic receives correct instructions 1.11.3.9

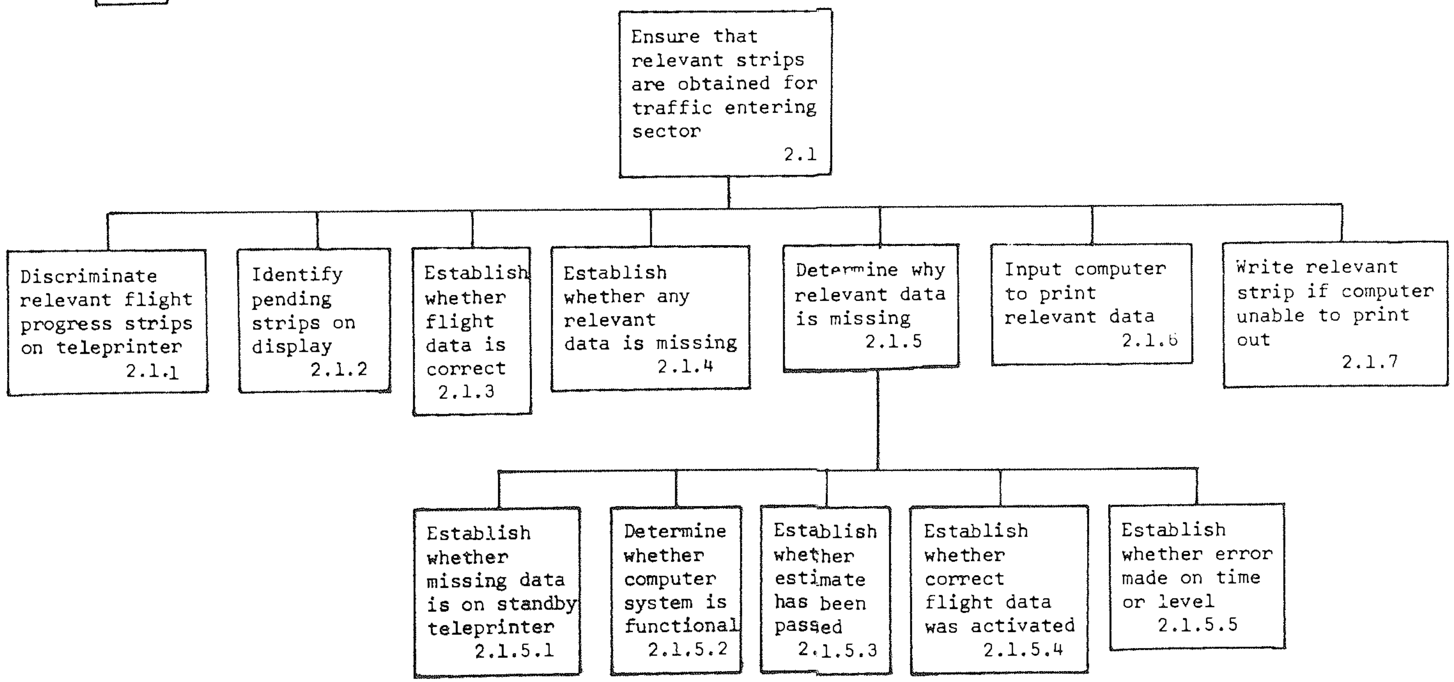
SC19

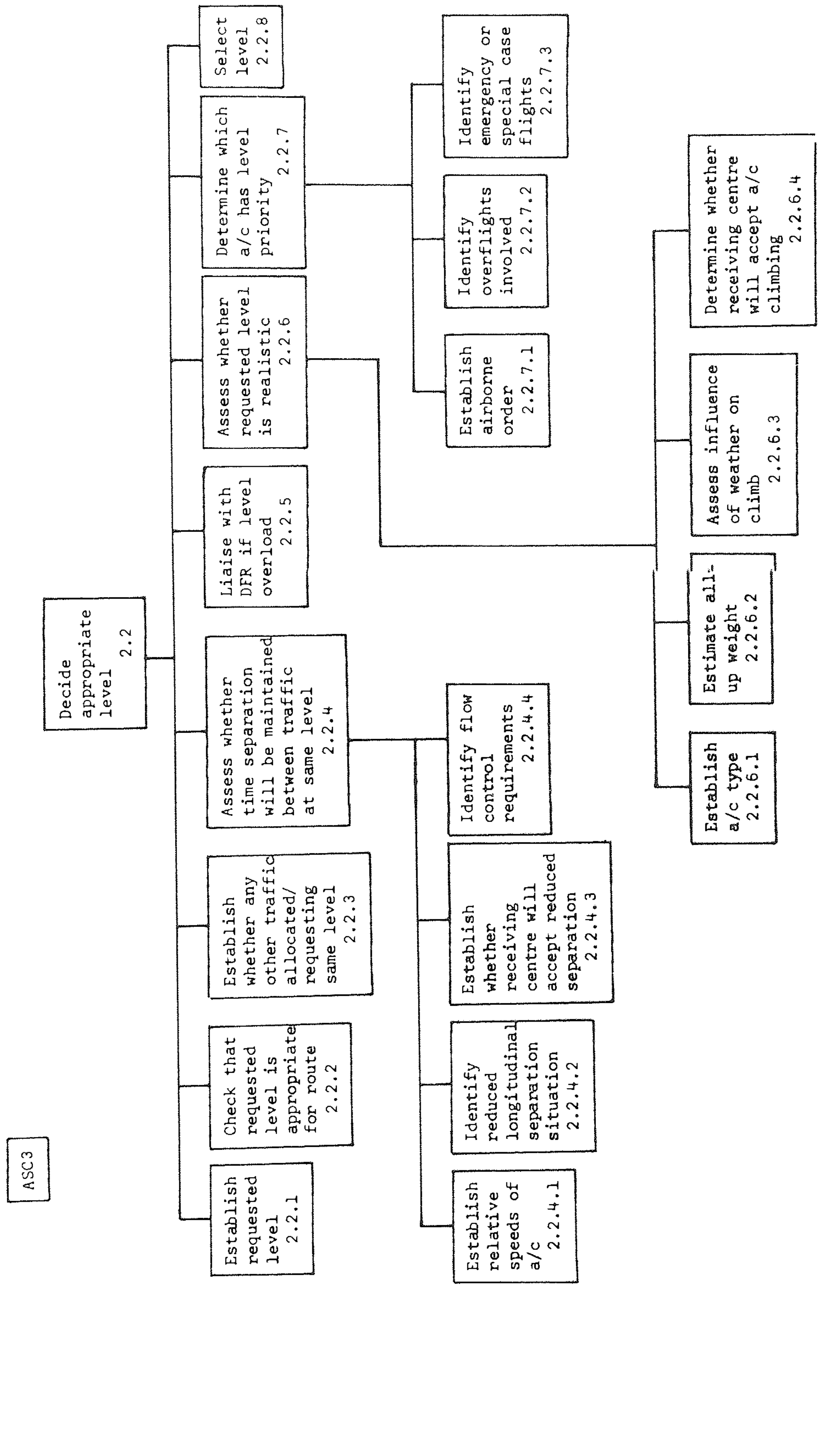

Ensure transfer of control and communication is carried out when appropriate 1.12
Establish whether traffic is operating under a standing agreement 1.12.1
Identify when traffic has entered receiving sector's air-space/radar cover 1.12.2
Ensure receiving sector is informed of any potential conflictions with traffic 1.12.3
Ensure receiving sector informed of heading/speed restrictions for radar separation 1.12.4
Establish whether radar handover is required 1.12.5
Establish whether radar identification message is required 1.12.6
Check R/T frequency of receiving sector 1.12.7
Ensure that aircraft is told to transfer communi-cation 1.12.8
Establish that traffic is being controlled by receiving sector 1.12.9

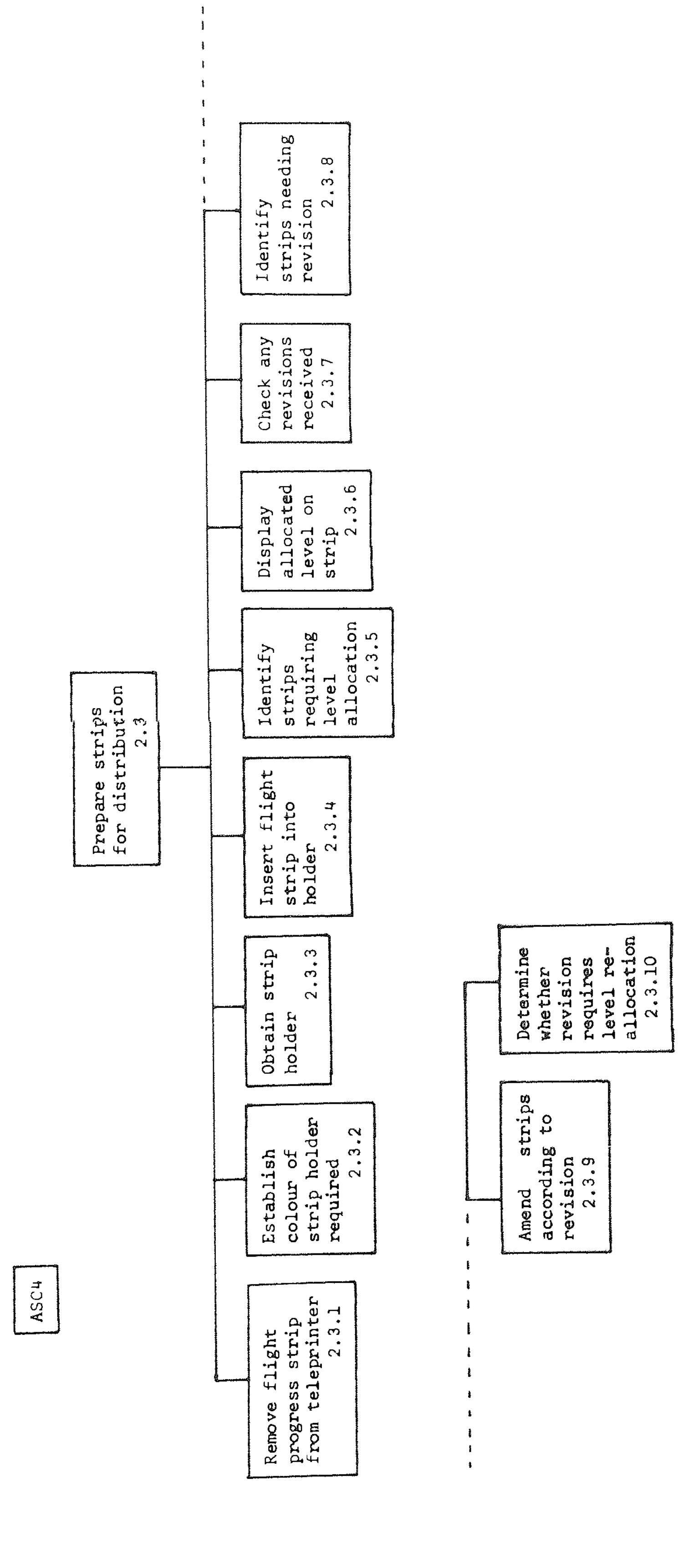
WING MAN (ASSISTANT SECTOR CONTROLLER): LATCC


ASC 1
Performs duties of Assistant Sector Controller 2
Ensure that relevant strips are obtained for traffic entering sector 2.1
Decide appropriate levels for departing traffic 2.2
Prepare strips for distribution 2.3
Ensure that strips are distributed as required 2.4
Ensure that pending strips are displayed so as to facilitate ASC work 2.5
Ensure that clearances are passed as required 2.6
Ensure that estimates are passed as required 2.7
Ensure that revisions are passed as required 2.8
ASC2
ASC3
ASC4
ASC5
ASC6
Ensure that estimates are received as required 2.9
Ensure that operational enquiries are dealt with as required 2.10
Ensure that discarded strips are removed from SC positions 2.11
Ensure that dead strips are filed in appropriate way 2.12
Ensure that irrelevant strips, etc. are discarded 2.13
ASC 6

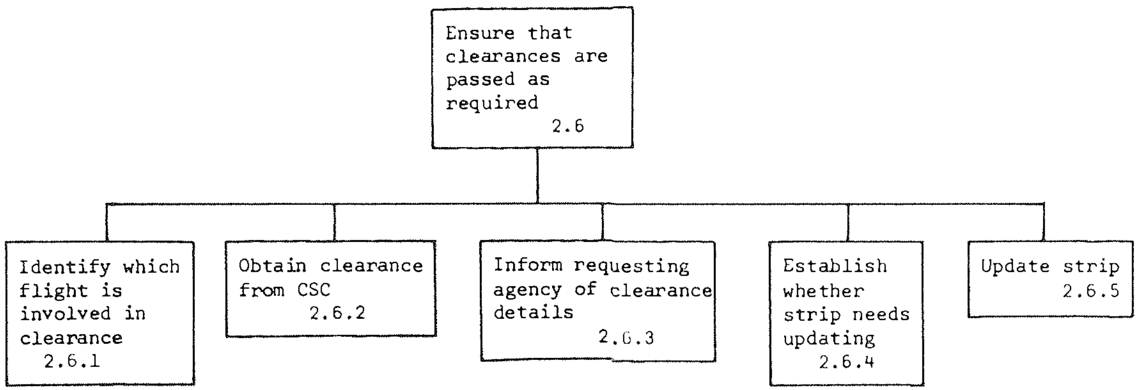
ASC2

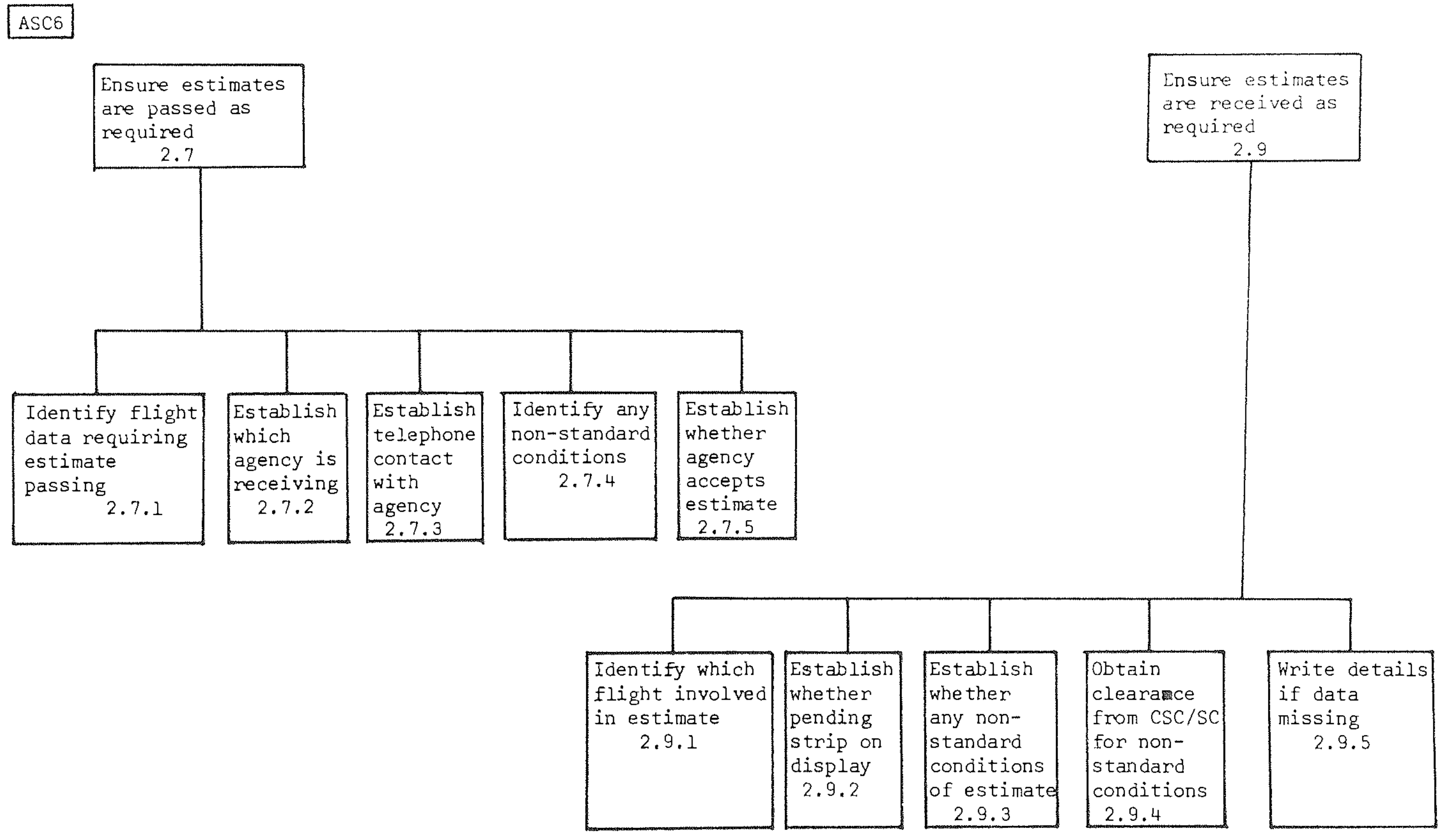

Ensure that relevant strips are obtained for traffic entering sector 2.1
Discriminate relevant flight progress strips on teleprinter 2.1.1
Identify pending strips on display 2.1.2
Establish whether flight data is correct 2.1.3
Establish whether any relevant data is missing 2.1.4
Determine why relevant data is missing 2.1.5
Input computer to print relevant data 2.1.6
Write relevant strip if computer unable to print out 2.1.7
Establish whether missing data is on standby teleprinter 2.1.5.1
Determine whether computer system is functional 2.1.5.2
Establish whether estimate has been passed 2.1.5.3
Establish whether correct flight data was activated 2.1.5.4
Establish whether error made on time or level 2.1.5.5


ASC3
Decide appropriate level 2.2
Establish requested level 2.2.1
Check that requested level is appropriate for route 2.2.2
Establish whether any other traffic allocated/ requesting same level 2.2.3
Assess whether time separation will be maintained between traffic at same level 2.2.4
Liaise with DFR if level overload 2.2.5
Assess whether requested level is realistic 2.2.6
Determine which a/c has level priority 2.2.7
Select level 2.2.8
Establish relative speeds of a/c 2.2.4.1
Identify reduced longitudinal separation situation 2.2.4.2
Establish whether receiving centre will accept reduced separation 2.2.4.3
Identify flow control requirements 2.2.4.4
Establish a/c type 2.2.6.1
Estimate all-up weight 2.2.6.2
Assess influence of weather on climb 2.2.6.3
Determine whether receiving centre will accept a/c climbing 2.2.6.4
Establish airborne order 2.2.7.1
Identify overflights involved 2.2.7.2
Identify emergency or special case flights 2.2.7.3


ASC4
Prepare strips for distribution 2.3
Remove flight progress strip from teleprinter 2.3.1
Establish colour of strip holder required 2.3.2
Obtain strip holder 2.3.3
Insert flight strip into holder 2.3.4
Identify strips requiring level allocation 2.3.5
Display allocated level on strip 2.3.6
Check any revisions received 2.3.7
Identify strips needing revision 2.3.8
Amend strips according to revision 2.3.9
Determine whether revision requires level re-allocation 2.3.10

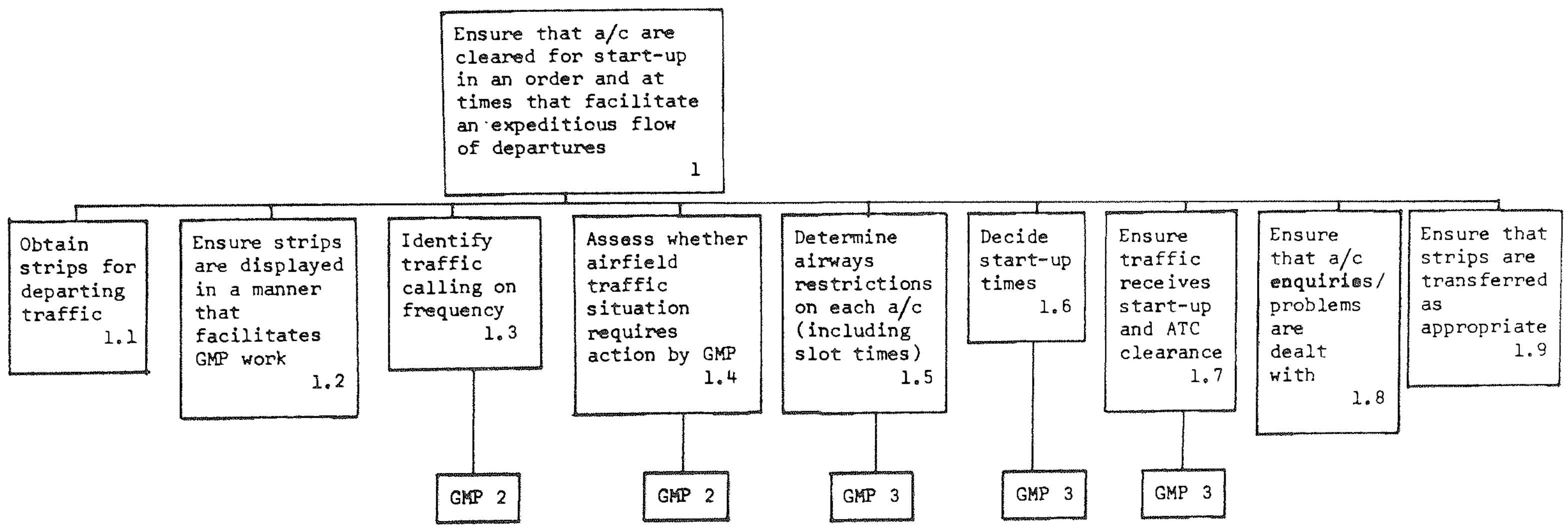
ASC5

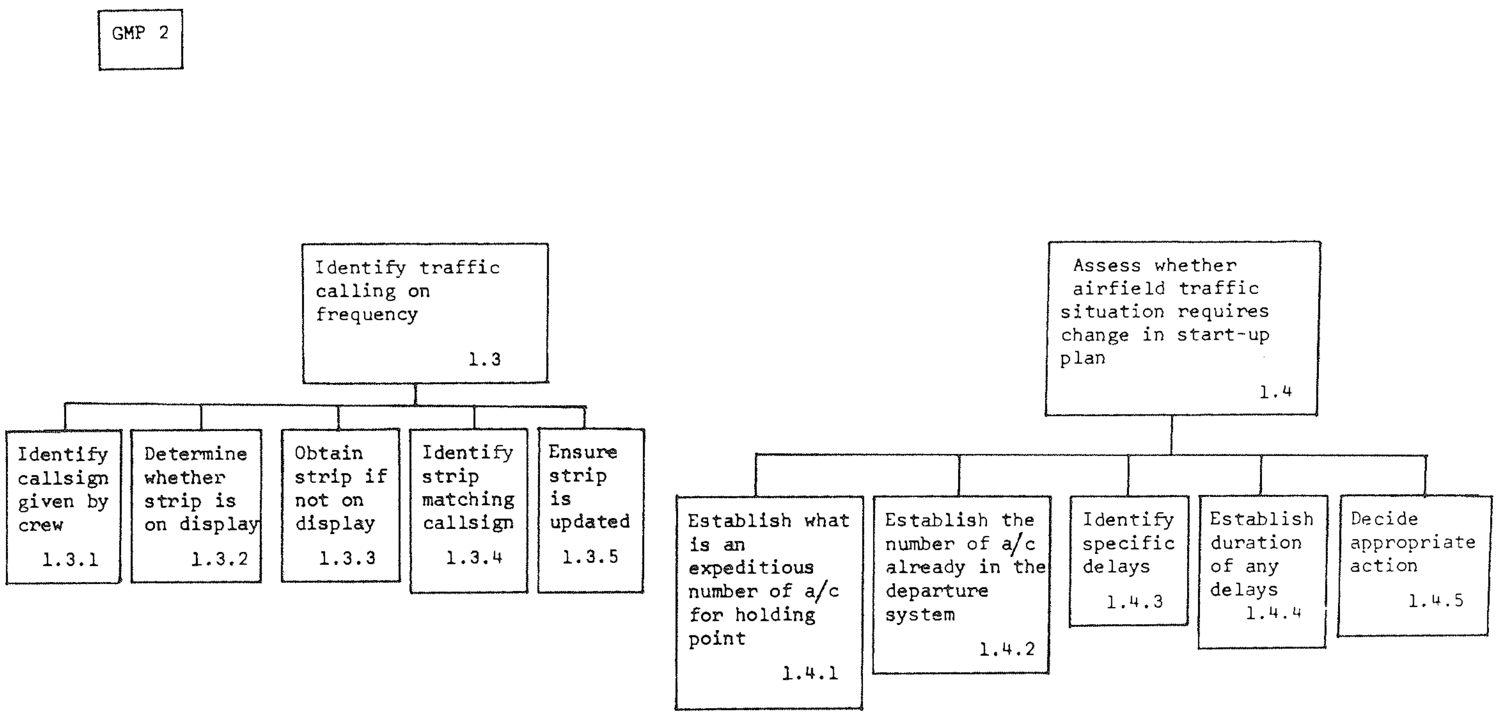

Ensure that clearances are passed as required 2.6
Identify which flight is involved in clearance 2.6.1
Obtain clearance from CSC 2.6.2
Inform requesting agency of clearance details 2.6.3
Establish whether strip needs updating 2.6.4
Update strip 2.6.5


ASC6
Ensure estimates are passed as required 2.7
Identify flight data requiring estimate passing 2.7.1
Establish which agency is receiving 2.7.2
Establish telephone contact with agency 2.7.3
Identify any non-standard conditions 2.7.4
Establish whether agency accepts estimate 2.7.5
Ensure estimates are received as required 2.9
Identify which flight involved in estimate 2.9.1
Establish whether pending strip on display 2.9.2
Establish whether any non-standard conditions of estimate 2.9.3
Obtain clearance from CSC/SC for non-standard conditions 2.9.4
Write details if data missing 2.9.5

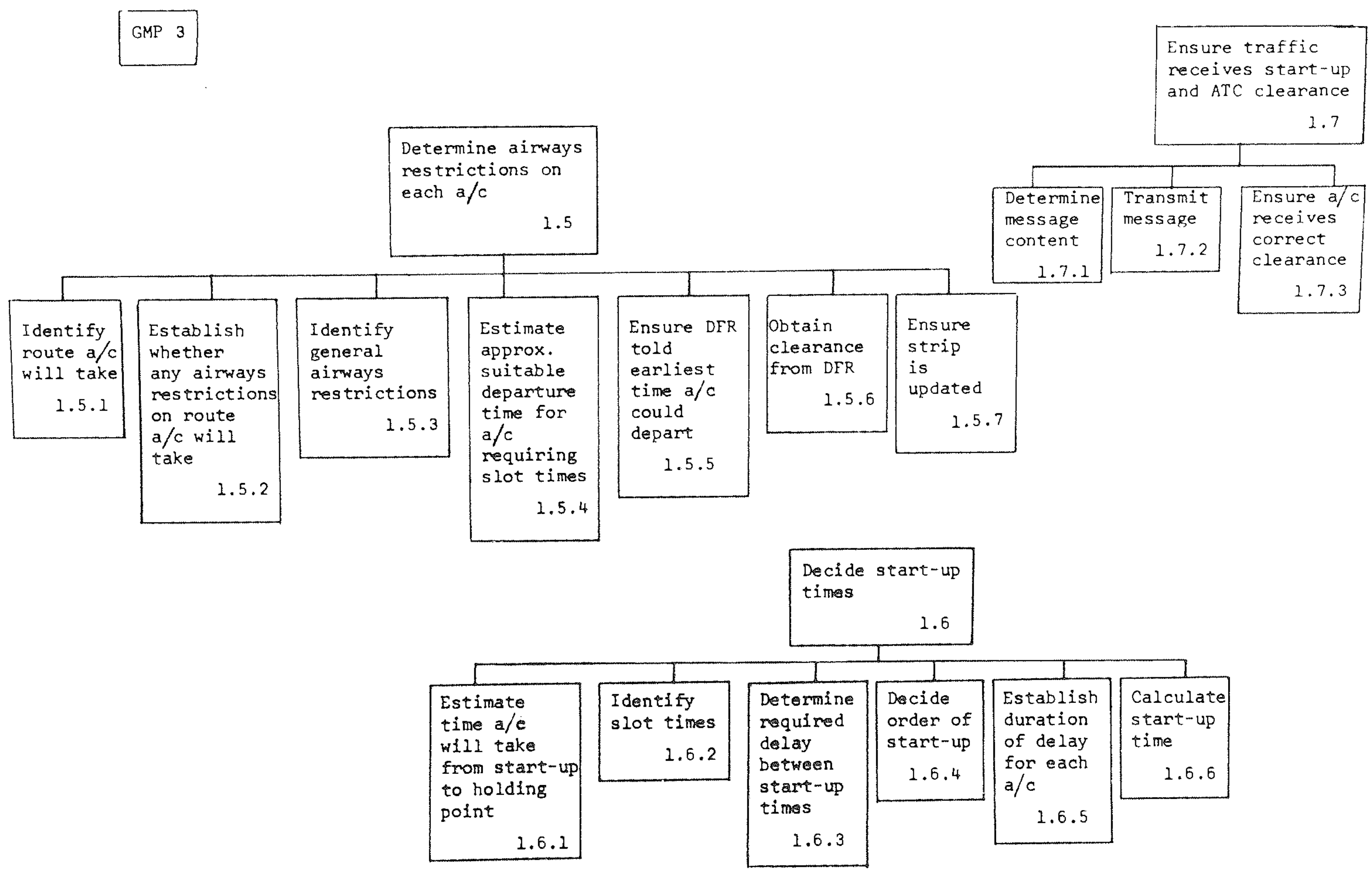
GROUND MOVEMENT PLANNER

GMP 1

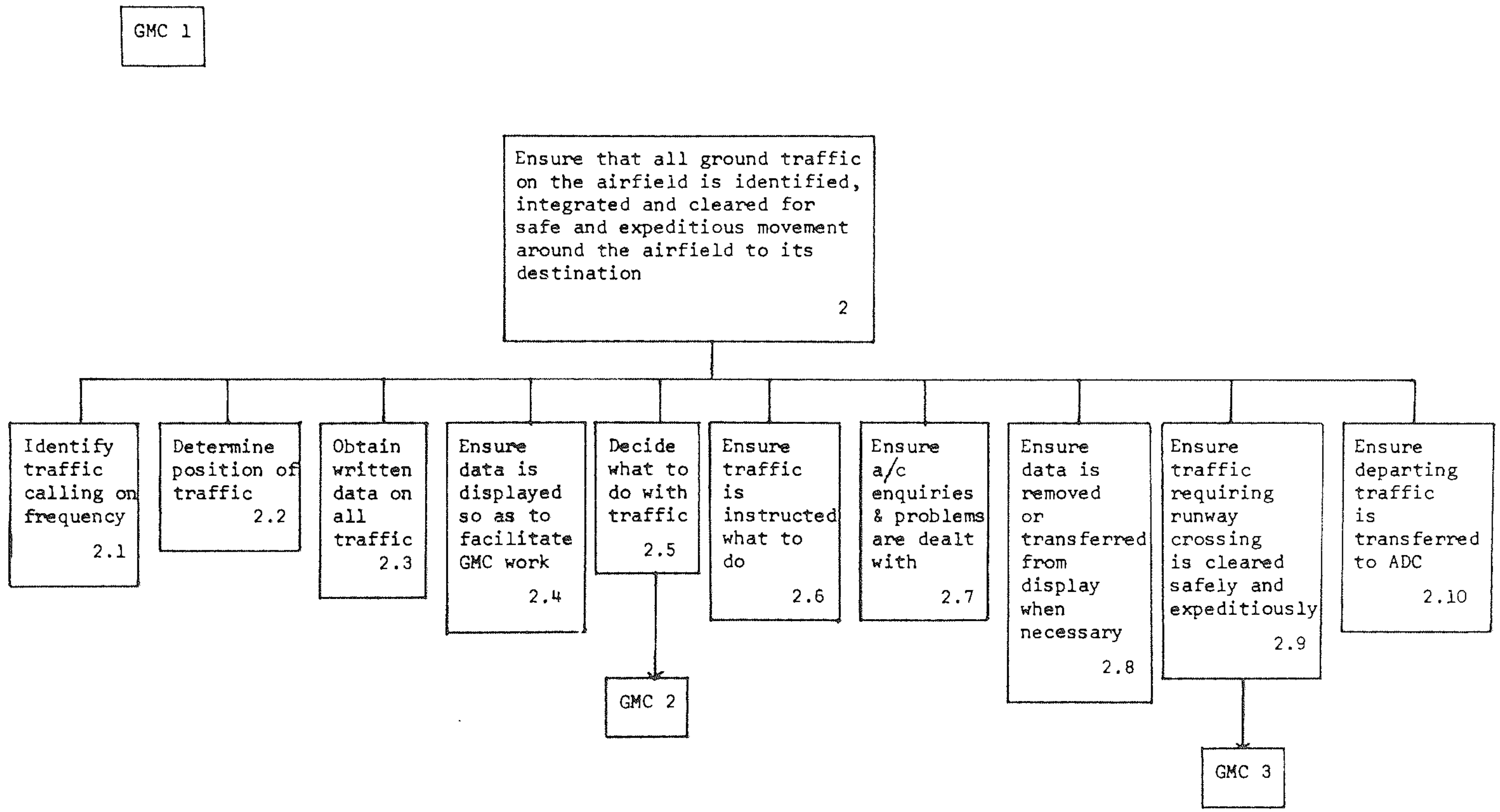

Ensure that a/c are cleared for start-up in an order and at times that facilitate an expeditious flow of departures 1
Obtain strips for departing traffic 1.1
Ensure strips are displayed in a manner that facilitates GMP work 1.2
Identify traffic calling on frequency 1.3
Assess whether airfield traffic situation requires action by GMP 1.4
Determine airways restrictions on each a/c (including slot times) 1.5
Decide start-up times 1.6
Ensure traffic receives start-up and ATC clearance 1.7
Ensure that a/c enquiries/ problems are dealt with 1.8
Ensure that strips are transferred as appropriate 1.9
GMP 2
GMP 2
GMP 3
GMP 3
GMP 3



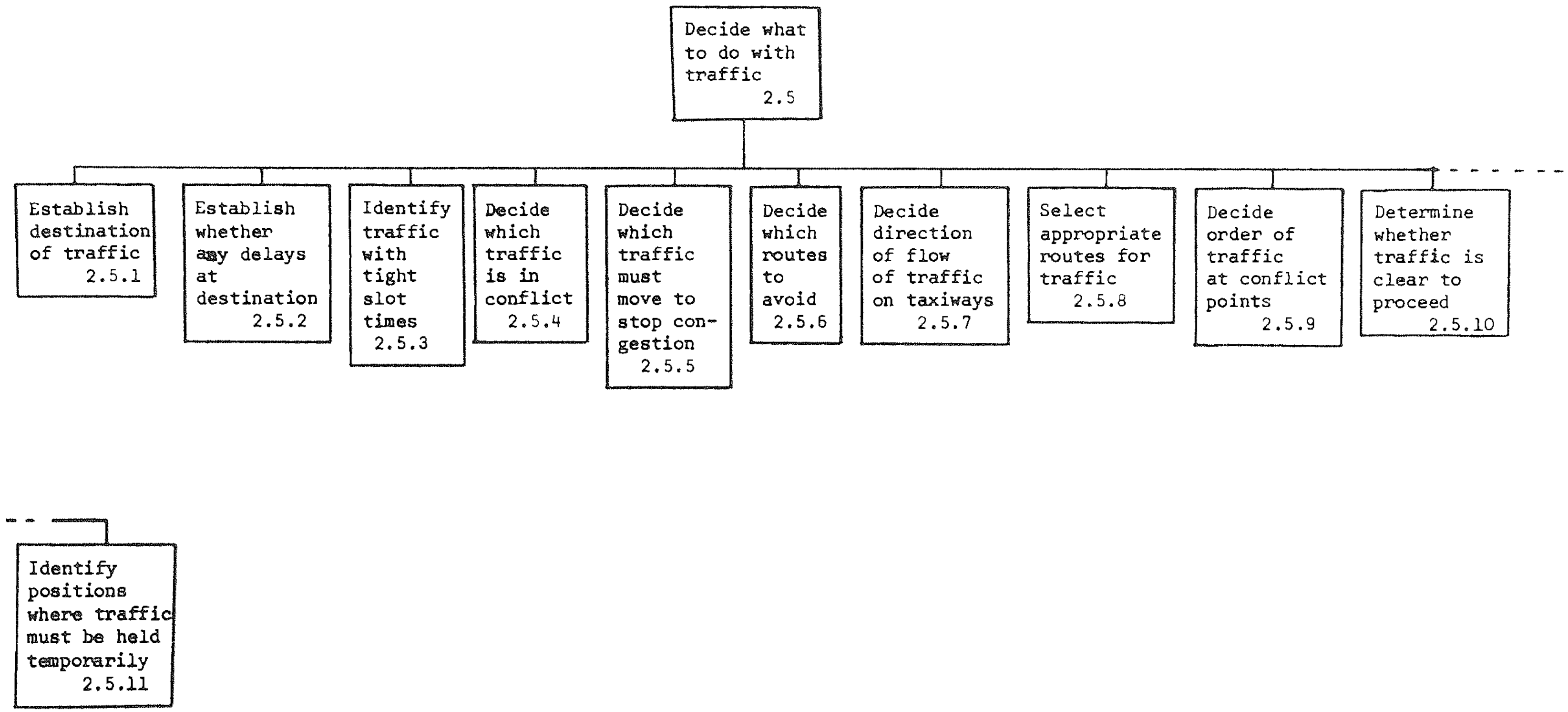
GMP 2
Identify traffic calling on frequency 1.3
Identify callsign given by crew 1.3.1
Determine whether strip is on display 1.3.2
Obtain strip if not on display 1.3.3
Identify strip matching callsign 1.3.4
Ensure strip is updated 1.3.5
Assess whether airfield traffic situation requires change in start-up plan 1.4
Establish what is an expeditious number of a/c for holding point 1.4.1
Establish the number of a/c already in the departure system 1.4.2
Identify specific delays 1.4.3
Establish duration of any delays 1.4.4
Decide appropriate action 1.4.5


GMP 3
Ensure traffic receives start-up and ATC clearance 1.7
Determine message content 1.7.1
Transmit message 1.7.2
Ensure a/c receives correct clearance 1.7.3
Determine airways restrictions on each a/c 1.5
Identify route a/c will take 1.5.1
Establish whether any airways restrictions on route a/c will take 1.5.2
Identify general airways restrictions 1.5.3
Estimate approx. suitable departure time for a/c requiring slot times 1.5.4
Ensure DFR told earliest time a/c could depart 1.5.5
Obtain clearance from DFR 1.5.6
Ensure strip is updated 1.5.7
Decide start-up times 1.6
Estimate time a/c will take from start-up to holding point 1.6.1
Identify slot times 1.6.2
Determine required delay between start-up times 1.6.3
Decide order of start-up 1.6.4
Establish duration of delay for each a/c 1.6.5
Calculate start-up time 1.6.6

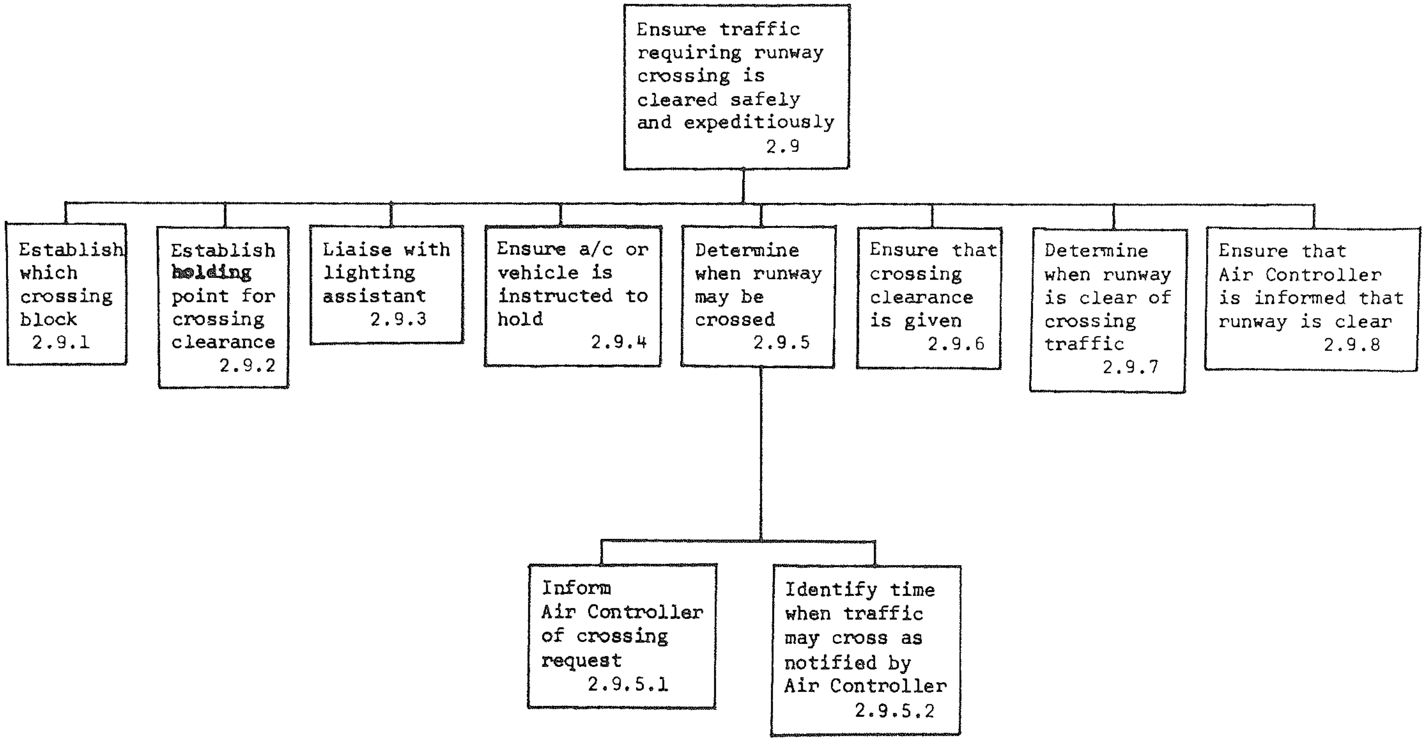
GROUND MOVEMENT CONTROLLER


GMC 1
Ensure that all ground traffic on the airfield is identified, integrated and cleared for safe and expeditious movement around the airfield to its destination 2
Identify traffic calling on frequency 2.1
Determine position of traffic 2.2
Obtain written data on all traffic 2.3
Ensure data is displayed so as to facilitate GMC work 2.4
Decide what to do with traffic 2.5
GMC 2
Ensure traffic is instructed what to do 2.6
Ensure a/c enquiries & problems are dealt with 2.7
Ensure data is removed or transferred from display when necessary 2.8
Ensure traffic requiring runway crossing is cleared safely and expeditiously 2.9
GMC 3
Ensure departing traffic is transferred to ADC 2.10

GMC 2

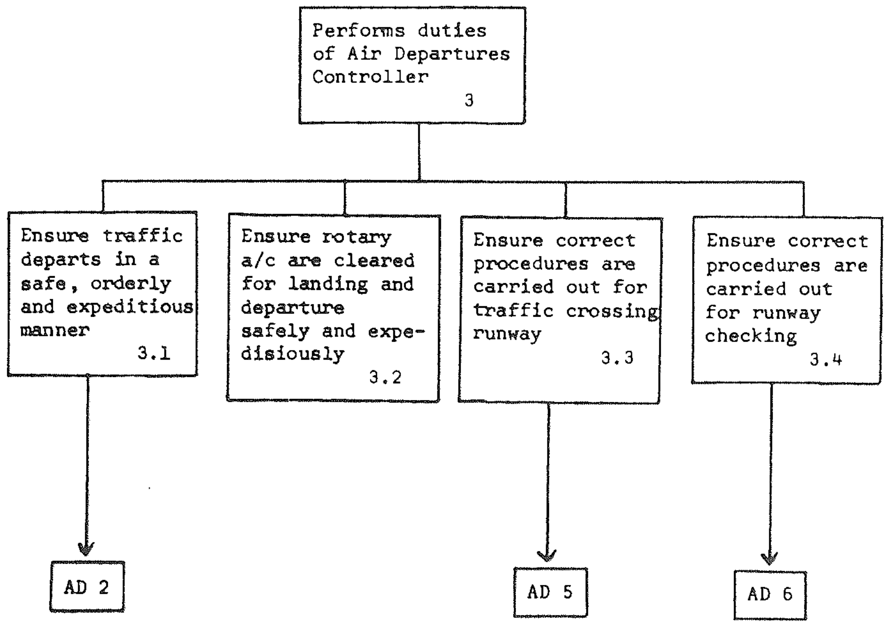

Decide what to do with traffic 2.5
Establish destination of traffic 2.5.1
Establish whether any delays at destination 2.5.2
Identify traffic with tight slot times 2.5.3
Decide which traffic is in conflict 2.5.4
Decide which traffic must move to stop congestion 2.5.5
Decide which routes to avoid 2.5.6
Decide direction of flow of traffic on taxiways 2.5.7
Select appropriate routes for traffic 2.5.8
Decide order of traffic at conflict points 2.5.9
Determine whether traffic is clear to proceed 2.5.10
Identify positions where traffic must be held temporarily 2.5.11

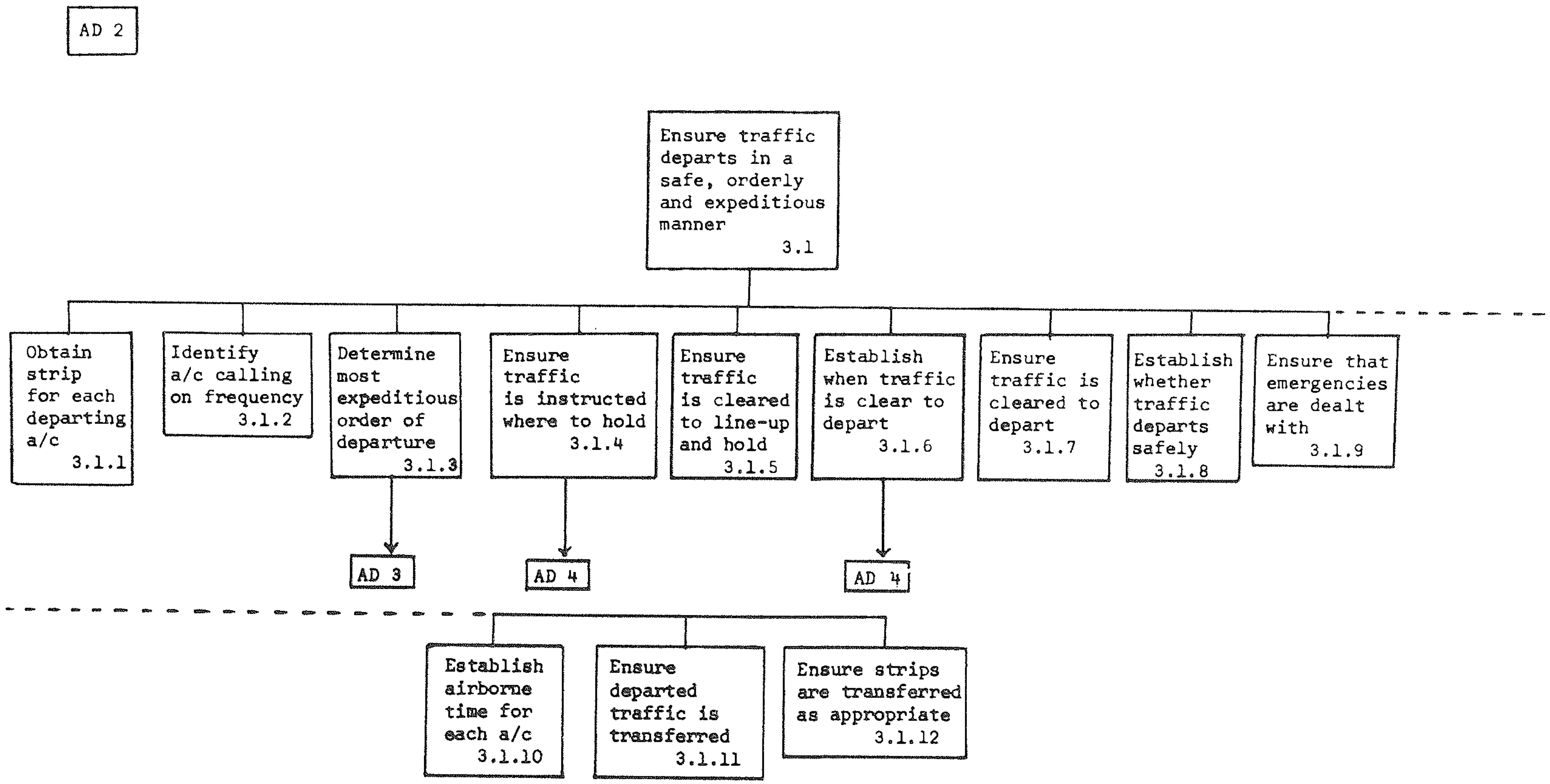
GMC 3


Ensure traffic requiring runway crossing is cleared safely and expeditiously 2.9
Establish which crossing block 2.9.1
Establish holding point for crossing clearance 2.9.2
Liaise with lighting assistant 2.9.3
Ensure a/c or vehicle is instructed to hold 2.9.4
Determine when runway may be crossed 2.9.5
Ensure that crossing clearance is given 2.9.6
Determine when runway is clear of crossing traffic 2.9.7
Ensure that Air Controller is informed that runway is clear 2.9.8
Inform Air Controller of crossing request 2.9.5.1
Identify time when traffic may cross as notified by Air Controller 2.9.5.2

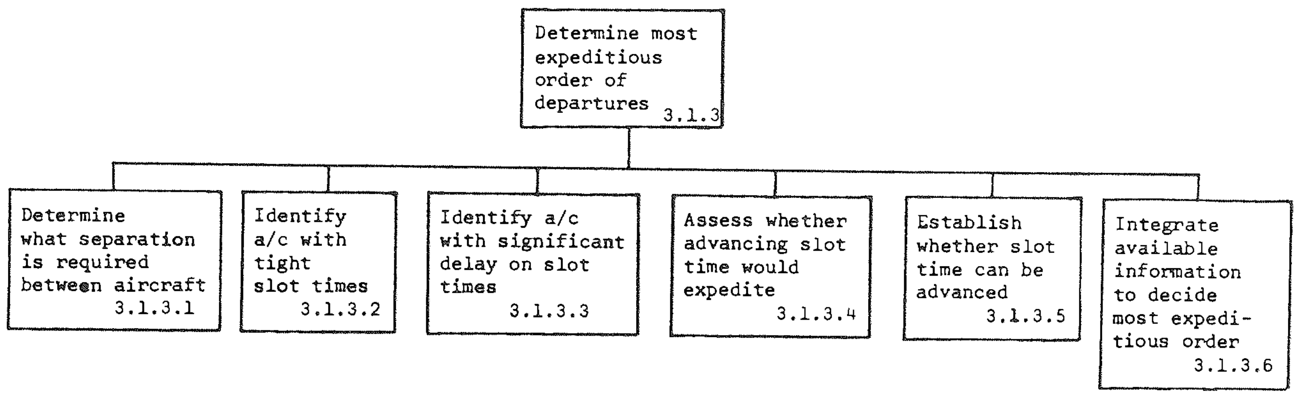
AIR DEPARTURES

AD 1

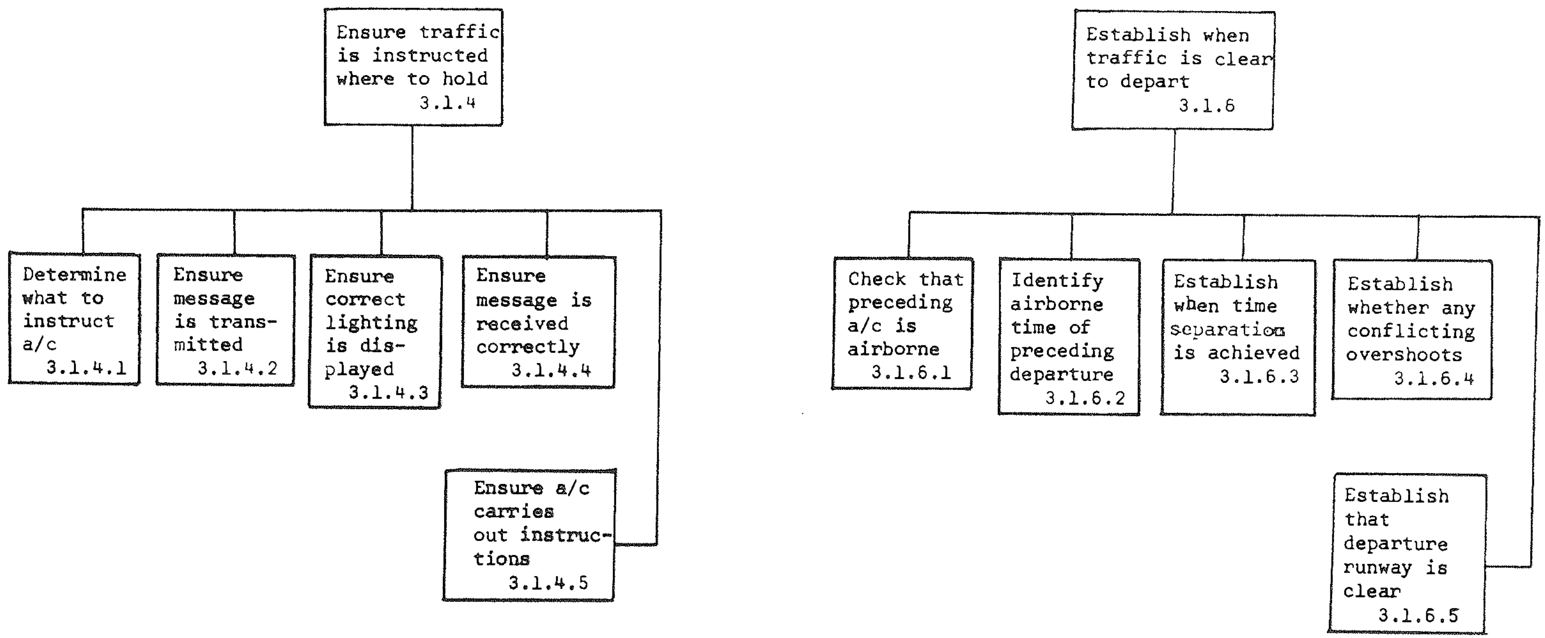

Performs duties of Air Departures Controller 3
Ensure traffic departs in a safe, orderly and expeditious manner 3.1
Ensure rotary a/c are cleared for landing and departure safely and expe-disiously 3.2
Ensure correct procedures are carried out for traffic crossing runway 3.3
Ensure correct procedures are carried out for runway checking 3.4
AD 2
AD 5
AD 6


AD 2
Ensure traffic departs in a safe, orderly and expeditious manner 3.1
Obtain strip for each departing a/c 3.1.1
Identify a/c calling on frequency 3.1.2
Determine most expeditious order of departure 3.1.3
Ensure traffic is instructed where to hold 3.1.4
Ensure traffic is cleared to line-up and hold 3.1.5
Establish when traffic is clear to depart 3.1.6
Ensure traffic is cleared to depart 3.1.7
Establish whether traffic departs safely 3.1.8
Ensure that emergencies are dealt with 3.1.9
AD 3
AD 4
AD 4
Establish airborne time for each a/c 3.1.10
Ensure departed traffic is transferred 3.1.11
Ensure strips are transferred as appropriate 3.1.12

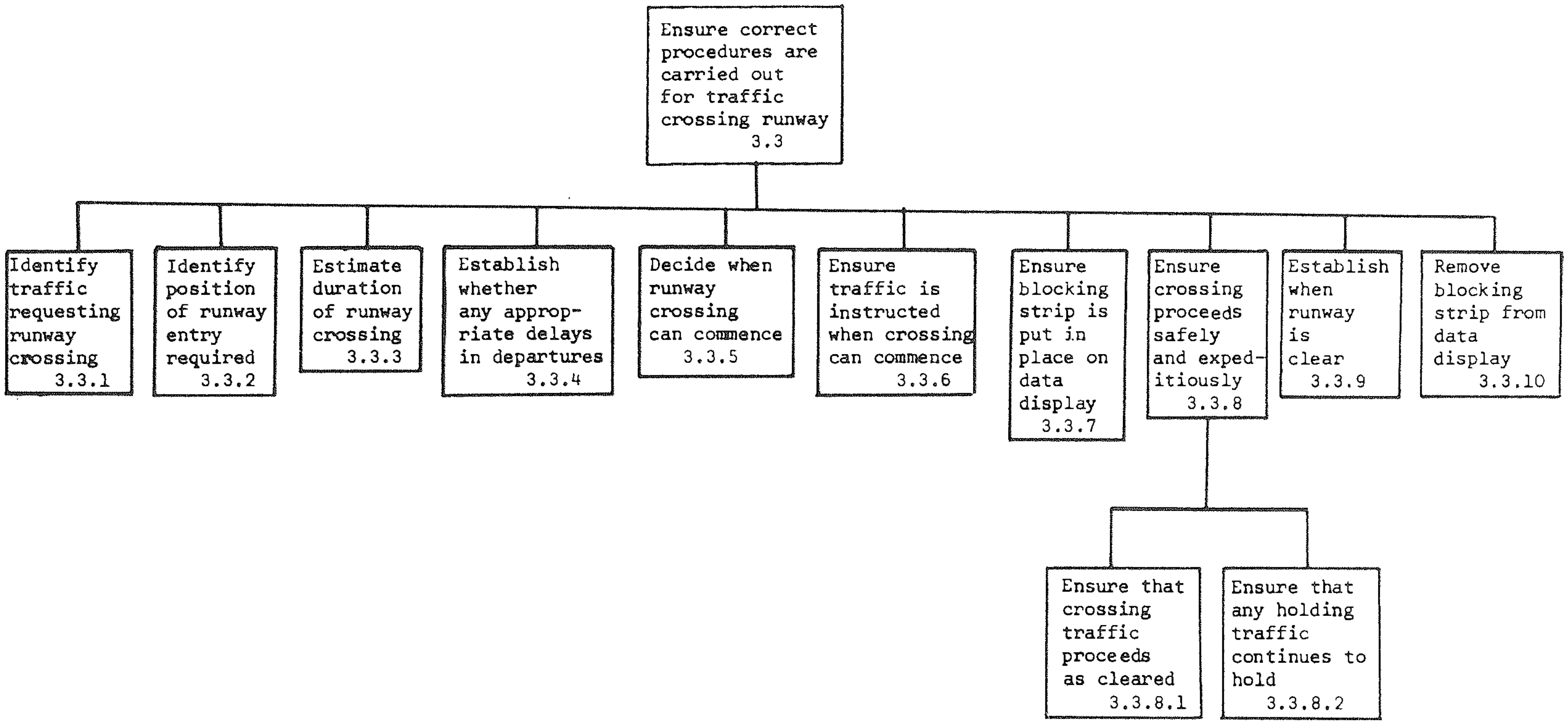
AD 3


Determine most expeditious order of departures 3.1.3
Determine what separation is required between aircraft 3.1.3.1
Identify a/c with tight slot times 3.1.3.2
Identify a/c with significant delay on slot times 3.1.3.3
Assess whether advancing slot time would expedite 3.1.3.4
Establish whether slot time can be advanced 3.1.3.5
Integrate available information to decide most expeditious order 3.1.3.6

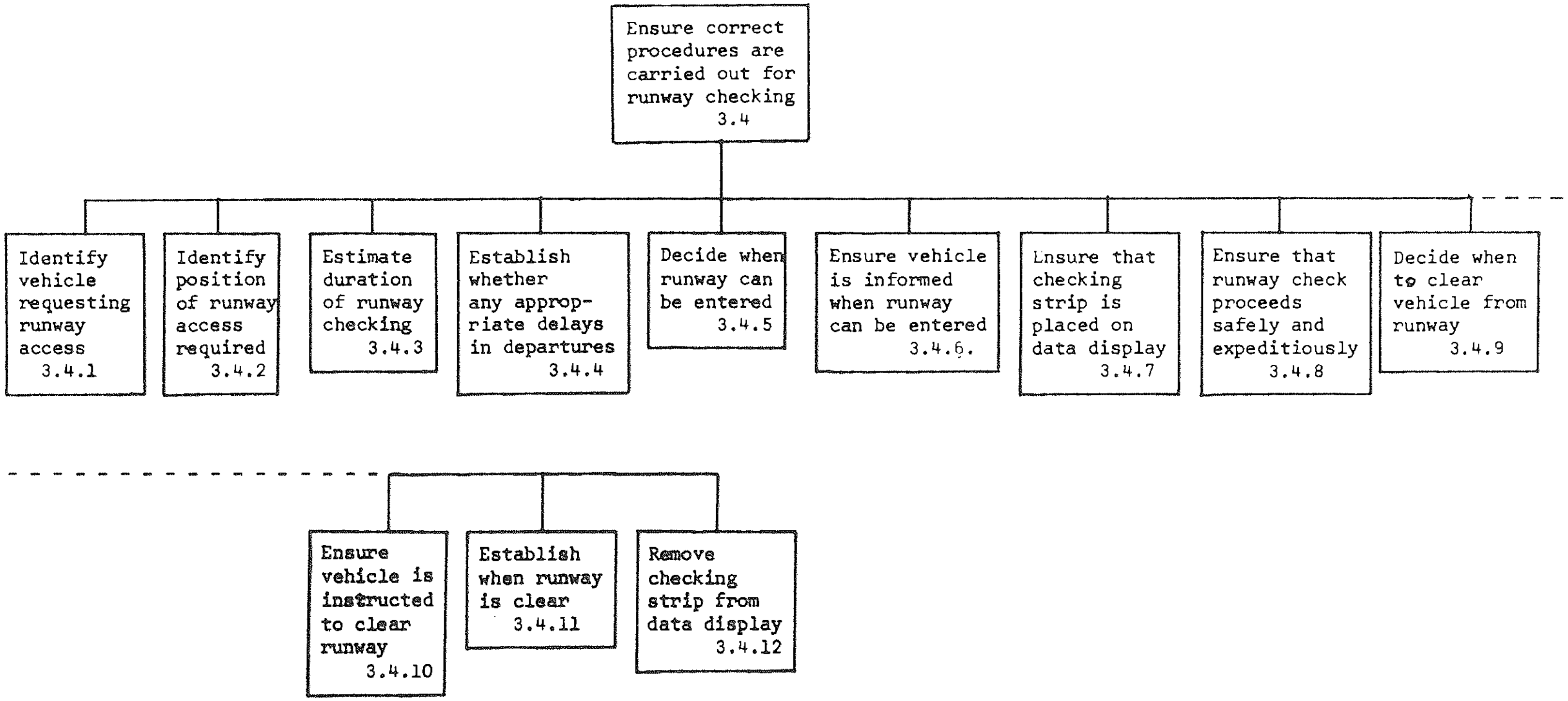
AD 4


Ensure traffic is instructed where to hold 3.1.4
Determine what to instruct a/c 3.1.4.1
Ensure message is transmitted 3.1.4.2
Ensure correct lighting is displayed 3.1.4.3
Ensure message is received correctly 3.1.4.4
Ensure a/c carries out instructions 3.1.4.5
Establish when traffic is clear to depart 3.1.6
Check that preceding a/c is airborne 3.1.6.1
Identify airborne time of preceding departure 3.1.6.2
Establish when time separation is achieved 3.1.6.3
Establish whether any conflicting overshoots 3.1.6.4
Establish that departure runway is clear 3.1.6.5

AD 5


Ensure correct procedures are carried out for traffic crossing runway 3.3
Identify traffic requesting runway crossing 3.3.1
Identify position of runway entry required 3.3.2
Estimate duration of runway crossing 3.3.3
Establish whether any appropriate delays in departures 3.3.4
Decide when runway crossing can commence 3.3.5
Ensure traffic is instructed when crossing can commence 3.3.6
Ensure blocking strip is put in place on data display 3.3.7
Ensure crossing proceeds safely and expeditiously 3.3.8
Establish when runway is clear 3.3.9
Remove blocking strip from data display 3.3.10
Ensure that crossing traffic proceeds as cleared 3.3.8.1
Ensure that any holding traffic continues to hold 3.3.8.2

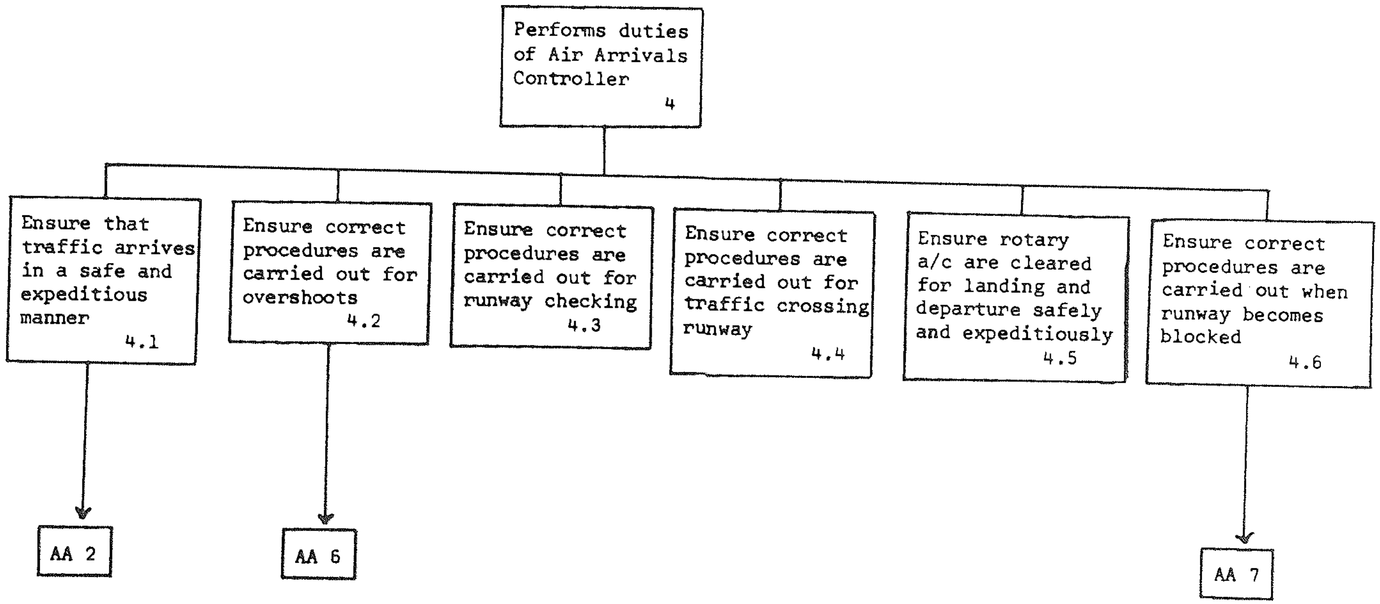
AD 6

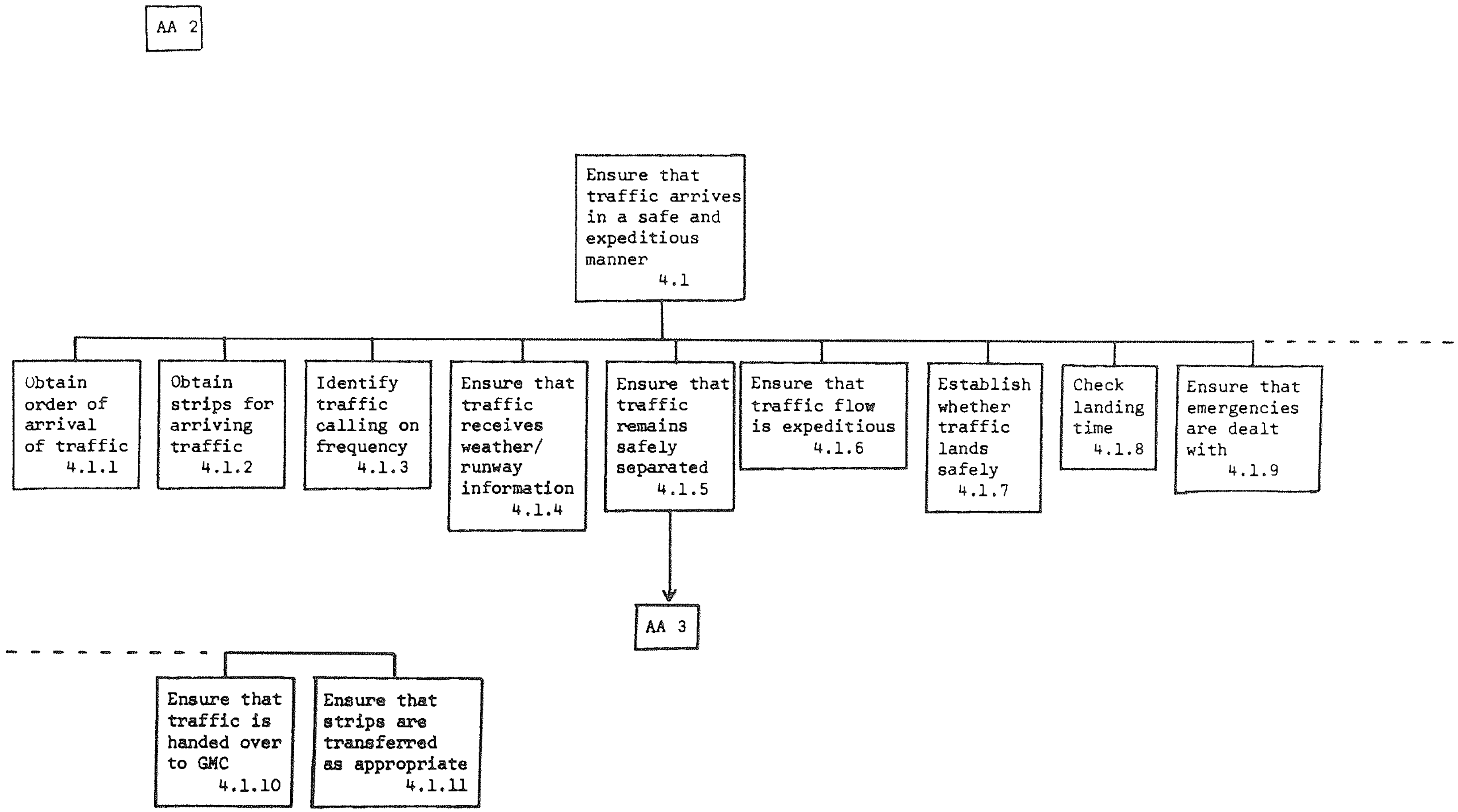


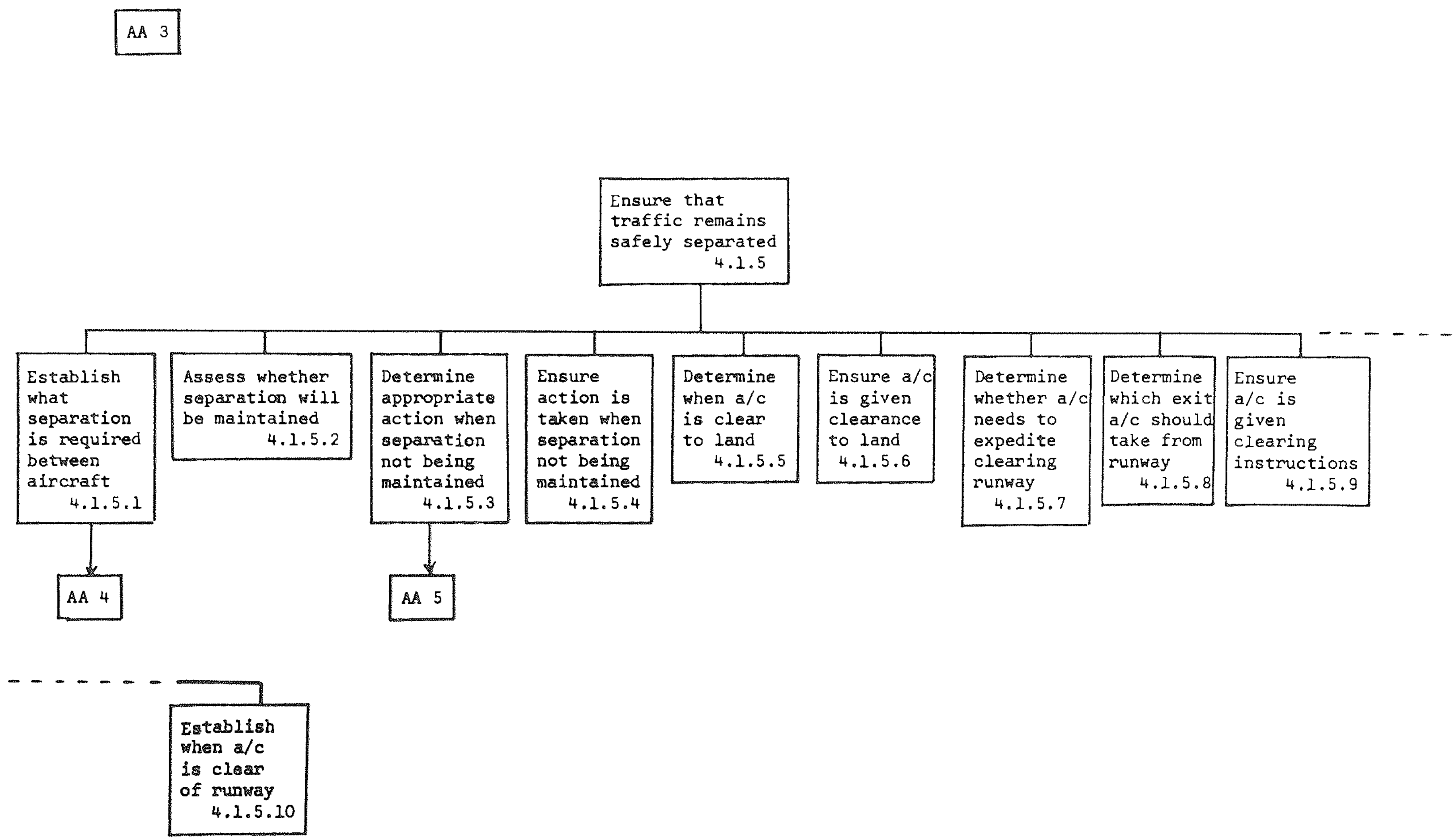
Ensure correct procedures are carried out for runway checking 3.4
Identify vehicle requesting runway access 3.4.1
Identify position of runway access required 3.4.2
Estimate duration of runway checking 3.4.3
Establish whether any approp- riate delays in departures 3.4.4
Decide when runway can be entered 3.4.5
Ensure vehicle is informed when runway can be entered 3.4.6.
Ensure that checking strip is placed on data display 3.4.7
Ensure that runway check proceeds safely and expeditiously 3.4.8
Decide when to clear vehicle from runway 3.4.9
Ensure vehicle is instructed to clear runway 3.4.10
Establish when runway is clear 3.4.11
Remove checking strip from data display 3.4.12

AIR ARRIVALS

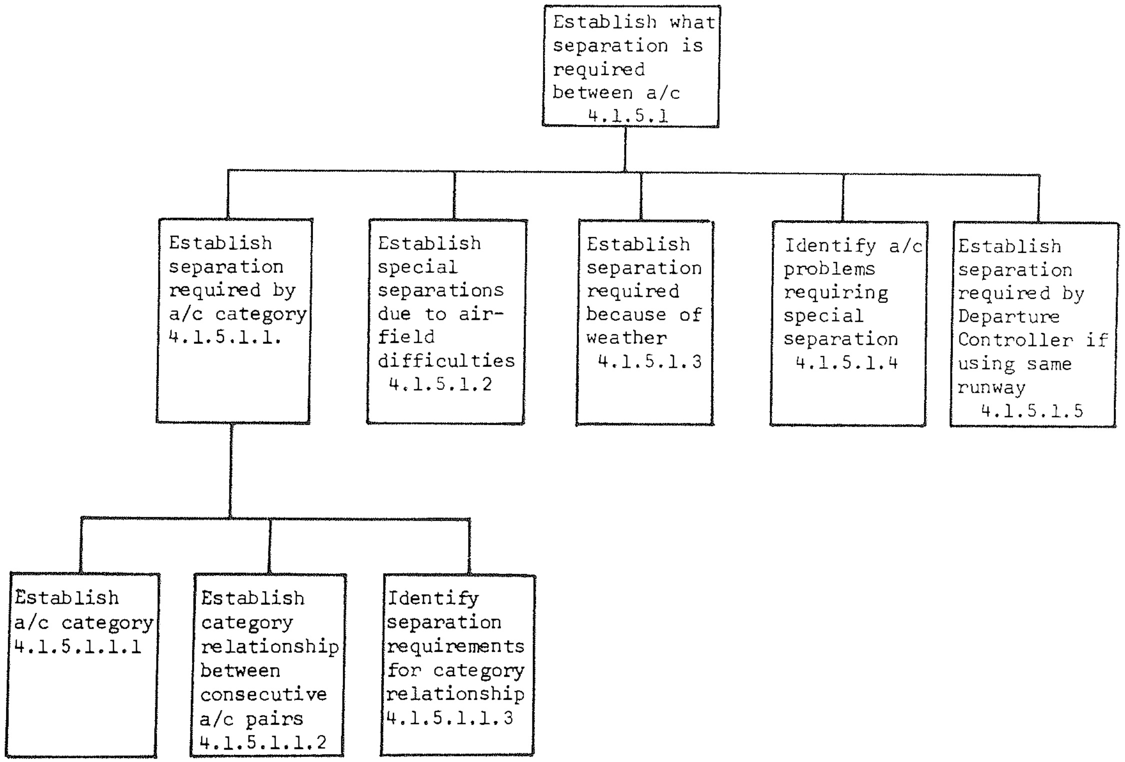
AA 1


Performs duties of Air Arrivals Controller 4
Ensure that traffic arrives in a safe and expeditious manner 4.1
Ensure correct procedures are carried out for overshoots 4.2
Ensure correct procedures are carried out for runway checking 4.3
Ensure correct procedures are carried out for traffic crossing runway 4.4
Ensure rotary a/c are cleared for landing and departure safely and expeditiously 4.5
Ensure correct procedures are carried out when runway becomes blocked 4.6
AA 2
AA 6
AA 7


AA 2
Ensure that traffic arrives in a safe and expeditious manner 4.1
Obtain order of arrival of traffic 4.1.1
Obtain strips for arriving traffic 4.1.2
Identify traffic calling on frequency 4.1.3
Ensure that traffic receives weather/ runway information 4.1.4
Ensure that traffic remains safely separated 4.1.5
Ensure that traffic flow is expeditious 4.1.6
Establish whether traffic lands safely 4.1.7
Check landing time 4.1.8
Ensure that emergencies are dealt with 4.1.9
AA 3
Ensure that traffic is handed over to GMC 4.1.10
Ensure that strips are transferred as appropriate 4.1.11


AA 3
Ensure that traffic remains safely separated 4.1.5
Establish what separation is required between aircraft 4.1.5.1
Assess whether separation will be maintained 4.1.5.2
Determine appropriate action when separation not being maintained 4.1.5.3
Ensure action is taken when separation not being maintained 4.1.5.4
Determine when a/c is clear to land 4.1.5.5
Ensure a/c is given clearance to land 4.1.5.6
Determine whether a/c needs to expedite clearing runway 4.1.5.7
Determine which exit a/c should take from runway 4.1.5.8
Ensure a/c is given clearing instructions 4.1.5.9
AA 4
AA 5
Establish when a/c is clear of runway 4.1.5.10

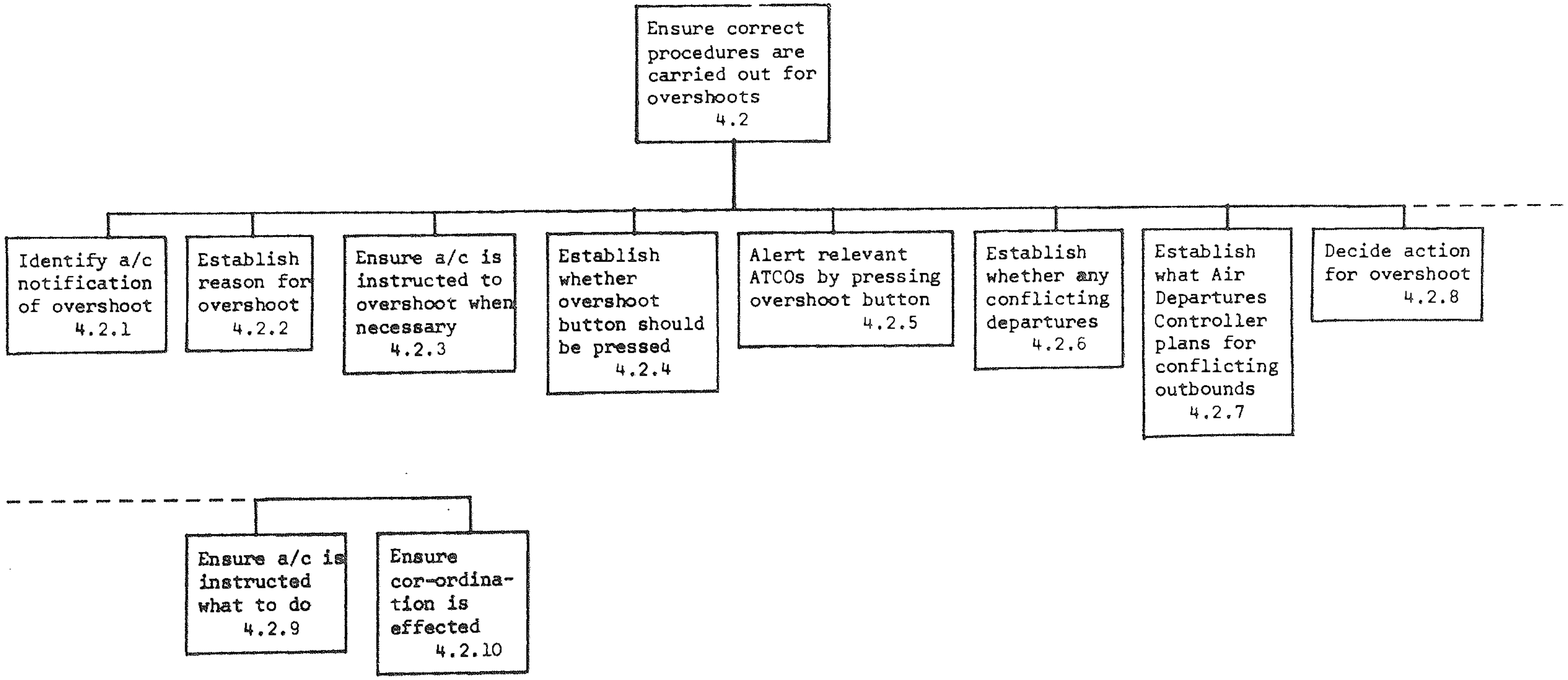
AA4


Establish what separation is required between a/c 4.1.5.1
Establish separation required by a/c category 4.1.5.1.1.
Establish special separations due to air-field difficulties 4.1.5.1.2
Establish separation required because of weather 4.1.5.1.3
Identify a/c problems requiring special separation 4.1.5.1.4
Establish separation required by Departure Controller if using same runway 4.1.5.1.5
Establish a/c category 4.1.5.1.1.1
Establish category relationship between consecutive a/c pairs 4.1.5.1.1.2
Identify separation requirements for category relationship 4.1.5.1.1.3

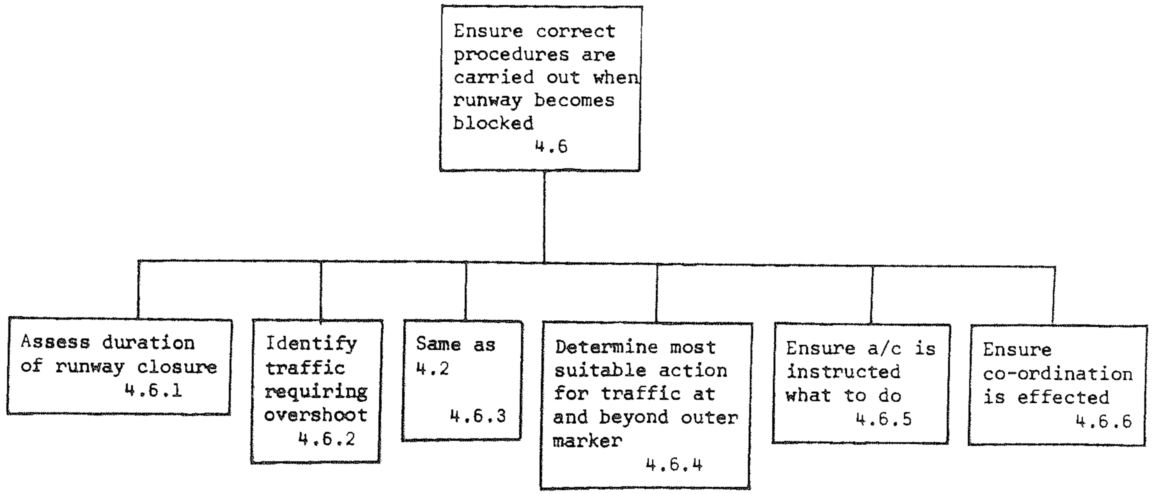
AA 5

- Determine appropriate action when separation not being maintained 4.1.5.3
  - Assess whether speed control would expedite 4.1.5.3.1
  - Determine whether runway switch is appropriate 4.1.5.3.2
  - Decide whether to discontinue approach 4.1.5.3.3
  - Decide which a/c to turn off approach 4.1.5.3.4
  - Assess whether overshoot is necessary 4.1.5.3.5
  - Select action 4.1.5.3.6
  - Establish whether vortex wake report is required 4.1.5.3.7

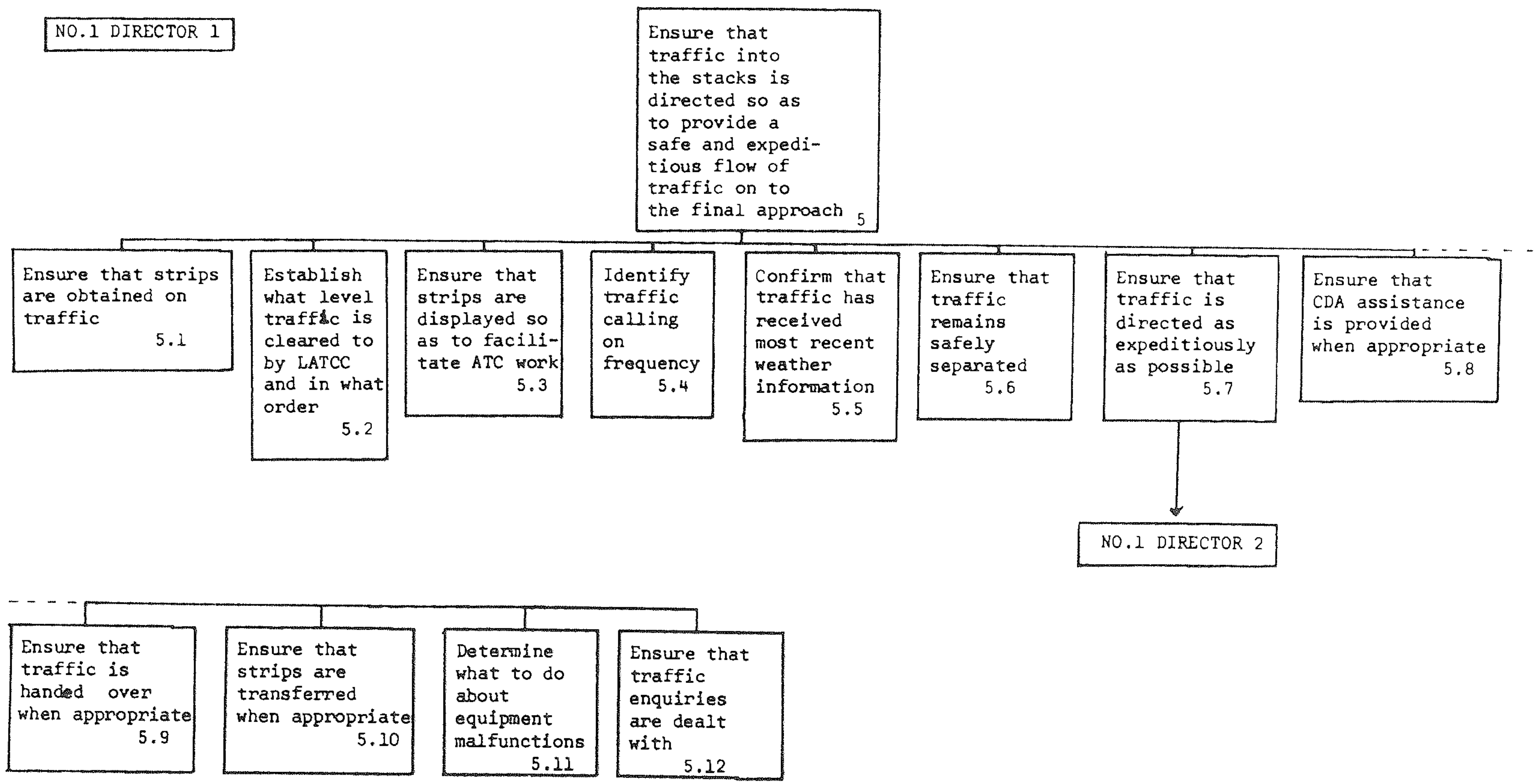
AA 6

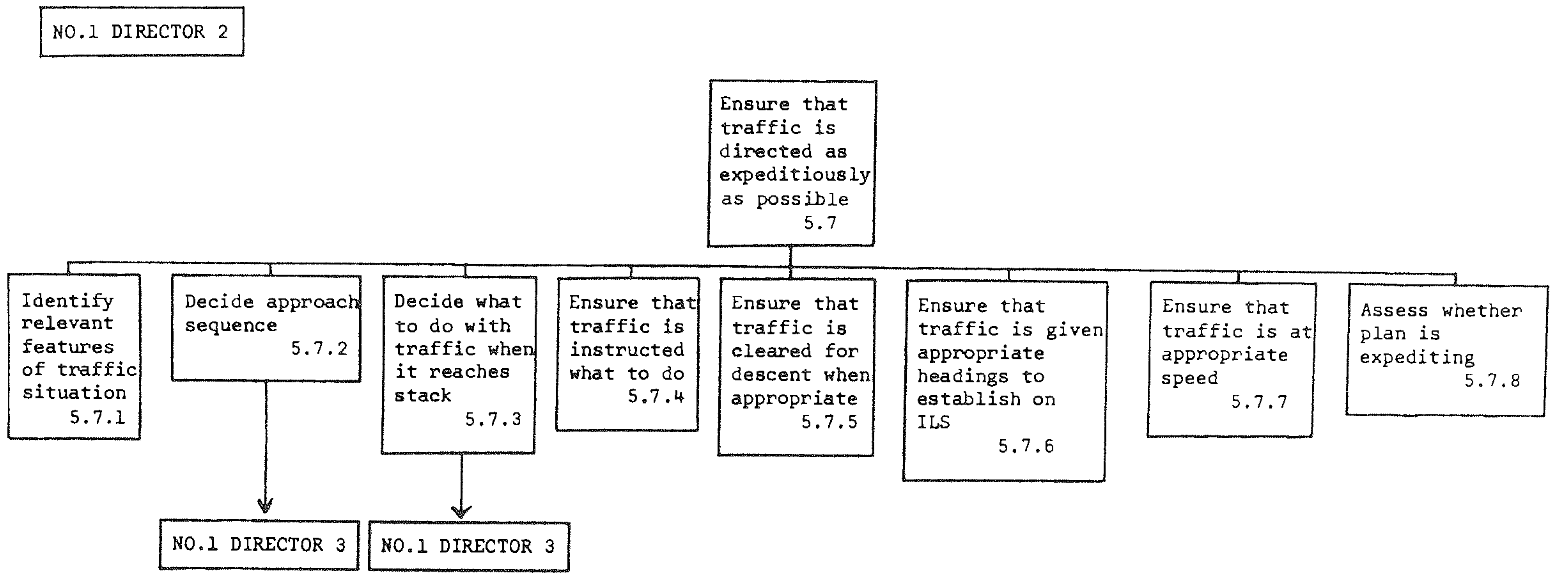

Ensure correct procedures are carried out for overshoots 4.2
Identify a/c notification of overshoot 4.2.1
Establish reason for overshoot 4.2.2
Ensure a/c is instructed to overshoot when necessary 4.2.3
Establish whether overshoot button should be pressed 4.2.4
Alert relevant ATCOs by pressing overshoot button 4.2.5
Establish whether any conflicting departures 4.2.6
Establish what Air Departures Controller plans for conflicting outbounds 4.2.7
Decide action for overshoot 4.2.8
Ensure a/c is instructed what to do 4.2.9
Ensure cor-ordination is effected 4.2.10

AA 7

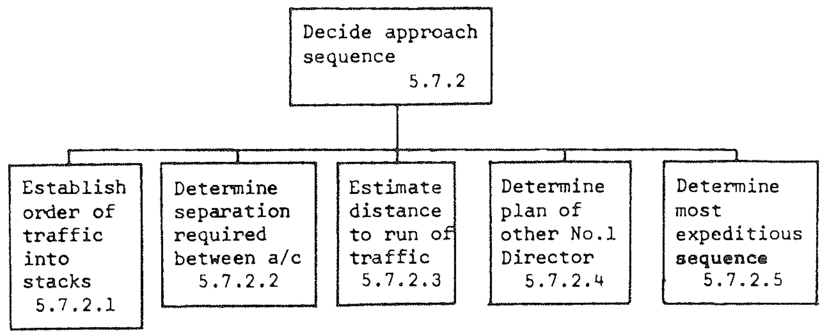

Ensure correct procedures are carried out when runway becomes blocked 4.6
Assess duration of runway closure 4.6.1
Identify traffic requiring overshoot 4.6.2
Same as 4.2 4.6.3
Determine most suitable action for traffic at and beyond outer marker 4.6.4
Ensure a/c is instructed what to do 4.6.5
Ensure co-ordination is effected 4.6.6

NO.1 DIRECTOR AND APPROACH

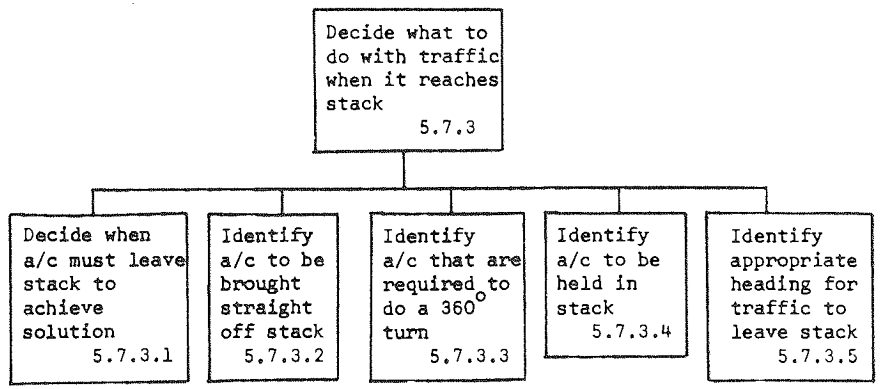

NO.1 DIRECTOR 1
Ensure that traffic into the stacks is directed so as to provide a safe and expeditious flow of traffic on to the final approach 5
Ensure that strips are obtained on traffic 5.1
Establish what level traffic is cleared to by LATCC and in what order 5.2
Ensure that strips are displayed so as to facilitate ATC work 5.3
Identify traffic calling on frequency 5.4
Confirm that traffic has received most recent weather information 5.5
Ensure that traffic remains safely separated 5.6
Ensure that traffic is directed as expeditiously as possible 5.7
Ensure that CDA assistance is provided when appropriate 5.8
NO.1 DIRECTOR 2
Ensure that traffic is handed over when appropriate 5.9
Ensure that strips are transferred when appropriate 5.10
Determine what to do about equipment malfunctions 5.11
Ensure that traffic enquiries are dealt with 5.12


NO.1 DIRECTOR 2
Ensure that traffic is directed as expeditiously as possible 5.7
Identify relevant features of traffic situation 5.7.1
Decide approach sequence 5.7.2
Decide what to do with traffic when it reaches stack 5.7.3
Ensure that traffic is instructed what to do 5.7.4
Ensure that traffic is cleared for descent when appropriate 5.7.5
Ensure that traffic is given appropriate headings to establish on ILS 5.7.6
Ensure that traffic is at appropriate speed 5.7.7
Assess whether plan is expediting 5.7.8
NO.1 DIRECTOR 3
NO.1 DIRECTOR 3

NO.1 DIRECTOR 3

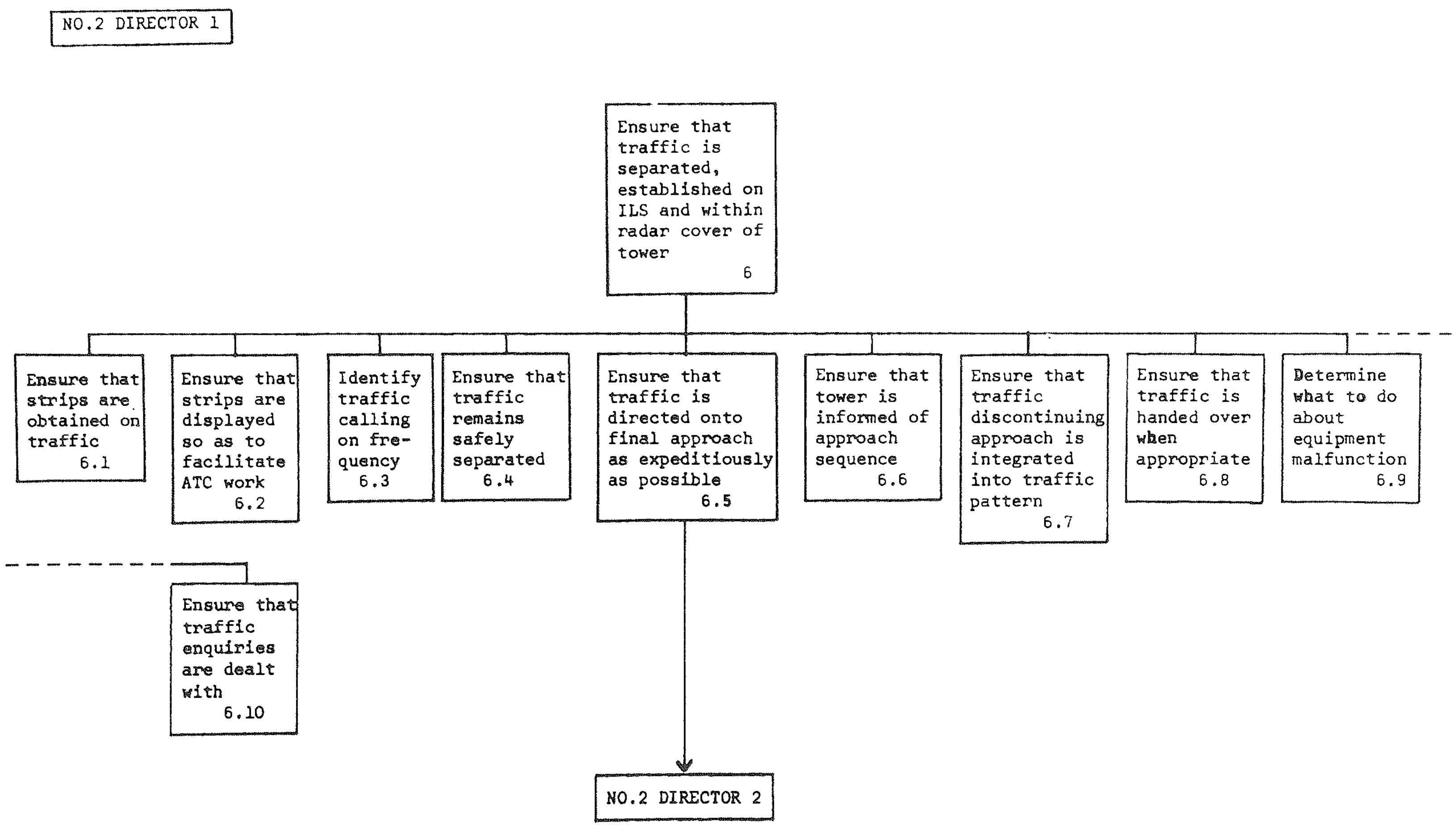


NO.1 DIRECTOR 3

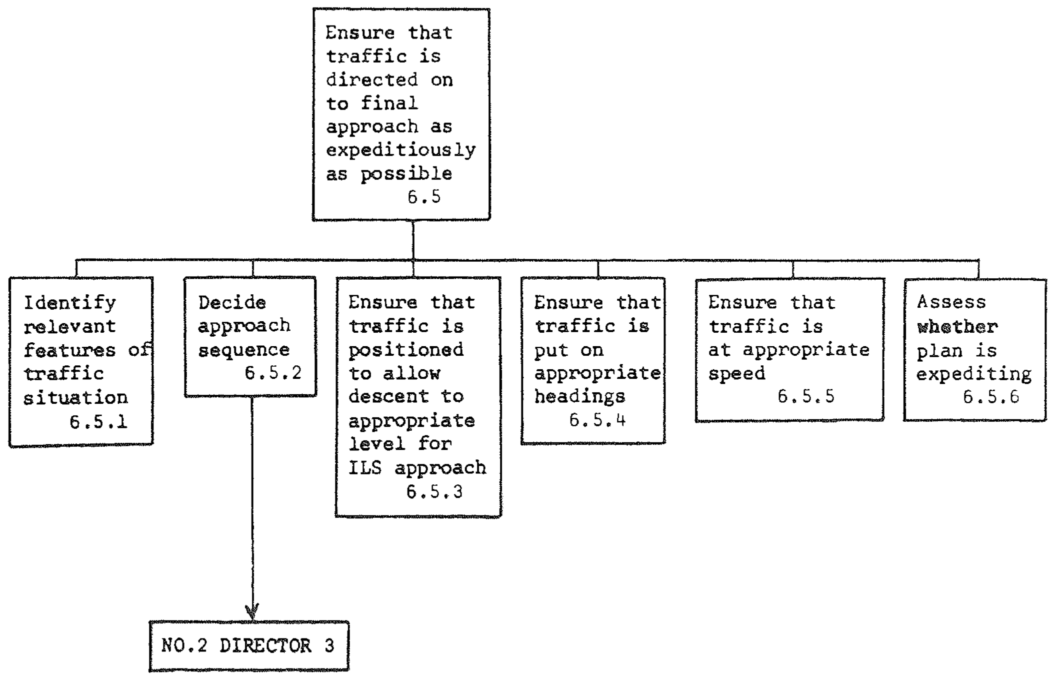


NO.2 DIRECTOR

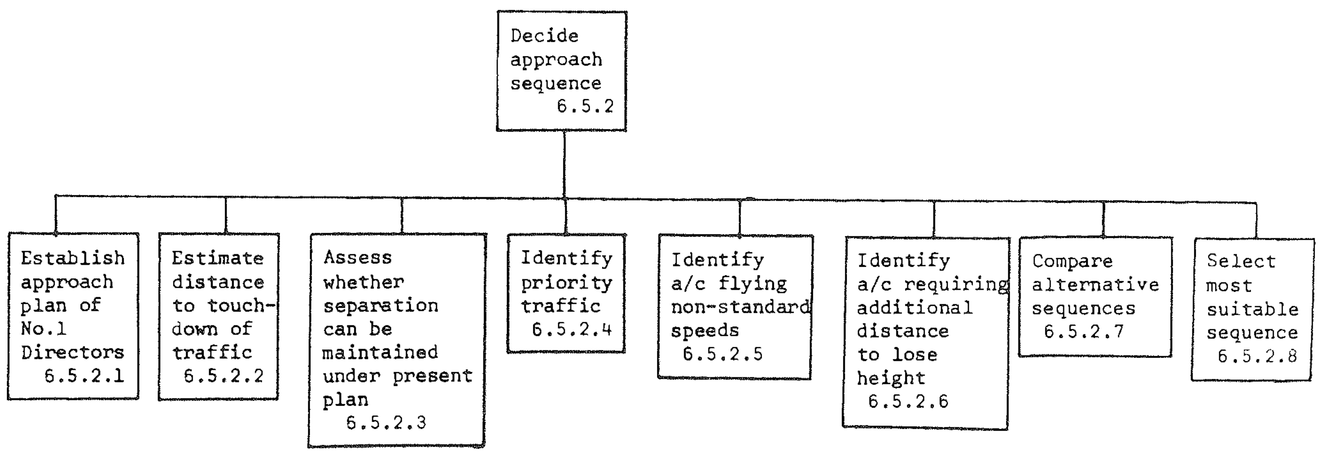
(ILS APPROACH ONLY)


NO.2 DIRECTOR 1
Ensure that traffic is separated, established on ILS and within radar cover of tower 6
Ensure that strips are obtained on traffic 6.1
Ensure that strips are displayed so as to facilitate ATC work 6.2
Identify traffic calling on fre- quency 6.3
Ensure that traffic remains safely separated 6.4
Ensure that traffic is directed onto final approach as expeditiously as possible 6.5
Ensure that tower is informed of approach sequence 6.6
Ensure that traffic discontinuing approach is integrated into traffic pattern 6.7
Ensure that traffic is handed over when appropriate 6.8
Determine what to do about equipment malfunction 6.9
Ensure that traffic enquiries are dealt with 6.10
NO.2 DIRECTOR 2

NO.2 DIRECTOR 2



NO.2 DIRECTOR 3



APPENDIX II: Job Diagnostic Survey (JDS)

JOB DIAGNOSTIC SURVEY

This questionnaire was developed as part of a Yale University study of jobs and how people react to them. The questionnaire helps to determine how jobs can be better designed, by obtaining information about how people react to different kinds of jobs.

On the following pages you will find several different kinds of questions about your job. Specific instructions are given at the start of each section. Please read them carefully. It should take no more than 30 minutes to complete the entire questionnaire. Please move through it quickly.

The questions are designed to obtain <u>your</u> perceptions of the job and <u>your</u> reactions to it.

There are no trick questions. Your individual answers will be kept completely confidential. Please answer each item as honestly and frankly as possible.

Thank you for your co-operation.

Richard Crawley
Applied Psychology Department
University of Aston in Birmingham
Gosta Green
Birmingham B4 7ET

SECTION ONE

This part of the questionnaire asks you to describe the job of .... as objectively as you can.

Please do not use this part of the questionnaire to show how much you like or dislike the job. Questions about that will come later. Instead, try to make your description as accurate and as objective as you possibly can.

A sample question is given below.

Ex. A To what extent does the job require you to observe visual data displays?

1 .... 2 .... 3 .... 4 .... 5 .... 6 7

very little — moderately — Very much; the job requires almost constant observation of visual data displays.

You are to circle the number which is the most accurate description of the job.

If, for example, the job requires you to observe visual data displays a good deal of the time - but also requires you to do some other things which prevent you from observing them - you might circle number six, as was done in the example above.

If you do not understand these instructions, please ask for assistance. If you do understand them, turn the page and begin.

1. To what extent does the job require you to work closely with other people, either face-to-face or by means of spoken communications?

1..........2..........3..........4..........5..........6..........7

Very little; dealing with others is not at all necessary in doing the job.	Moderately	Very much; dealing with other people is an absolutely essential part of the job.

2. How much autonomy is there in the job? That is, to what extent does the job permit you to decide on your own how and when the work is done?

1..........2..........3..........4..........5..........6..........7

Very little; I have hardly any decisions to make on my own.	Moderate autonomy; many things are standardised or not under my control, but I can make some decisions about the work.	Very much; the job gives me almost complete responsibility for deciding how and when the work is done.

3. To what extent does the job involve doing a whole and identifiable piece of work? That is, is the job a complete service that has an obvious beginning and end? Or is it only a small part of the overall service at this Unit, which is finished by other people?

1..........2..........3..........4..........5..........6..........7

The job is only a tiny part of the overall service; its contribution to the overall service cannot be seen.	The job is a moderate sized 'chunk' of the overall service; its contribution can be seen.	The job involves doing a whole service from beginning to end; its contribution is very easily identifiable

4. How much variety is there in the job? That is, to what extent does the job require you to do many different things, using a variety of your skills and talents?

1..........2..........3..........4..........5..........6..........7

Very little variety.	Moderate variety.	Very much variety.

5. In general, how significant or important is the job? That is, are the results of the work likely to significantly affect the lives or well-being of other people?

1..........2..........3..........4..........5..........6..........7

Not very significant; the outcomes of the work are not likely to have important effects on other people.	Moderately significant.	Highly significant; the outcomes of the work can affect other people in very important ways.

6. To what extent do supervisors or colleagues inform you about how well you are doing on the job?

1..........2..........3..........4..........5..........6..........7

Very little; people almost never inform me how well I am doing.	Moderately; sometimes people give me feedback; other times they do not.	Very much; people provide me with almost constant feedback about how well I am doing.

7. To what extent does doing the job itself provide you with information about how well you are doing? (excluding any feedback from other people covered in question 6).

1..........2..........3..........4..........5..........6..........7

Very little; the job is set up so I could work for ever without finding out how well I am doing.	Moderately; sometimes the job provides feedback to me; other times it does not.	Very much; the job is set up so that I get almost constant feedback as I work about how well I am doing.

SECTION TWO

Listed below are a number of statements which could be used to describe a job.

You are to indicate whether each statement is an accurate or an inaccurate description of the job you are rating.

Once again, please try to be as objective as you can in deciding how accurately each statement describes the job - regardless of whether you like or dislike the job.

Write a number in the box beside each statement, based on the following scales:

How accurate is the statement in describing the job?

1	2	3	4	5	6	7
very inaccurate	mostly inaccurate	slightly inaccurate	uncertain	slightly accurate	mostly accurate	very accurate

☐ 1. The job requires me to use a number of complex or high-level skills.

☐ 2. The job requires a lot of co-operative work with other people.

☐ 3. The job is arranged so that I do not have the chance to provide an entire service from beginning to end.

☐ 4. Doing the work itself provides me with many opportunities to assess how well I am doing.

☐ 5. The job is quite simple and repetitive.

☐ 6. The job can be done adequately by a person working alone - without talking or checking with other people.

☐ 7. The supervisors and my colleagues on the job almost never give me any 'feedback' about how well I am doing.

☐ 8. This job is one where a lot of other people can be affected by how well the work is done.

☐ 9. The job denies me any chance to use my personal initiative or judgement in carrying out the work.

☐ 10. Supervisors often let me know how well they think I am performing the job.

☐ 11. The job provides me with the chance to completely finish the work I begin.

☐ 12. The job itself provides very little feedback on how well I am doing.

☐ 13. The job gives me considerable opportunity for independence and freedom in how I do the work.

☐ 14. The job is <u>not</u> very significant or important in the broader scheme of things.

SECTION THREE

Now please indicate how you personally feel about your job. Each of the statements below is something that a person might say about his or her job. You are to indicate your own, personal feelings about your job by marking how much you agree with each of the statements.

Write a number in the box for each statement, based on this scale.

How much do you agree with the statement?

1	2	3	4	5	6	7
Disagree strongly	Disagree	Disagree slightly	Neutral	Agree slightly	Agree	Agree strongly

☐ 1. It is hard, on this job, for me to care very much about whether or not the work gets done right.

☐ 2. My opinion of myself goes up when I do this job well.

☐ 3. Generally speaking, I am very satisfied with this job.

☐ 4. Most of the things I have to do on this job seem useless or trivial.

☐ 5. I usually know whether or not my work is satisfactory on this job.

☐ 6. I feel a great sense of personal satisfaction when I do this job well.

☐ 7. The work I do on this job is very meaningful to me.

☐ 8. I feel a very high degree of personal responsibility for the work I do on this job.

☐ 9. I frequently think of leaving this job.

☐ 10. I feel bad and unhappy when I discover that I have performed poorly on this job.

☐ 11. I often have trouble assessing whether I am doing well or poorly on this job.

☐ 12. I feel I should personally take the credit or blame for the results of my work on this job.

☐ 13. I am generally satisfied with the kind of work I do in this job.

☐ 14. My own feelings generally are <u>not</u> affected much one way or the other by how well I do on this job.

☐ 15. Whether or not this job gets done right is clearly <u>my</u> responsibility.

SECTION FOUR

Now please indicate how satisfied you are with each aspect of the job listed below. Once again write the appropriate number in the box beside each statement.

How satisfied are you with this aspect of the job?

1............2.............3.............4.............5.............6...........7

1	2	3	4	5	6	7
Extremely dissatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Extremely satisfied

☐ 1. The amount of personal growth and development I get in doing the job.

☐ 2. The feeling of worthwhile accomplishment I get from doing the job.

☐ 3. The amount of independent thought and action I can exercise in the job.

☐ 4. The amount of challenge in the job.

SECTION FIVE

Now please think of the other people in your organisation who hold the same job as you.

Please think about how accurately each of the statements describes the feelings of those people about the job you are rating.

It is quite alright if your answers here are different from when you described your own reactions to the job. Often different people feel quite differently about the same job.

Once again, write a number in the box for each statement, based on this scale:

How much do you agree with the statement?

1	2	3	4	5	6	7
Disagree strongly	Disagree	Disagree slightly	Neutral	Agree Slightly	Agree	Agree strongly

☐ 1. Most people on this job feel a great sense of personal satisfaction when they do the job well.

☐ 2. Most people on this job are very satisfied with the job.

☐ 3. Most people on this job feel that the work is useless or trivial.

☐ 4. Most people on this job feel a great deal of personal responsibility for the work they do.

☐ 5. Most people on this job have a pretty good idea of how well they are performing their work.

☐ 6. Most people on this job find the work very meaningful.

☐ 7. Most people on this job feel that whether or not the job gets done right is clearly their own responsibility.

☐ 8. People on this job often think of leaving it.

☐ 9. Most people on this job feel bad or unhappy when they find that they have performed their work poorly.

☐ 10. Most people on this job have trouble assessing how well they are doing.

SECTION SIX

Listed below are a number of characteristics which could be present on any job. People differ about how much they would like to have each one present in their own job. We are interested in learning how much you would like to have each one present in your job.

Using the scale below, please indicate the degree to which you would like to have each characteristic present in your job.

NOTE: The numbers on this scale are different from those used in previous scales.

4..........5........6.........7..........8..........9........10

Would like a moderate amount or less.	Would like very much.	Would like **extremely** much.

☐ 1. High job security.

☐ 2. Stimulating and challenging work.

☐ 3. Opportunities to exercise independent thought and action in my job.

☐ 4. Convenient geographical location.

☐ 5. Opportunity for making friends at work.

☐ 6. Opportunities to learn new things from my work.

☐ 7. Good physical working conditions.

☐ 8. Opportunities to be creative and imaginative in my work.

☐ 9. Quick promotion.

☐ 10. Opportunities for personal growth and development in my job.

☐ 11. A sense of worthwhile accomplishment in my work.

SECTION SEVEN

People differ in the kinds of jobs they would most like to hold. The questions in this section give you a chance to say just what it is about a job that is most important to you.

For each question, two different kinds of jobs are briefly described. You are to indicate which of the jobs you personally would prefer - if you had to choose between them.

In answering each question, assume that everything else about the job is the same. Pay attention only to the characteristics actually listed.

Two examples are given below

JOB A				JOB B
A job requiring work with mechanical equipment most of the day.				A job requiring work with other people most of the day.
1	2	3	4	5
Strongly prefer A	Slightly prefer A	Neutral	Slightly prefer B	Strongly prefer B

If you like working with people plus working with equipment equally well, you would circle the number 3, as has been done in this example.

Here is another example. This one asks for a harder choice - between 2 jobs which both have some undesirable features.

JOB A				JOB B
A job requiring you to expose yourself to considerable physical danger.				A job located 200 miles from your home and family.
1	2	3	4	5
Strongly prefer A	Slightly prefer A	Neutral	Slightly prefer B	Strongly prefer B

If you would slightly prefer risking physical danger to working far from your home, you would circle number 2, as has been done in this example.

Please ask for assistance if you do not understand exactly how to do these questions.

JOB A	JOB B
1. A job where the pay is very good.	A job where there is considerable opportunity to be creative and innovative.

1..............2.................3...............4..............5

Strongly prefer A	Slightly prefer A	Neutral	Slightly prefer B	Strongly prefer B

2. A job where you are often required to make important decisions.	A job with many pleasant people to work with.

1..............2.................3...............4..............5

3. A job in which greater responsibility is given to those who do the best work.	A job in which greater responsibility is given to loyal employees who have the most seniority.

1..............2.................3...............4..............5

4. A job in an organisation which is in financial trouble - and might have to close down within the year.	A job in which you are not allowed to have any say whatsoever in how your work is scheduled, or in the procedures to be used in carrying it out.

1..............2.................3...............4..............5

5. A very routine job.	A job where your co-workers are not very friendly.

1..............2.................3...............4..............5

6. A job with a supervisor who is often very critical of you and your work in front of other people.	A job which prevents you from using a number of skills that you worked hard to develop.

1..............2.................3...............4..............5

7. A job with a supervisor who respects you and treats you fairly.	A job which provides constant opportunities for you to learn new and interesting things.

1..............2.................3...............4..............5

JOB A		JOB B
8.	A job where there is a real chance you could be laid off.	A job with very little chance to do challenging work.

1.............2................3..............4.............5

9.	A job in which there is a real chance for you to develop new skills and advance in the organisation.	A job which provides lots of vacation time and an excellent fringe benefit scheme.

1.............2................3..............4.............5

10.	A job with little freedom and independence to do your work in the way you think best.	A job where the working conditions are poor.

1.............2................3..............4.............5

11.	A job with very satisfying team-work.	A job which allows you to use your skills and abilities to the fullest extent.

1.............2................3..............4.............5

12.	A job which offers little or no challenge.	A job which requires you to be completely isolated from co-workers.

1.............2................3..............4.............5

APPENDIX III

SCORING KEY FOR THE JOB DIAGNOSTIC SURVEY (Hackman and Oldham, 1980)

The scoring manual for the Job Diagnostic Survey (JDS) is presented below. For each variable measured by the JDS, the questionnaire items that are averaged to yield a summary score for the variable are listed.

1. JOB CHARACTERISTICS

a) Skill variety. Average the following items:

Section One: No. 4

Section Two: No. 1

No. 5 (reversed scoring - i.e. subtract the number entered by the respondent from 8)

b) Task identity. Average the following items:

Section One: No. 3

Section Two: No. 11

No. 3 (reversed scoring)

c) Task significance. Average the following items:

Section One: No. 5

Section two: No. 8

No. 14 (reversed scoring)

d) Autonomy. Average the following items:

Section One: No. 2

Section Two: No. 13

No. 9 (reversed scoring)

e) Feedback from the job itself. Average the following items:

Section One: No. 7

Section Two: No. 4

No. 12 (reversed scoring)

f) Feedback from agents. Average the following items:

Section One: No. 6

Section Two: No. 10

No. 7 (reversed scoring)

g) Dealing with others. Average the following items:

Section One: No. 1

Section Two: No. 2

No. 6 (reversed scoring)

II. EXPERIENCED PSYCHOLOGICAL STATES.

Each of the three constructs are measured both directly (Section Three) and indirectly, via projective-type items (Section Five)

a) Experienced meaningfulness of the work. Average the following items:

Section Three: No. 7

No. 4 (reversed scoring)

Section Five: No. 6

No. 3 (reversed scoring)

b) Experienced responsibility for the work. Average the following items:

Section Three: Nos. 8, 12, 15.

No. 1 (reversed scoring)

Section Five: Nos. 4, 7.

c) Knowledge of results: Average the following items:

Section Three: No. 5

No. 11 (reversed scoring)

Section Five: No. 5

No. 10 (reversed scoring)

III. AFFECTIVE OUTCOMES.

The first two constructs (general satisfaction and internal work motivation) are measured both directly (Section Three) and indirectly (Section Five): growth satisfaction is measured only directly (Section Four).

a) General satisfaction. Average the following items:

Section Three: Nos. 3, 13.

No. 9 (reversed scoring)

Section Five: No. 2

No. 8 (reversed scoring)

b) Internal work motivation. Average the following items:

Section Three: Nos. 2, 6, 10.

No. 14 (reversed scoring)

Section Five: Nos. 1, 9.

c) Growth satisfaction. Average the following items:

Section Four: Nos. 1, 2, 3, 4.

IV. INDIVIDUAL GROWTH NEED STRENGTH.

The questionnaire yields two separate measures of growth need strength, one from Section Six (the "would like" format) and one from Section Seven (the "job choice" format).

a) "Would like" format (Section Six). Average the six items from Section Six listed below. Before averaging, subtract 3 from each item score; this will result in a summary scale ranging from one to seven. The items are:

Nos. 2, 3, 6, 8, 10, 11.

b) "Job choice" format (Section Seven). Each item in Section Seven yields a number from 1 - 5 (i.e., "Strongly prefer A" is scored 1; "Neutral" is scored 3; and "Strongly prefer B" is scored 5). Compute the need strength measure by averaging the twelve items as follows:

1, 5, 7, 10, 11, 12 (direct scoring)

2, 3, 4, 6, 8, 9 (reversed scoring - i.e. subtract the respondent's score from 6)

Note: To transform the job choice summary score from a 5-point scale to a 7-point scale, use this formula:

$Y = 1.5X - .5.$

c) Combined growth need strength score.
To obtain an overall estimate of growth need strength based on both "would like" and "job choice" data, first transform the "job choice" summary score to a 7-point scale (using the formula given above), and then average the "would like" and the transformed "job choice" summary scores.

APPENDIX IV: Forced Choice Pair Comparison Questionnaire

Listed below are a number of ATC positions found at Heathrow Airport, and grouped into pairs. For each pair in the list, indicate by ticking the appropriate box which position of the pair you would look forward more to working on generally.

If you find it impossible to distinguish between two positions you may tick the middle box, but only do this as a last resort.

Here is an example in which the rater has indicated that generally he would look forward more to working on Air Departures than GMC.

Example 1

☐	☐	☑
GMC		Air Departures

Now complete all the items below. Work quickly and do not check earlier answers.

	☐	☐	☐
1.	Air Arrivals		North Approach
	☐	☐	☐
2.	GMP		No. 1 Director South
	☐	☐	☐
3.	Air Departures		No. 2 Director
	☐	☐	☐
4.	North Approach		No. 2 Director

5. ☐ ☐ ☐

GMC ———————————————————— GMP

6. ☐ ☐ ☐

No. 1 Director South ———————————————————— No. 2 Director

7. ☐ ☐ ☐

GMC ———————————————————— No. 1 Director North

8. ☐ ☐ ☐

North Approach ———————————————————— Air Departures

9. ☐ ☐ ☐

GMP ———————————————————— Air Arrivals

10. ☐ ☐ ☐

Air Departures ———————————————————— GMP

11. ☐ ☐ ☐

No. 1 Director North ———————————————————— North Approach

12. ☐ ☐ ☐

Air Arrivals ———————————————————— GMC

13. ☐ ☐ ☐

No. 2 Director ———————————————————— GMP

14. ☐ ☐ ☐

GMC ———————————————— No. 1 Director South

15. ☐ ☐ ☐

GMP ———————————————— No. 1 Director North

16. ☐ ☐ ☐

North approach ———————————————— No. 1 Director South

17. ☐ ☐ ☐

No. 1 Director South ———————————————— Air Departures

18. ☐ ☐ ☐

GMP ———————————————— North Approach

19. ☐ ☐ ☐

No. 1 Director North ———————————————— No. 2 Director

20. ☐ ☐ ☐

GMC ———————————————— No. 2 Director

21. ☐ ☐ ☐

Air Arrivals ———————————————— No. 1 Director South

22. ☐ ☐ ☐

GMC ———————————————— North Approach

23. ☐ ☐ ☐

No. 1 Director North ———————— No. 1 Director South

24. ☐ ☐ ☐

GMC ———————— Air Departures

25. ☐ ☐ ☐

Air Departures ———————— No. 1 Director North

26. ☐ ☐ ☐

Air Arrivals ———————— No. 1 Director North

27. ☐ ☐ ☐

Air Departures ———————— Air Arrivals

28. ☐ ☐ ☐

Air Arrivals ———————— No. 2 Director

29. ☐ ☐ ☐

Any Position in tower ———————— Any Position in Approach

APPENDIX V: Rank Preference Raw Data and Kendall's ω calculations.

a) Forced Choice Pair Comparisons

Subject	GMP	GMC	AA	AD	NAPC	No.1N	No.1S	No.2	
					Positions				
1	6	4	7	3	5	1	2	8	
2	6	1.5	6	1.5	8	3.5	3.5	6	
3	8	2	5	2	7	4	6	2	
4	6	2	8	5	7	1	3	4	
5	7	2	8	5	6	1	3	4	
6	6	1	7	2	8	3	4	5	
7	7	2	7	4	7	2	2	5	
8	5	3	8	1	7	4	6	2	
9	7	1.5	6	1.5	8	4	4	4	
10	6.5	1	6.5	2	8	3	5	4	
11	7	1	6	5	8	3	3	3	
12	8	1	7	4	6	2	5	3	
13	5	1	7	2	8	3.5	6	3.5	
14	7	1	6	2	8	3	4	5	
15	6	2	7	3	8	1	4	5	
16	6	2	8	5	7	1	3	4	
17	6	1	7	5	4	3	2	8	
18	5.5	1.5	7.5	4	7.5	1.5	5.5	3	
19	7	4	6	2	8	1	5	3	
20	7	1	6	3	8	2	4	5	
21	7	2	5	3	8	4	5	1	
22	8	1	6	2	7	3	5	4	
23	8	3	7	4	6	1	5	2	
24	6	5	7	2.5	8	1	2.5	4	
25	8	3	6	1.5	7	1.5	5	4	
26	6	2	8	5	7	1	3	4	
27	5	5	7	1	8	2.5	5	2.5	
28	7	2	5	1	8	3	6	4	
29	7	2	6	4	8	1	3	5	
30	7	4.5	6	1.5	8	1.5	3	4.5	
31	7	1	6	2	8	3	5	4	
32	6	2	7	1	8	4	5	3	
33	7.5	3	5.5	1	7.5	2	5.5	4	
34	7	1	6	2	8	4	5	3	
35	6	4	8	3	7	2	5	1	
36	6.5	1	8	3.5	6.5	2	5	3.5	
37	3.5	2	5	1	7.5	6	7.5	3.5	
	241.5	79	245.5	101	271	90	160.5	143.5	$\Sigma R_j = 166.5$
	75	-87.5	79	-65.5	104.5	-76.5	-6	-23	
	5625	7656.25	6241	4290.25	10920.25	5852.25	36	529	

s=41,150

$$\omega = \frac{41{,}150}{\frac{37^2}{12}\,(8^3 - 8)} = \frac{41{,}150}{114.08\ (504)} = \frac{41{,}150}{57497.998}$$

$$= 0.716$$

$$\chi^2 = 37\ (7)\ (0.716)$$

$$= 185.4$$

Ho $p < 0.001$

(b) Simple Ranking

				Positions					
Subject	GMP	GMC	AA	AD	APC	No.1N	No.1S	No.2	SVFR
1	7	2	8	2	6	2	4	5	9
2	8	2	7	5	9	3.5	3.5	1	6
3	6	4	9	3	8	1	7	2	5
4	6	2.5	8	2.5	7	2.5	5	2.5	9
5	8	3	6	5	9	1	2	4	7
6	8	5	9	3	7	1	2	5	5
7	7	4	8	5	9	1	3	2	6
8	9	3	6	2	8	1	5	4	7
9	7.5	1.5	7.5	5	7.5	3	4	1.5	7.5
10	7	1	8	2	9	3	4.5	4.5	6
11	7	1	8	4	6	2.5	2.5	5	9
12	7	1	9	5	8	2	4	3	6
13	7	6	8	3	9	1	2	5	4
14	8	1	9	2.5	7	2.5	4.5	4.5	6
15	8	3	5	4	7	1	2	6	9
16	8	1	6	3	9	2	5	4	7
17	6	1	7	4	9	2	3	5	8
18	6	4	8	2	9	1	3	5	7
19	9	5	6	4	8	1	3	2	7
20	9	1	6	5	7	2	3	8	4
21	7	1	9	4	8	2	6	3	5
22	5	7	9	4	8	1	2	3	6
23	6.5	1	9	2	6.5	3	4	6.5	6.5
24	6.5	2	8	2	6.5	2	4.5	4.5	9
TOTAL	173.5	63	183.5	83	187.5	44	88.5	96	161
	53.5	-57	63.5	-37	67.5	-76	-31.5	-24	41
	2862.25	3249	4032.25	1369	4556.25	5776	992.25	576	1681

s = 25,094

$$\text{Kendall's } \omega = \frac{25{,}094}{\frac{24^2}{12}\,(9^3 - 9)} = \frac{25{,}094}{48\ (720)} = \frac{25{,}094}{34{,}560}$$

$$= 0.726$$

$$\chi^2 = 24\ (9 - 1)\ 0.726$$

$$= 139.392$$

Ho $p < 0.001$

APPENDIX VI

HEATHROW POSITIONS: TESTS ON MEANS BY NEWMAN-KEULS PROCEDURE

(a) Skill Variety

Ordered Means	2.834	4.000	4.250	4.960	5.668	5.916		Critical values	
Positions	AA	GMP	APC	AD	GMC	No.1	r	.01	.05
AA		1.166	1.416	2.126	2.834	3.082	6	1.873	1.571
GMP			0.250	0.960	1.668	1.916	5	1.808	1.502
APC				0.710	1.418	1.666	4	1.728	1.415
AD					0.708	0.956	3	1.613	1.285
GMC						0.248	2	1.418	1.074

(b) Task Identity

Ordered Means	2.541	3.000	3.374	3.959	4.249	4.334		Critical values	
Positions	AA	APC	GMP	No.1	GMC	AD	r	.01	.05
AA		0.459	0.833	1.418	1.708	1.793	6	1.873	1.571
APC			0.374	0.959	1.249	1.334	5	1.808	1.502
GMP				0.585	0.875	0.960	4	1.728	1.415
No.1					0.290	0.375	3	1.613	1.285
GMC						0.085	2	1.418	1.074

(c) Autonomy

Ordered Means	3.834	4.083	4.584	4.999	5.540	6.626		Critical values	
Positions	APC	AA	No.1	GMP	AD	GMC	r	.01	.05
APC		0.249	0.750	1.165	1.706	2.791	6	1.873	1.571
AA			0.501	0.916	1.457	2.542	5	1.808	1.502
No.1				0.415	0.956	2.041	4	1.728	1.415
GMP					0.541	1.626	3	1.613	1.285
AD						1.085	2	1.418	1.074

(d) Feedback from Job

Ordered Means	2.834	4.960	5.084	5.625	5.626	5.668		Critical values	
Positions	AA	GMP	APC	GMC	No.1	AD	r	.01	.05
AA		2.126	2.250	2.791	2.792	2.834	6	1.873	1.571
GMP			0.124	0.665	0.666	0.708	5	1.808	1.502
APC				0.541	0.542	0.584	4	1.728	1.415
GMC					0.001	0.043	3	1.613	1.285
No.1						0.042	2	1.418	1.074

(e) Dealing with Others

Ordered Means	4.083	5.333	5.709	6.168	6.293	6.374		Critical values	
Positions	AD	GMC	AA	GMP	No.1	APC	r	.01	.05
AD		1.250	1.626	2.085	2.210	2.291	6	1.873	1.571
GMC			0.376	0.835	0.960	1.041	5	1.808	1.502
AA				0.459	0.584	0.665	4	1.728	1.415
GMP					0.125	0.206	3	1.613	1.285
No.1						0.081	2	1.418	1.074

(f) Experienced Meaningfulness

Ordered Means	4.031	4.500	5.063	5.813	5.875	5.906		Critical values	
Positions	AA	GMP	APC	GMC	No.1	Ad	r	.01	.05
AA		0.469	1.032	1.782	1.844	1.875	6	1.873	1.571
GMP			0.563	1.313	1.375	1.406	5	1.808	1.502
APC				0.750	0.812	0.843	4	1.728	1.415
GMC					0.062	0.093	3	1.613	1.285
No. 1						0.031	2	1.418	1.074

(g) General Satisfaction

Ordered Means	3.425	3.950	4.375	5.075	5.450	5.725		Critical values	
Positions	AA	GMP	APC	No. 1	AD	GMC	r	.01	.05
AA		0.525	0.950	1.650	2.025	2.300	6	1.873	1.571
GMP			0.425	1.125	1.500	1.775	5	1.808	1.502
APC				0.700	1.075	1.350	4	1.728	1.415
No. 1					0.375	0.650	3	1.613	1.285
AD						0.275	2	1.418	1.074

(h) Growth Satisfaction

Ordered Means	3.406	4.406	4.531	4.719	5.125	6.000		Critical values	
Positions	AA	APC	GMP	No.1	AD	GMC	r	.01	.05
AA		1.000	1.125	1.313	1.719	2.594	6	1.873	1.571
APC			0.125	0.313	0.719	1.594	5	1.808	1.502
GMP				0.188	0.594	1.469	4	1.728	1.415
No. 1					0.406	1.281	3	1.613	1.285
AD						0.875	2	1.418	1.074

APPENDIX VII

Common Construct Clusters from Initial Rep Grid Interviews

Preferred Pole	Non-preferred Pole
JOB SATISFACTION	
1. Gives satisfaction	Bored by it
2. Greatly enjoy it	Boring
3. Extremely likeable	Most frustrating
4. Gives me job satisfaction when I do it well	No job satisfaction at all
5. Can feel I've done something to the best of my ability	Merely has to be done
6. More interesting part of job	Mundane
7. Get job satisfaction from	Distinctly dissatisfying
DECISION-MAKING	
1. Calls for decisions requiring judgement and skill	Doesn't require much effort
2. Decision-making	Decision made for me
3. Requires decision	Done automatically
4. Requires me to think	No brain power needed
5. Requires me to be thinking entity	Like a cog in a machine
SKILL AND EXPERIENCE	
1. Requires knowledge	Not much thought required
2. Must have knowledge and experience	Basic information
3. Draws on my skill and experience	Mundane
4. Uses large amount of my expertise	Uses very little expertise
5. Requires all my experience and skill	Requires no experience and skill
6. Allows me to use judgement	Requires no judgement
CONCENTRATION	
1. Requires constant attention	Routine
2. Important to keep on top of it	Can come back to later
3. Must concentrate when doing	Get slightly lazy doing
4. Very high concentration	No concentration needed
5. Requires continuous assessment	Not much assessment needed
SIGNIFICANCE	
1. Very important	Less important
2. Can see the point of it	Can't see the point of it
3. Primary function	Supplementary task
4. What I'm paid to do	No bearing on what I'm paid to do
5. Essence of radar control	Bits and pieces
6. Describes crux of job	Peripheral
7. What I'm here to do	Administrative
AUTONOMY	
1. At my discretion	Present with fait accompli
2. Don't have to consult anyone else	Involves communication with others
3. Creating my own situation	Presented with situation already worked out
4. Can deal with it myself	May mean consulting others
5. I can make more expeditious	Predetermined

APPENDIX VIII

TASKS USED ON STANDARD GRIDS

(a) Tasks from Heathrow Task Analysis

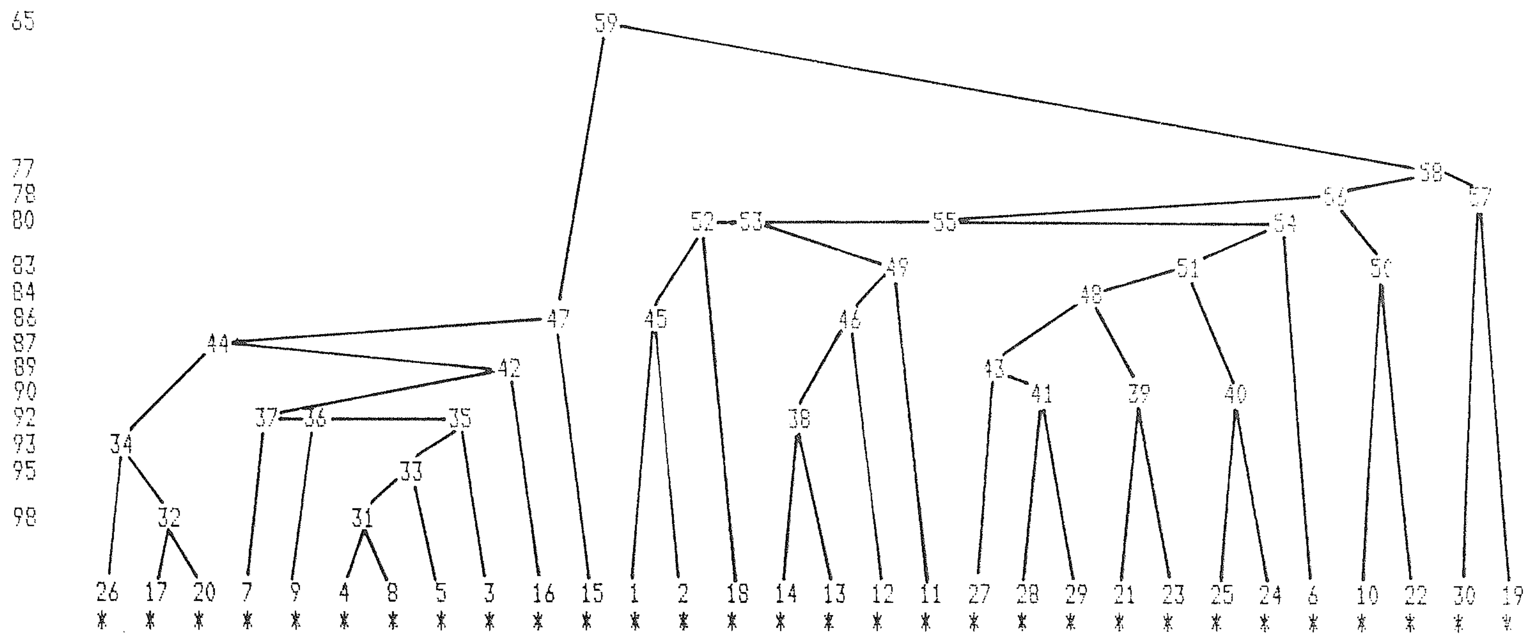
1. Ensure that traffic flow is expeditious (Air Arrivals)
2. Ensure that procedures are carried out for overshoots (Air Arrivals)
3. Establish whether traffic lands safely (Air Arrivals)
4. Ensure that emergencies are dealt with (Air Arrivals)
5. Ensure that traffic remains safely separated (No. 2 Director)
6. Ensure that Tower is informed of approach sequence (No. 2 Director)
7. Ensure that aircraft operational enquiries are dealt with (No. 1 Director)
8. Ensure that traffic remains safely separated (No.1 Director)
9. Ensure that traffic discontinuing approach is integrated into traffic pattern (No. 2 Director)
10. Confirm that traffic has received most recent airfield information (APC/No. 1 Director)
11. Establish what level traffic is cleared to by LATCC and in what order (APC/No. 1 Director)
12. Ensure that CDA assistance is provided when appropriate (No. 1 Director)
13. Ensure that traffic is directed as expeditiously as possible (No. 1 Director)
14. Determine what to do about equipment malfunctions (No. 1 Director)
15. Ensure that traffic is directed on to final approach as expeditiously as possible (No. 2)
16. Establish when traffic is clear to depart (Air Departures)
17. Ensure that procedures are carried out when runway becomes blocked (Air Arrivals)
18. Ensure that traffic remains safely separated (Air Arrivals)
19. Establish whether traffic departs safely (Air Departures)
20. Ensure that emergencies are dealt with (Air Departures)
21. Determine most expeditious order of departures (Air Departures)
22. Decide what to do with traffic (GMC)
23. Ensure that procedures are carried out for traffic crossing runway (Air Departures)
24. Ensure that rotary aircraft are cleared for landing and departure (Air Departures)
25. Assess whether airfield traffic situation requires action by GMP (GMP)
26. Ensure that traffic requiring runway crossing is cleared safely and expeditiously (GMC)
27. Decide start-up times (GMP)
28. Determine airways restrictions (including slot times) on each aircraft (GMP)
29. Ensure that strips are transferred as appropriate (Any position)
30. Identify traffic calling on frequency (Radar)

(b) Tasks from LATCC Task Analysis

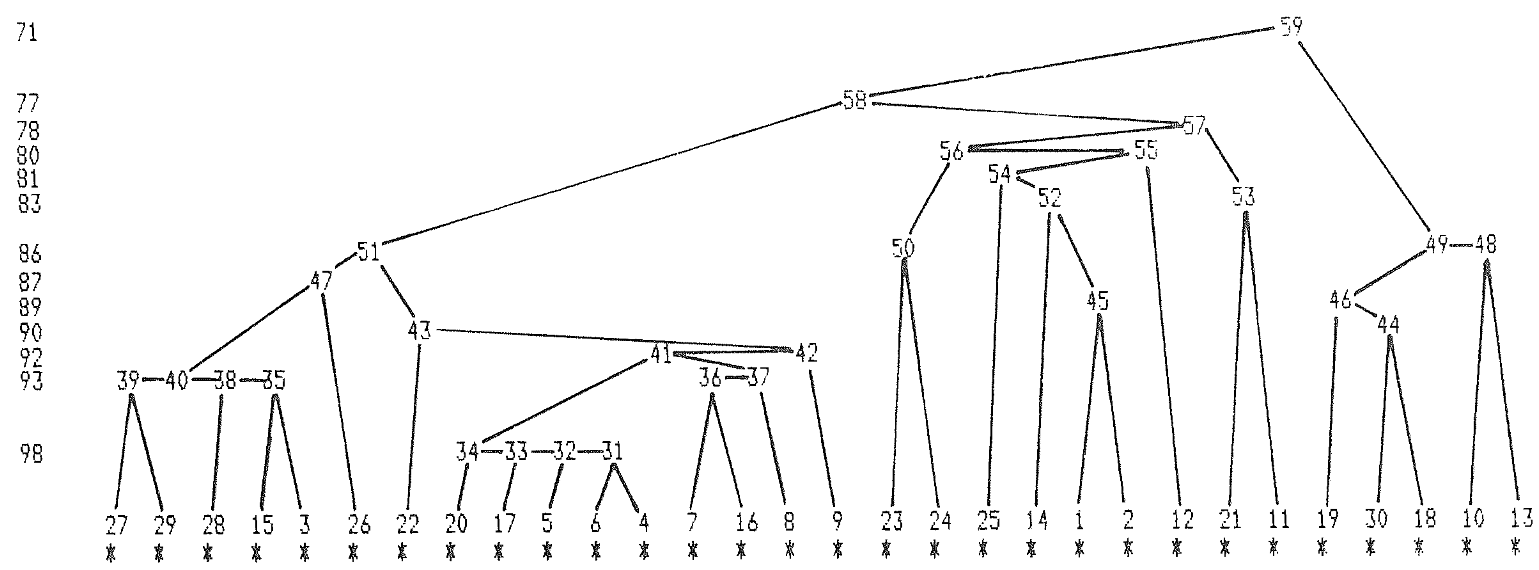
1. Ensure that strips are obtained on all relevant traffic (SC)
2. Identify amendments to strip information e.g. E.T.A.'s (SC)
3. Identify traffic calling on frequency (SC)
4. Assess whether traffic could be climbed/descended to resolve situation (SC)
5. Assess whether vectoring could resolve situation (SC)
6. Assess whether speed change could resolve situation (SC)
7. Ensure that traffic receives and adheres to correct instructions (SC)
8. Assess whether solution is expediting (SC)
9. Ensure that traffic is at appropriate level, speed and heading for handover (SC)
10. Ensure that strips are removed from display when appropriate (SC)
11. Ensure that operational enquiries are dealt with as required (ASC)
12. Ensure that clearances and estimates and revisions are passed as required (ASC)
13. Ensure that strips are distributed as required (ASC)
14. Decide appropriate levels for departing traffic (ASC)
15. Decide priorities for action (SC)
16. Determine relevant features of traffic situation (SC)
17. Identify possible conflictions from strips and radar (SC)
18. Ensure that relevant strips are obtained for traffic entering sector (ASC)
19. Ensure that dead strips are removed and filed as required (ASC)
20. Decide most suitable solution to traffic situation (SC)
21. Ensure that strips are displayed so as to facilitate S.C.'s work (SC)
22. Assess effect of leaving departing traffic on SIDs (SC)
23. Ensure that transfer of control and communication is carried out when appropriate (SC)
24. Ensure that aircraft operational enquiries are dealt with (SC)
25. Ensure that strip amendments are passed to relevant people when appropriate (SC)
26. Ensure that traffic remains safely separated (SC)
27. Evaluate effect of solutions on own and others' workload (SC)
28. Assess relevant aircraft characteristics (SC)
29. Evaluate expediency of solutions for aircraft (SC)
30. Prepare strips for distribution (ASC)

APPENDIX IX: FOCUSed Grids showing Task Clusters - LATCC

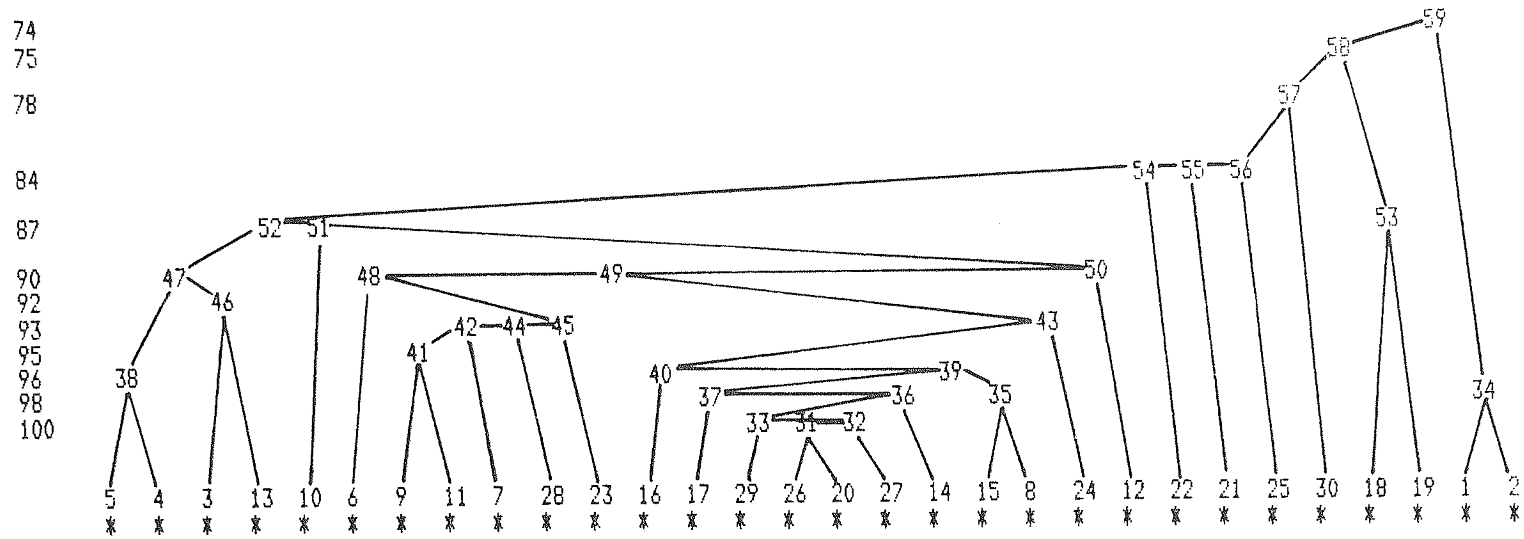
TREE FOR ELEMENTS -- GRID 1



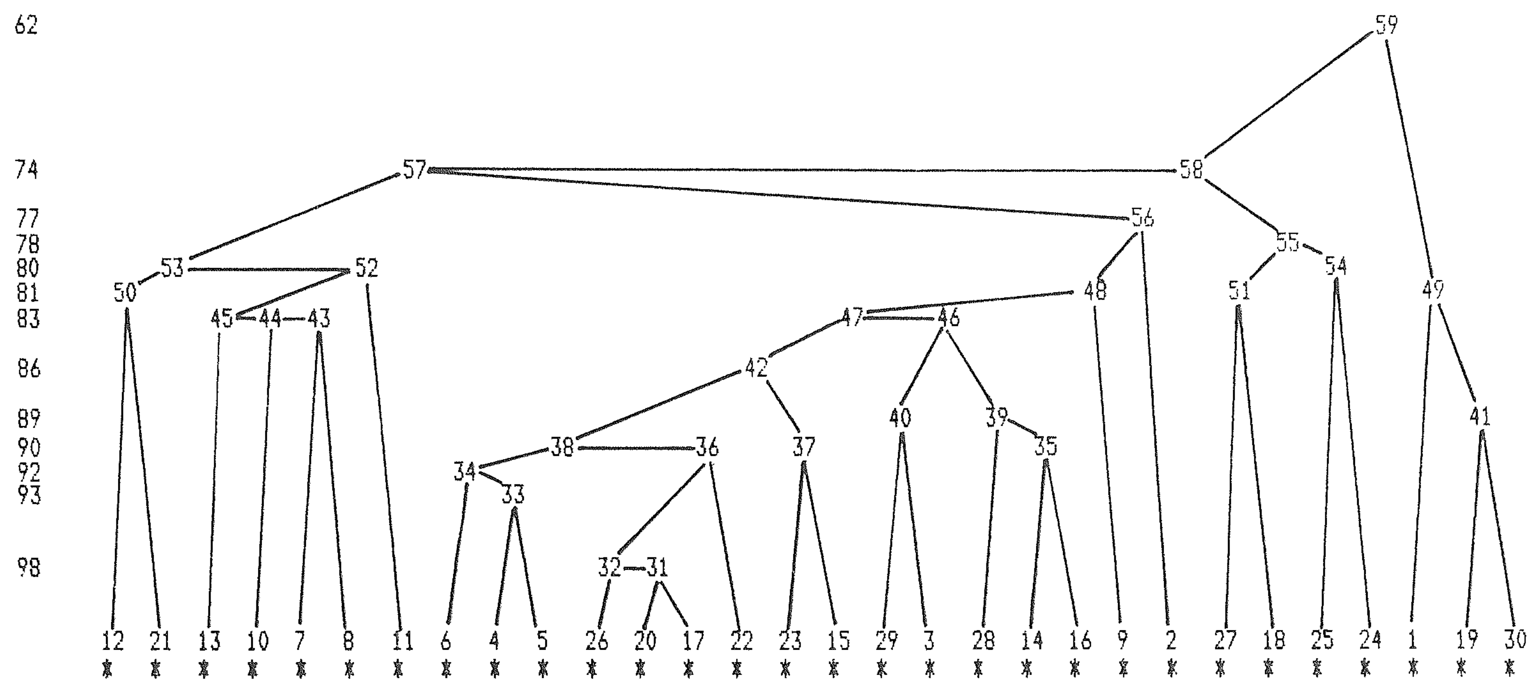
TREE FOR ELEMENTS -- GRID 2



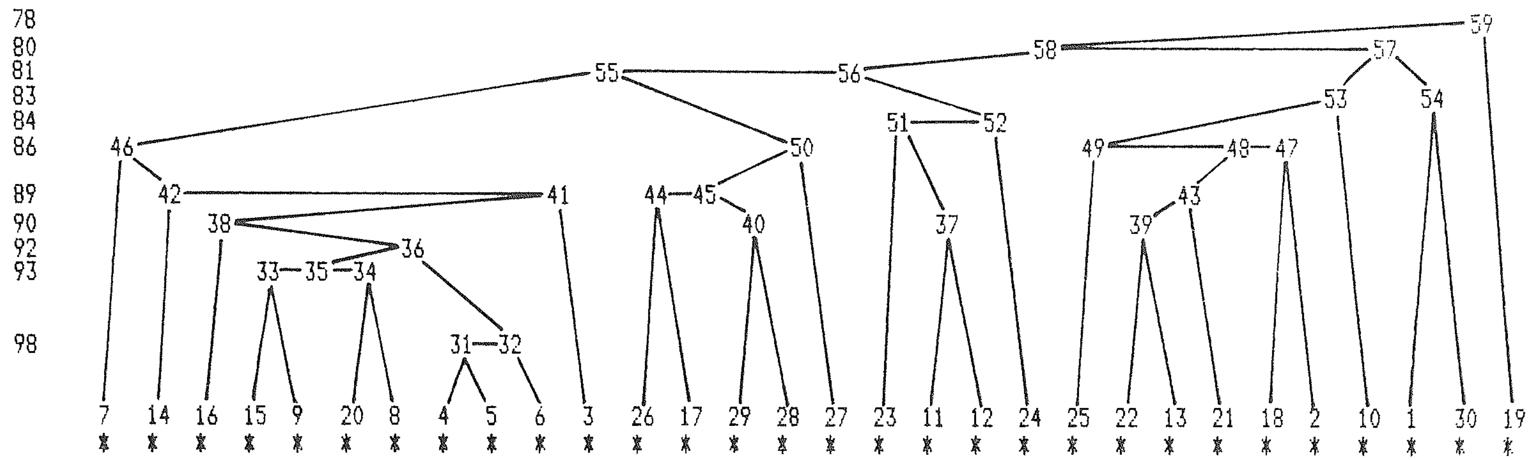
TREE FOR ELEMENTS -- GRID 3



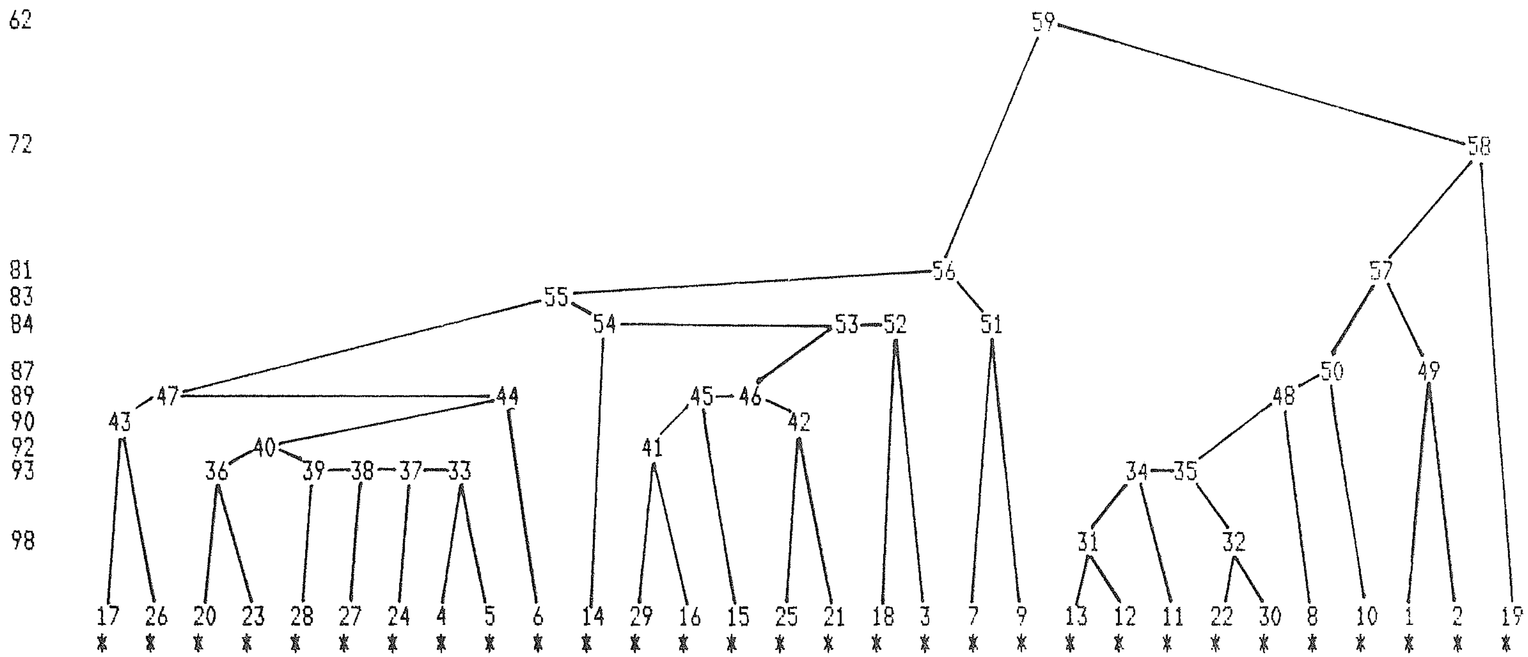
TREE FOR ELEMENTS -- GRID 4



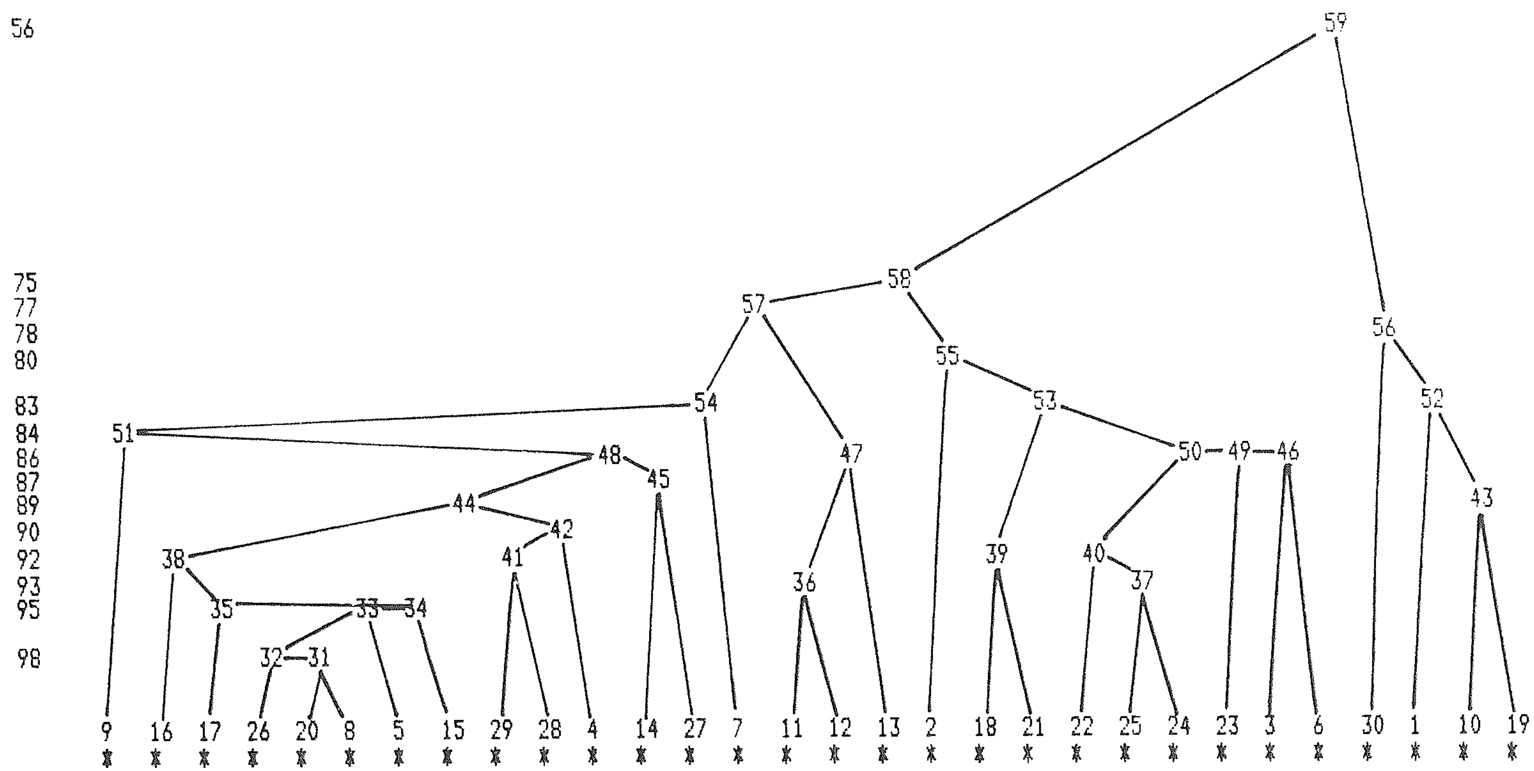
TREE FOR ELEMENTS -- GRID 5



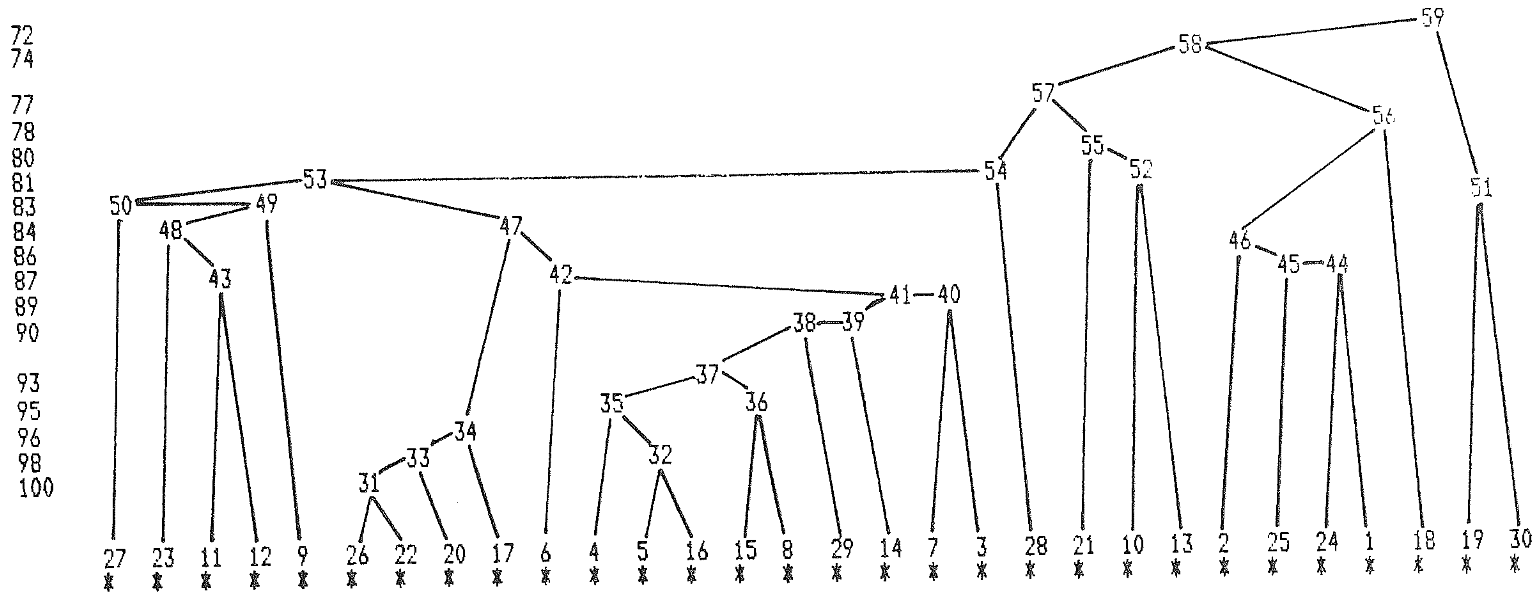
TREE FOR ELEMENTS -- GRID 6



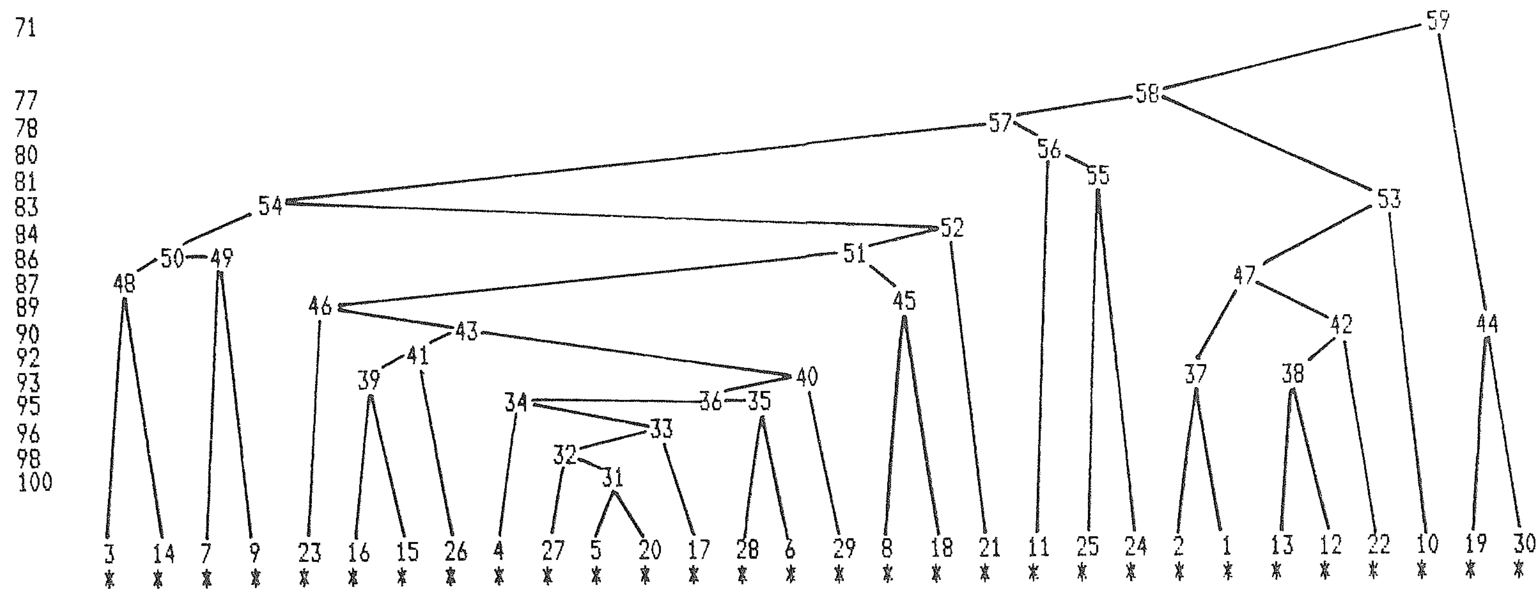
TREE FOR ELEMENTS -- GRID 7



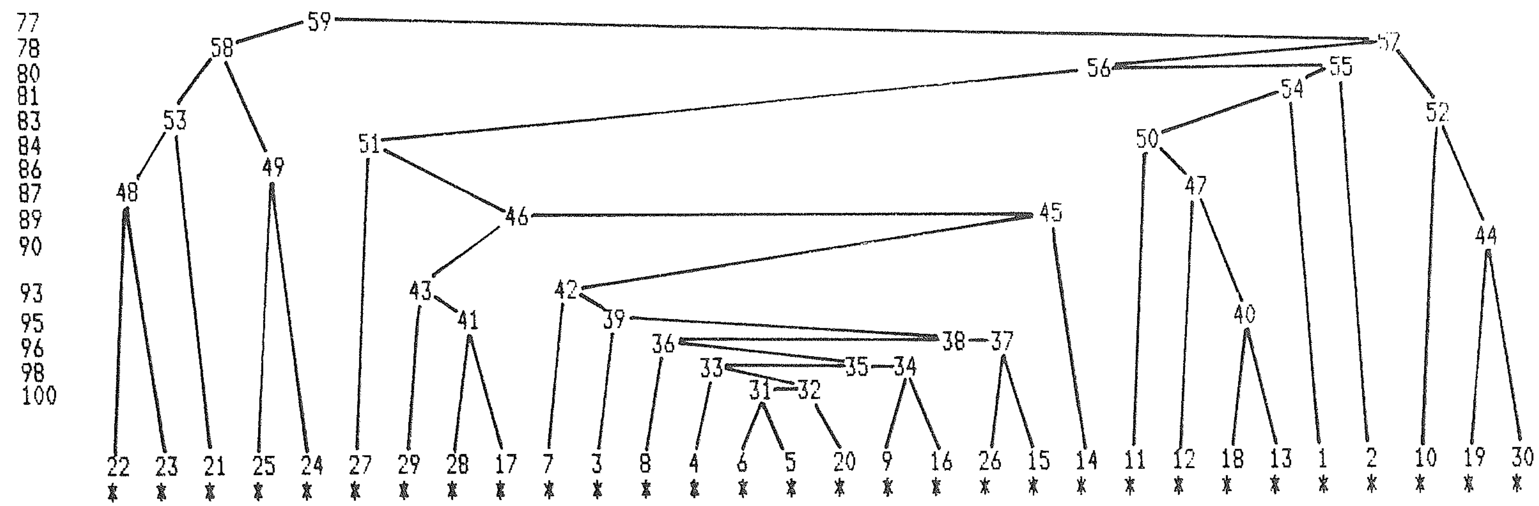
TREE FOR ELEMENTS -- GRID 8



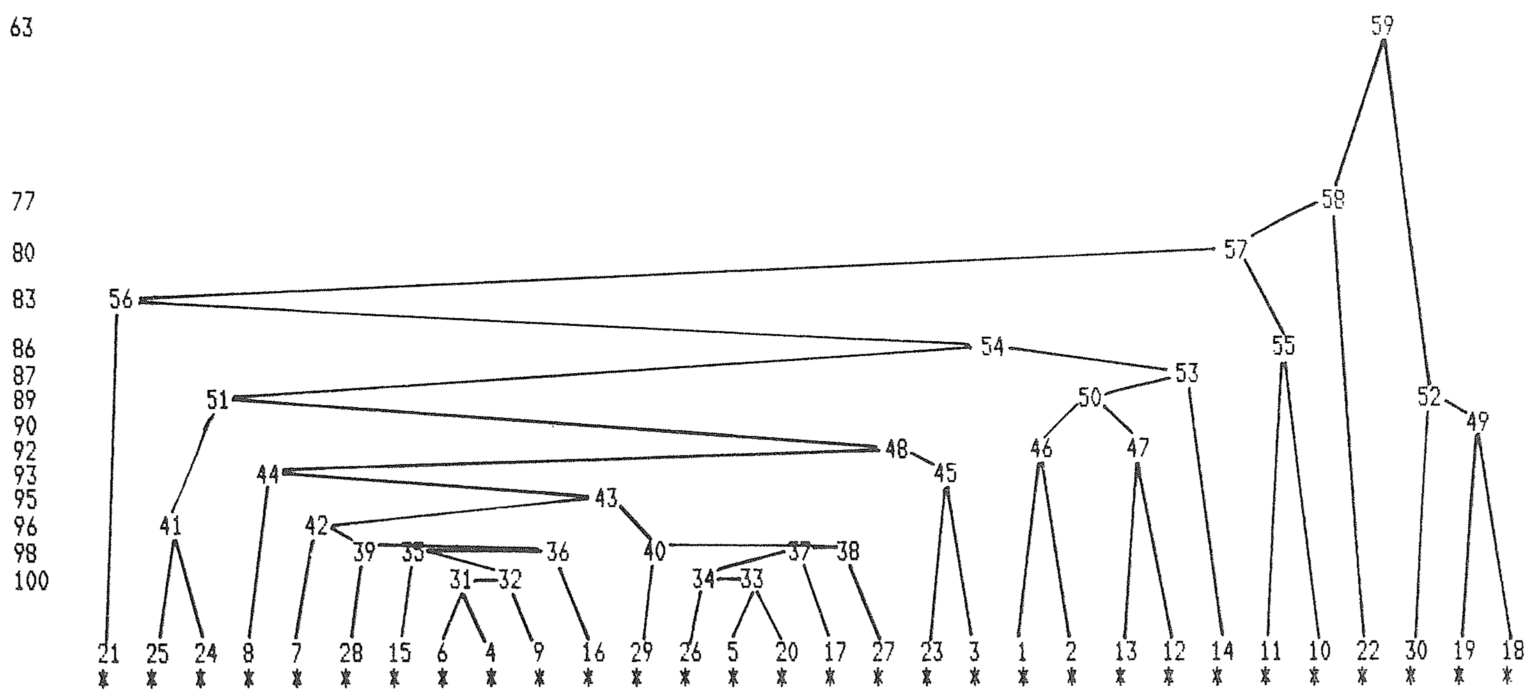
TREE FOR ELEMENTS -- GRID 9



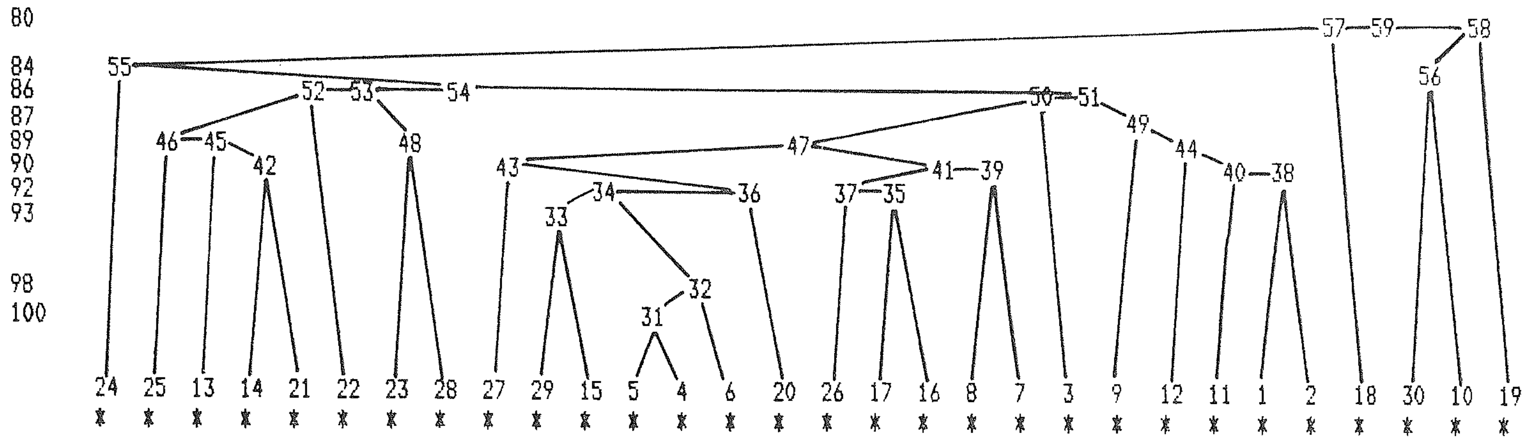
TREE FOR ELEMENTS -- GRID 10



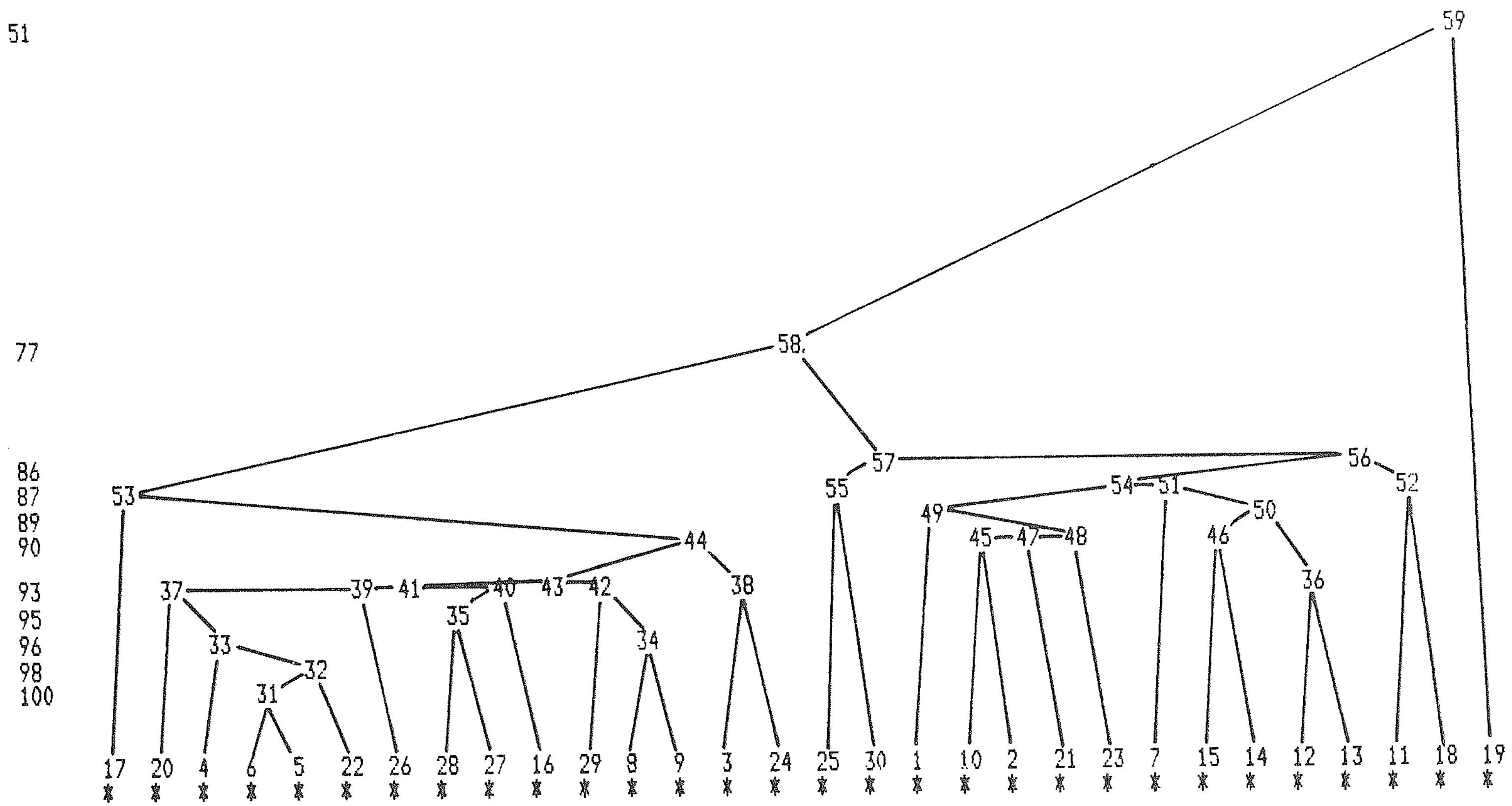
TREE FOR ELEMENTS -- GRID 11



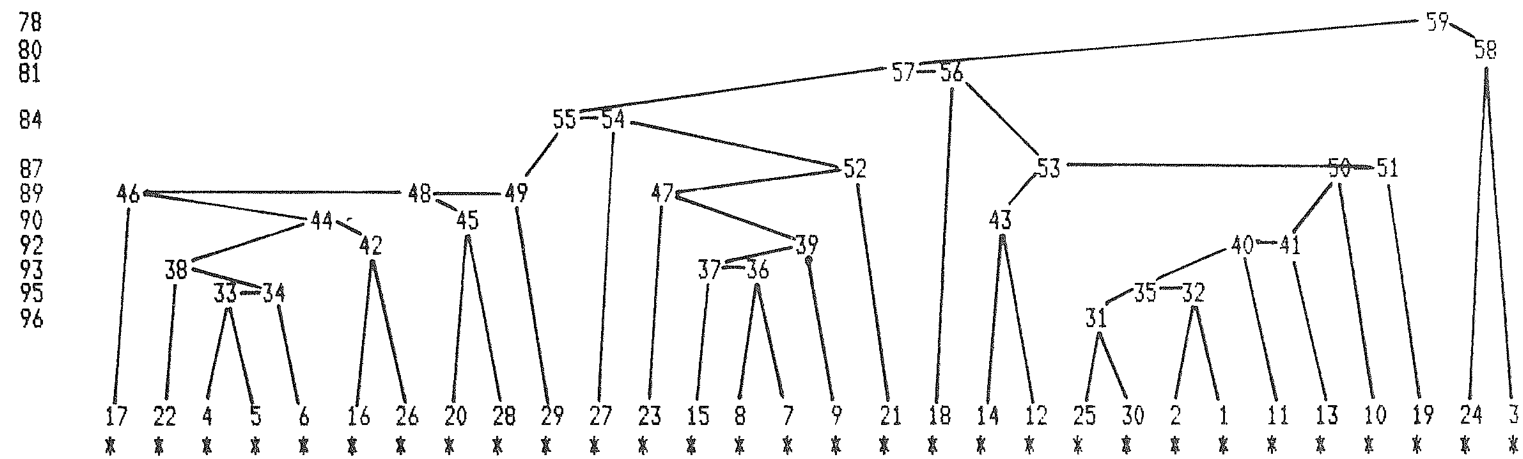
TREE FOR ELEMENTS -- GRID 12



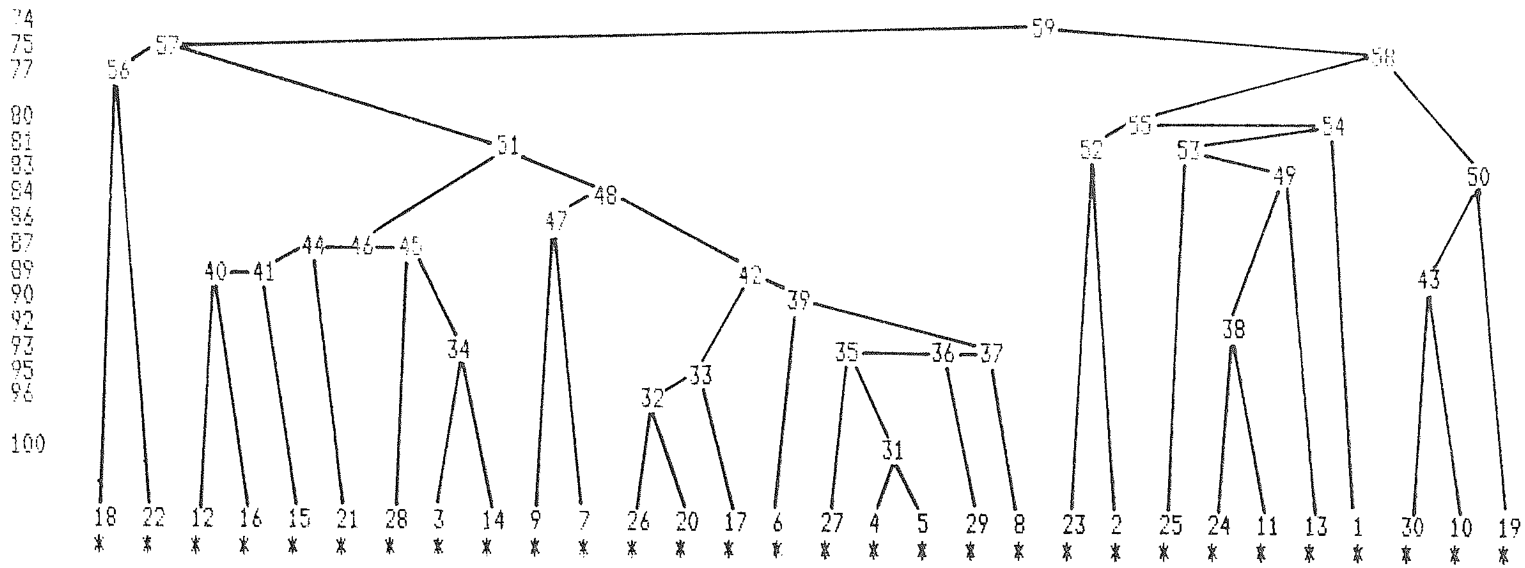
TREE FOR ELEMENTS -- GRID 13



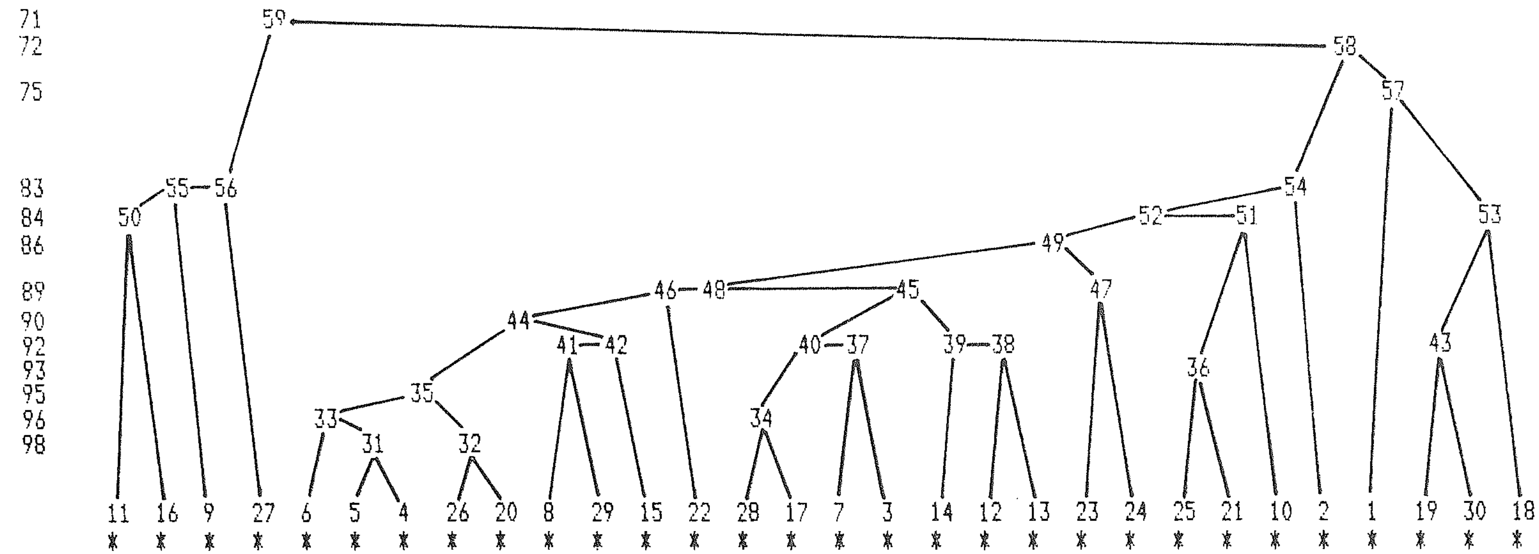
TREE FOR ELEMENTS -- GRID 14



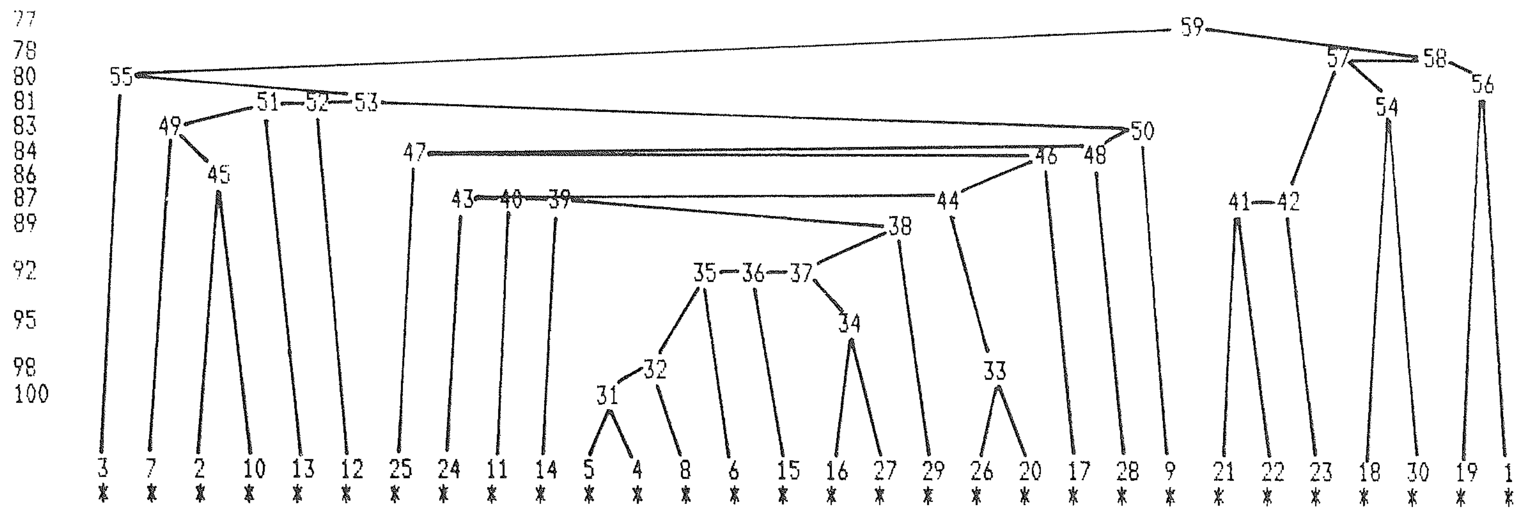
TREE FOR ELEMENTS -- GRID 15



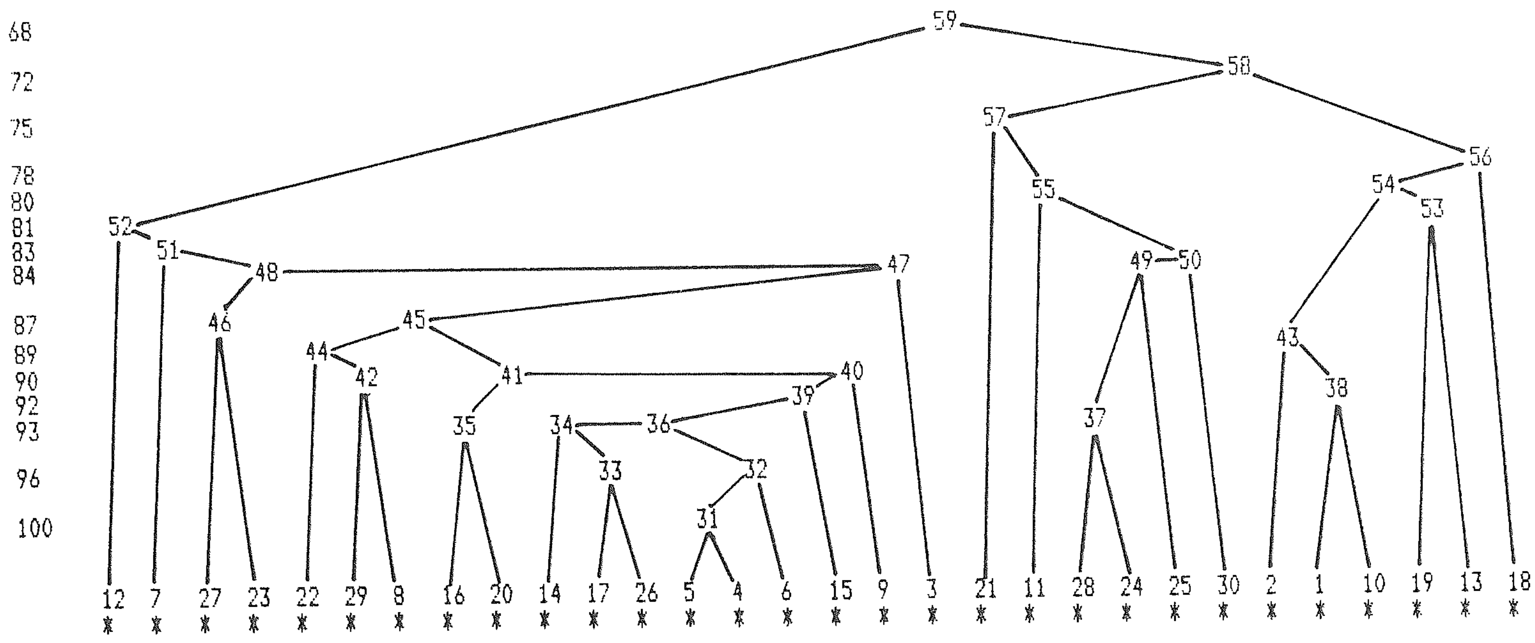
TREE FOR ELEMENTS -- GRID 16

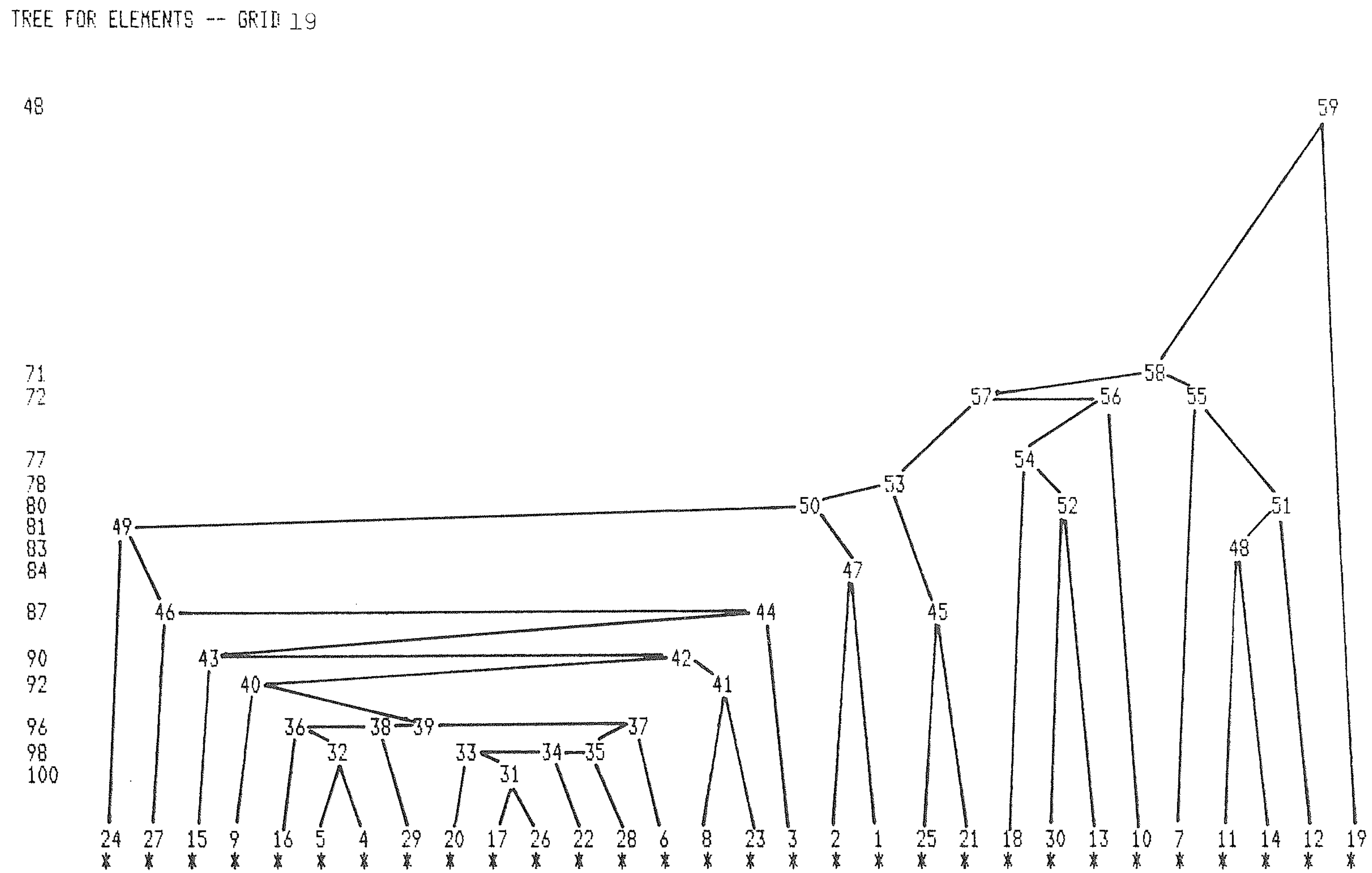


TREE FOR ELEMENTS -- GRID 17



TREE FOR ELEMENTS -- GRID 18

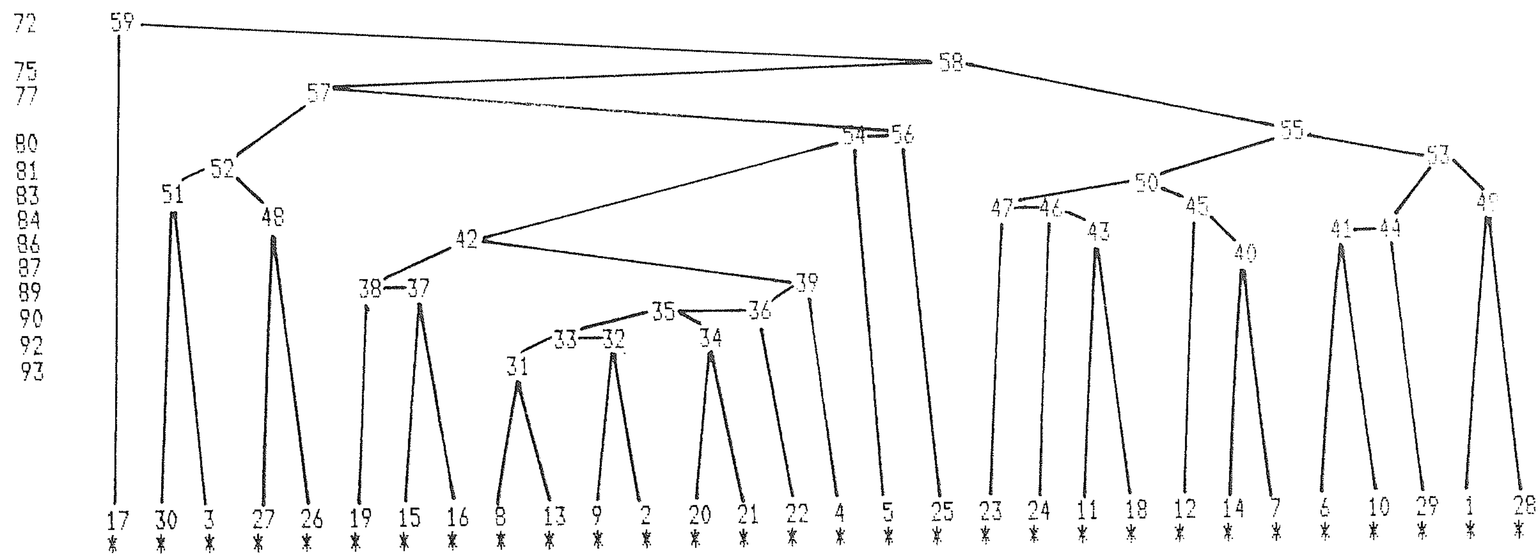




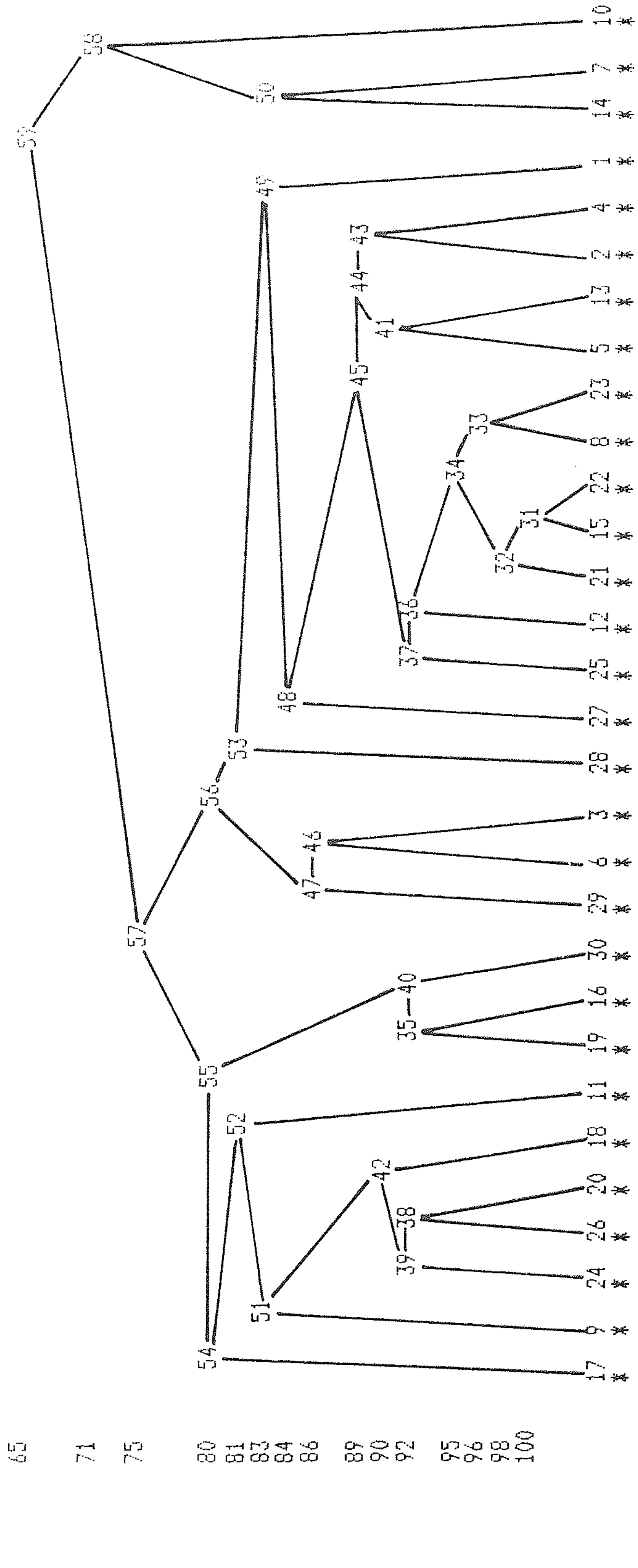
TREE FOR ELEMENTS -- GRID 19
48
71
72
77
78
80
81
83
84
87
90
92
96
98
100

APPENDIX X: FOCUSed Grids showing Task Clusters - Heathrow

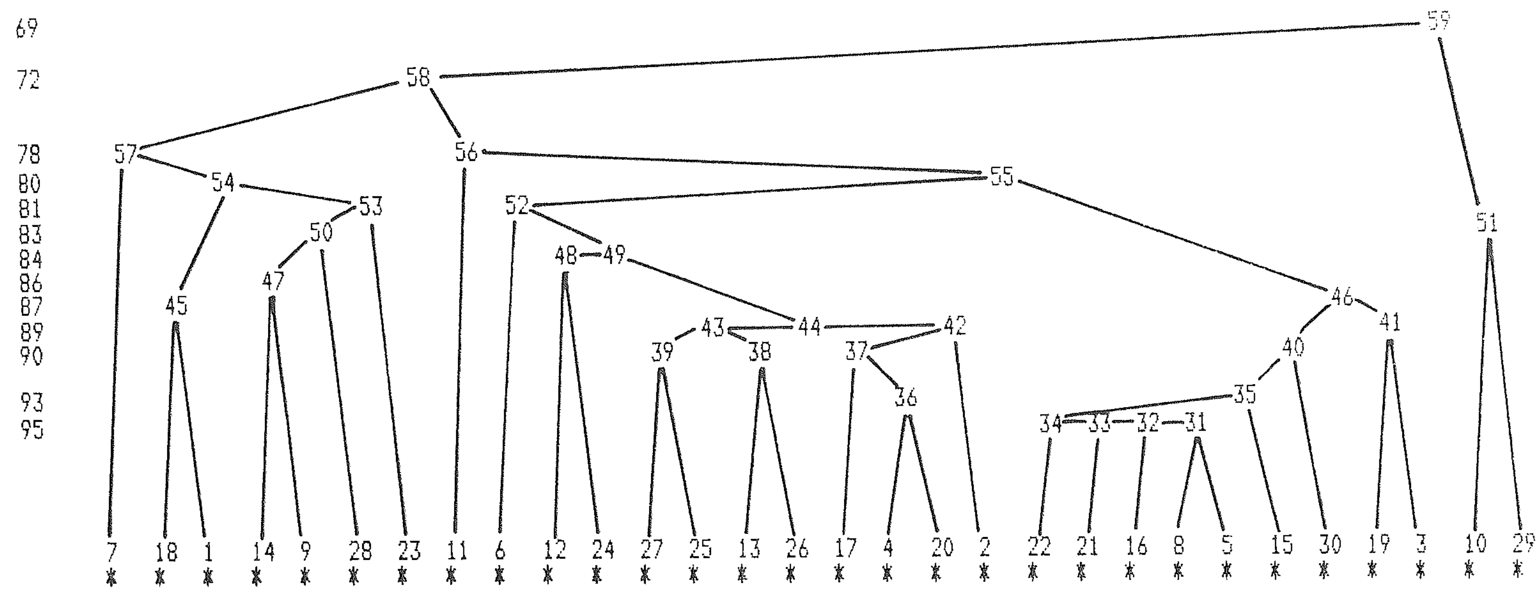
TREE FOR ELEMENTS -- GRID 1



TREE FOR ELEMENTS -- GRID 2

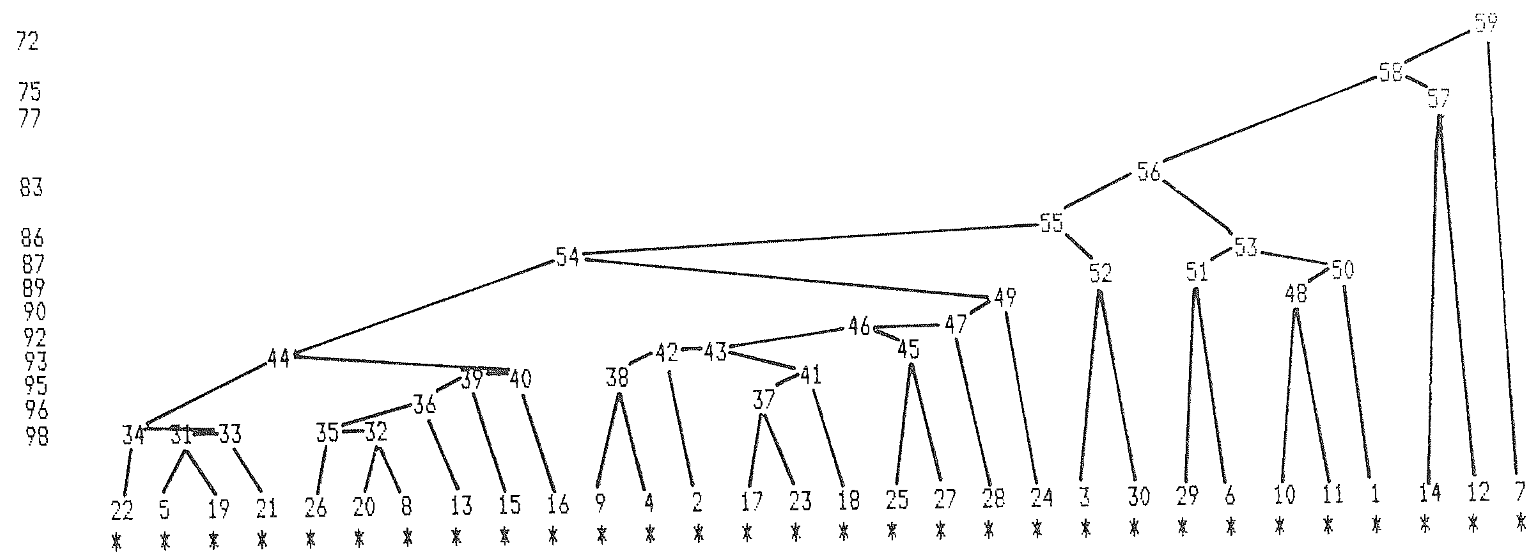


TREE FOR ELEMENTS -- GRID 3

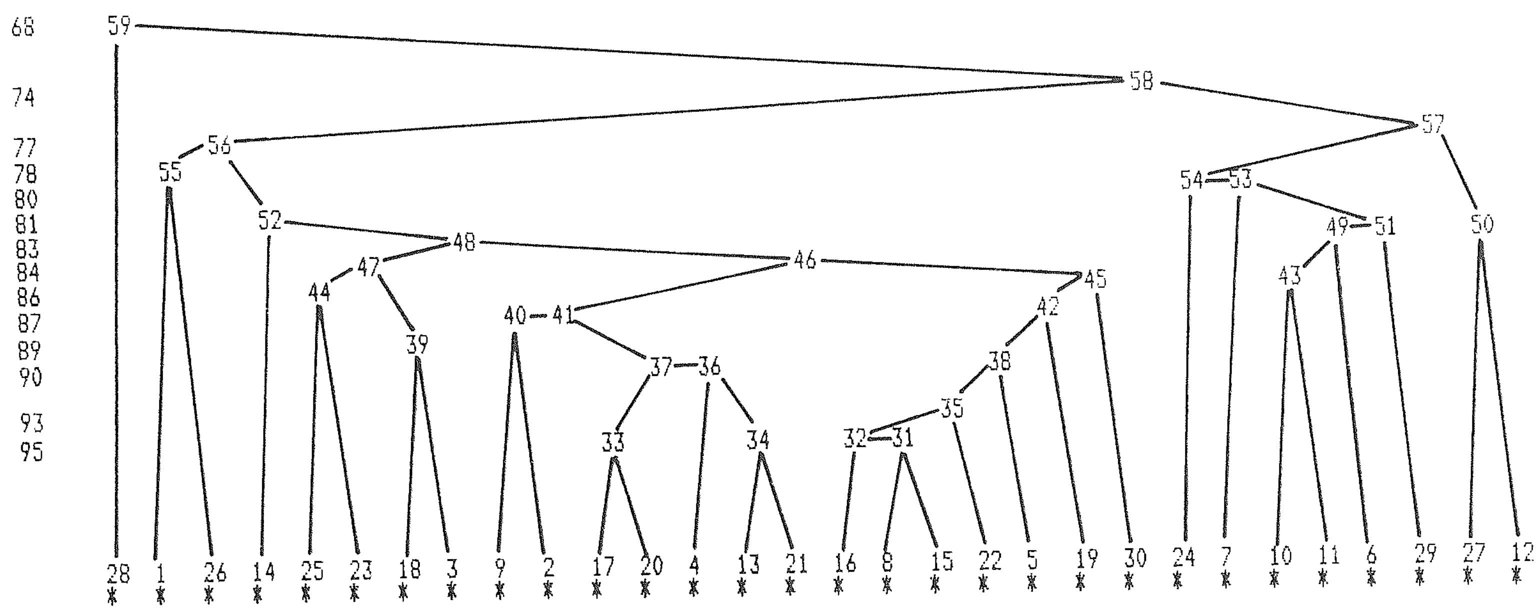


TREE FOR ELEMENTS -- GRID 4

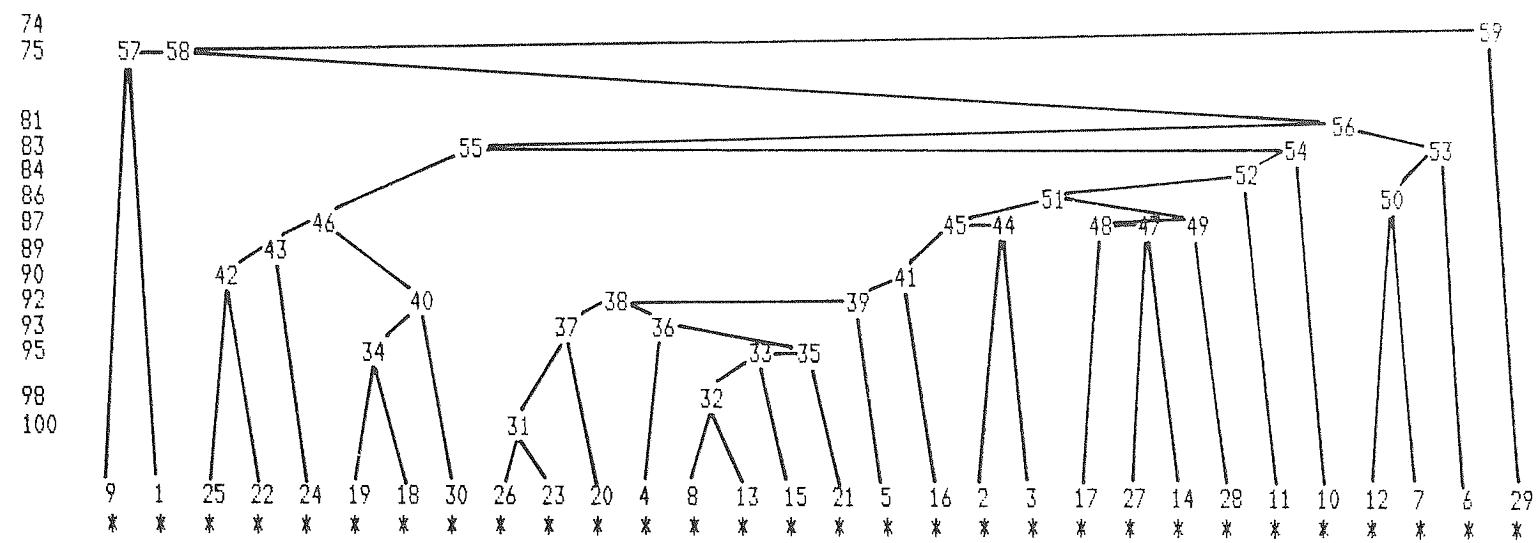
TREE FOR ELEMENTS -- GRID 5



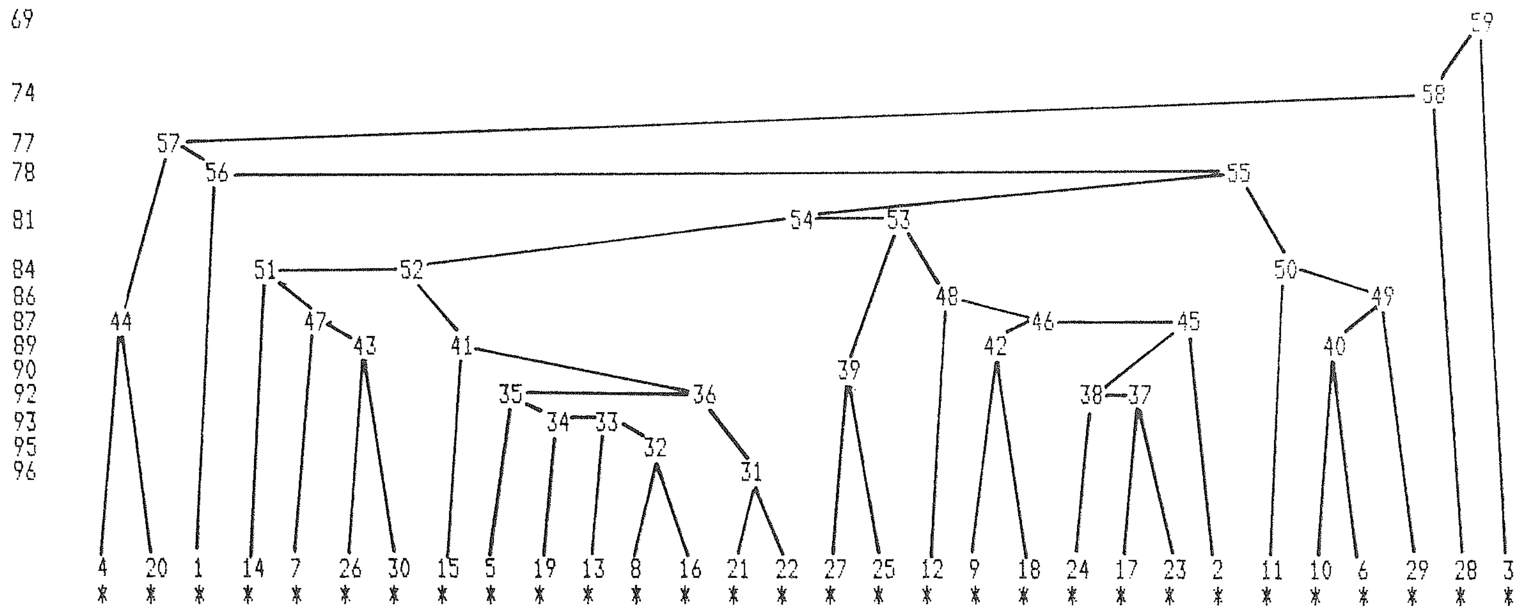
TREE FOR ELEMENTS -- GRID 6



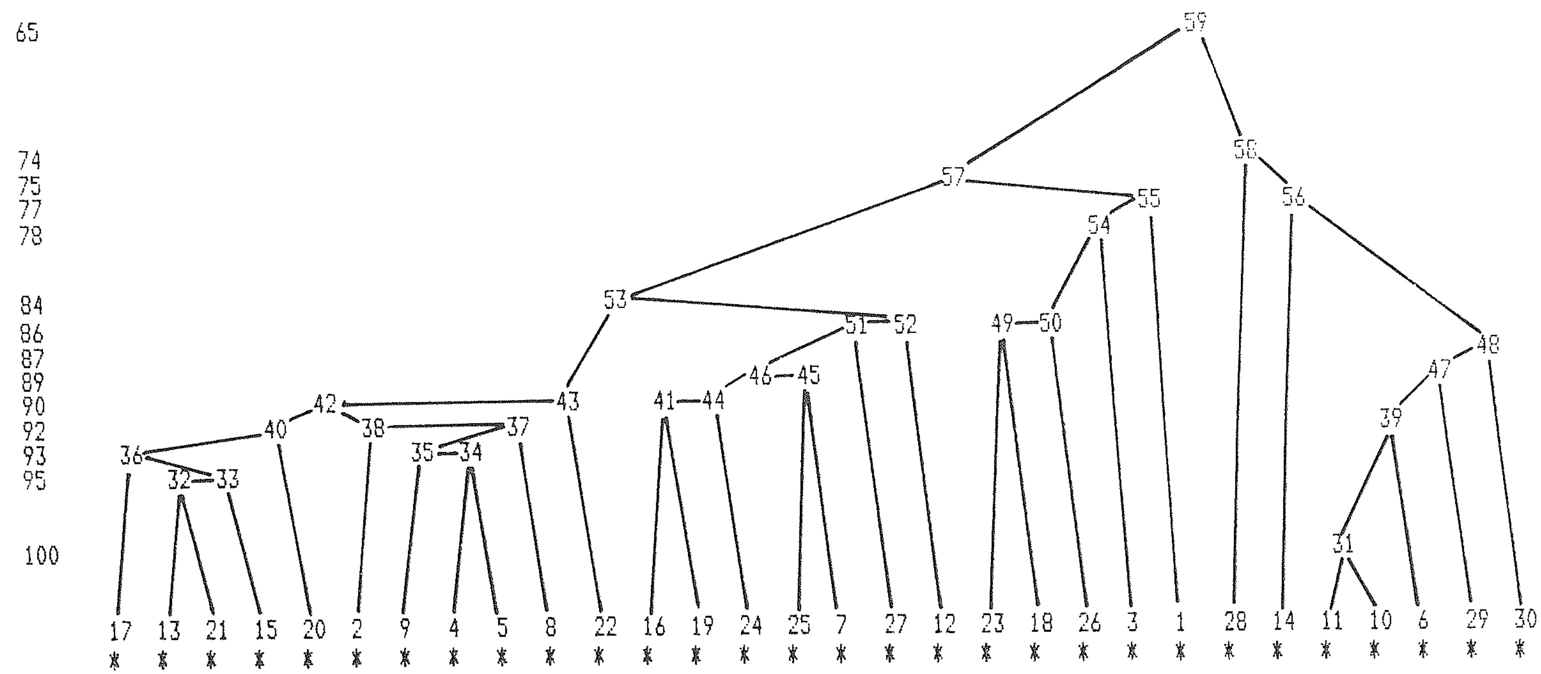
TREE FOR ELEMENTS -- GRID 7



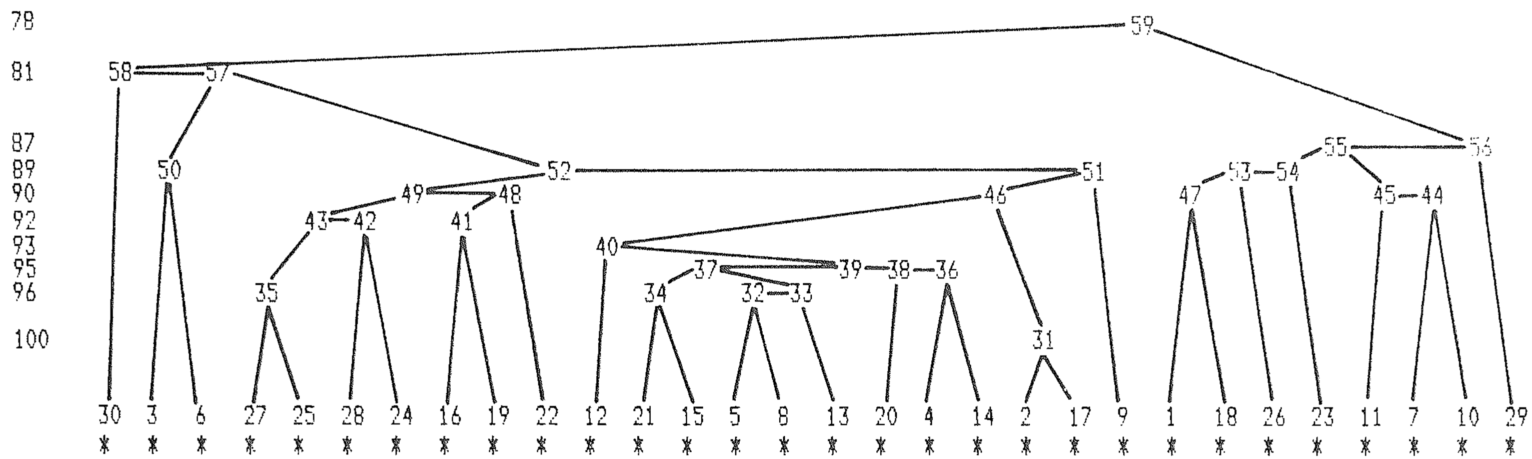
TREE FOR ELEMENTS -- GRID 8



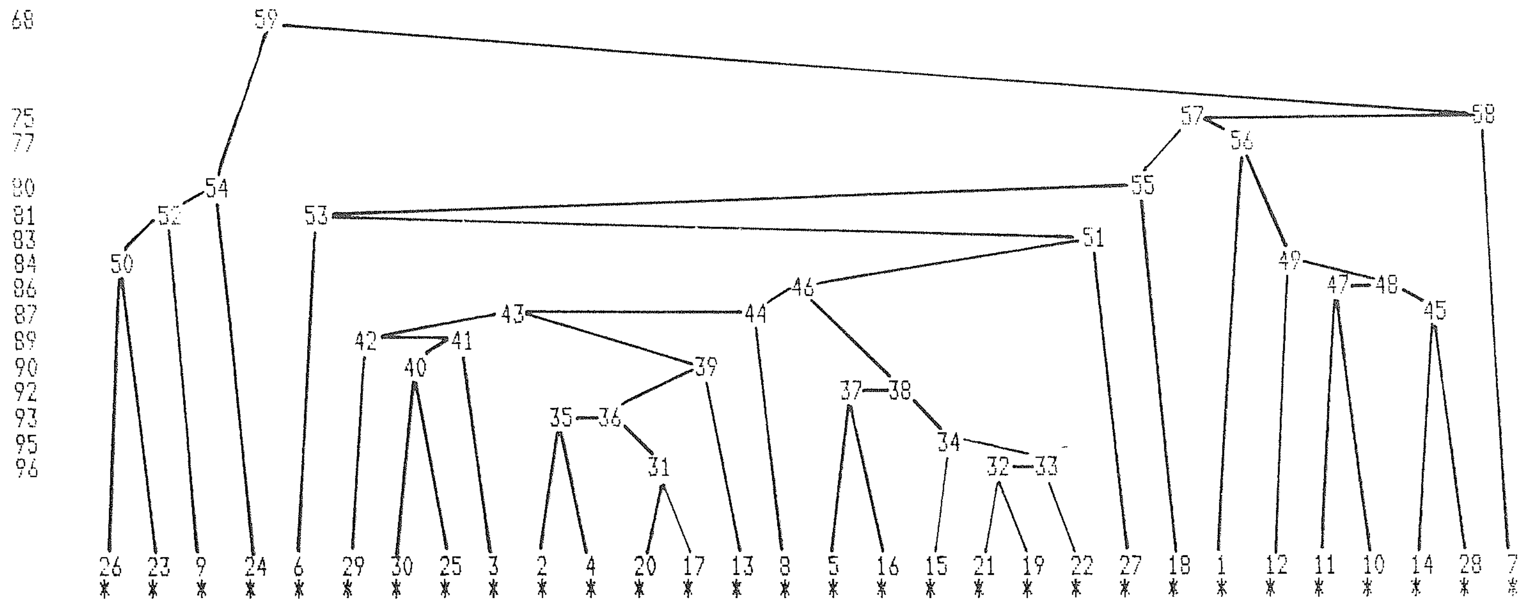
TREE FOR ELEMENTS -- GRID 9



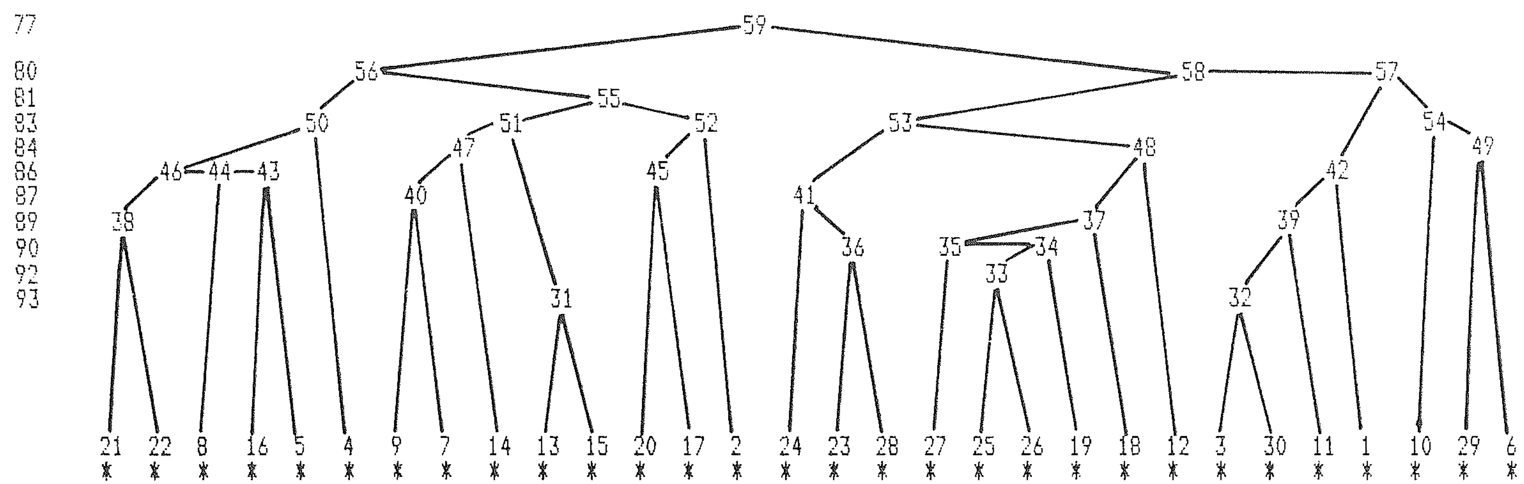
TREE FOR ELEMENTS -- GRID10



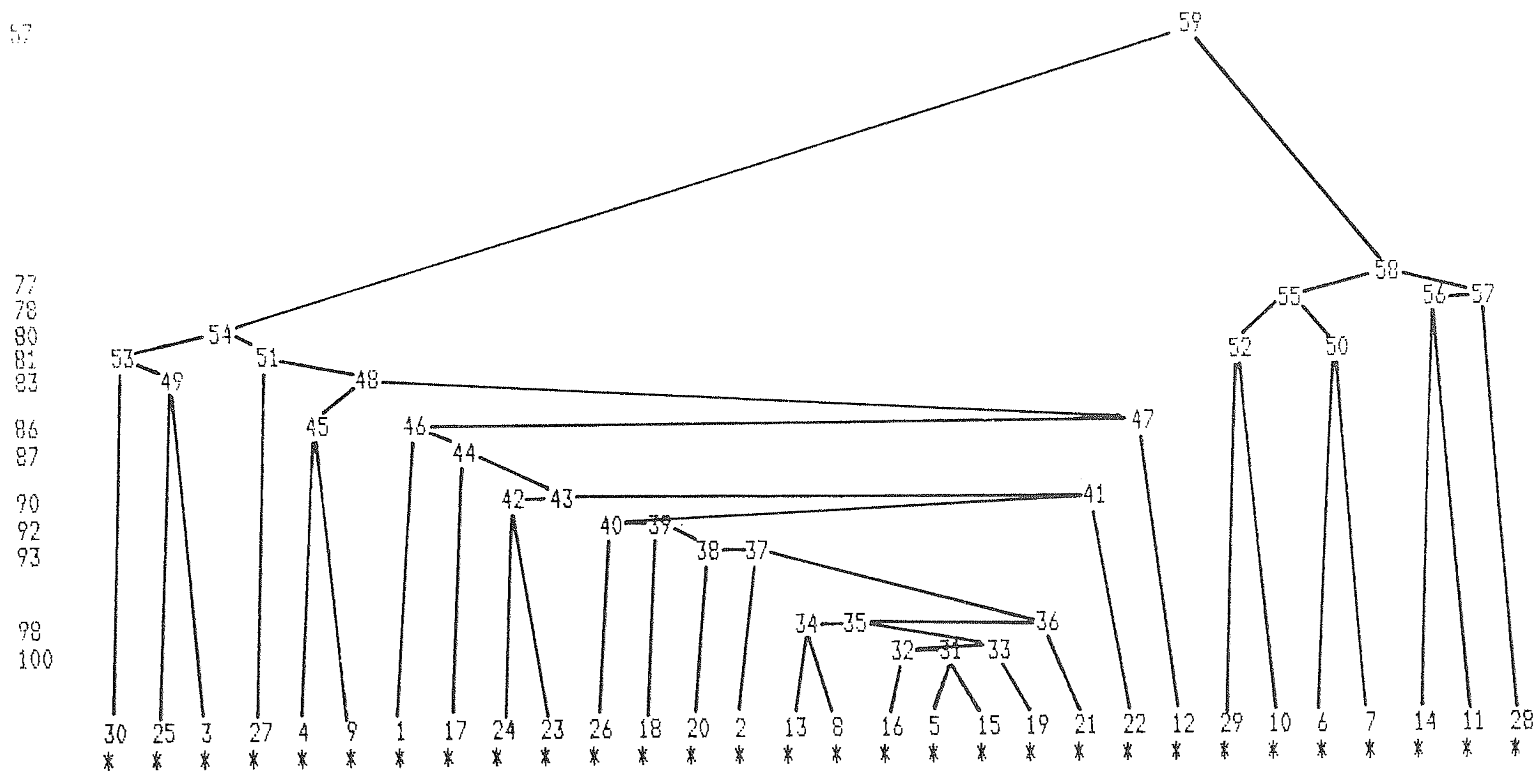
TREE FOR ELEMENTS -- GRID 11



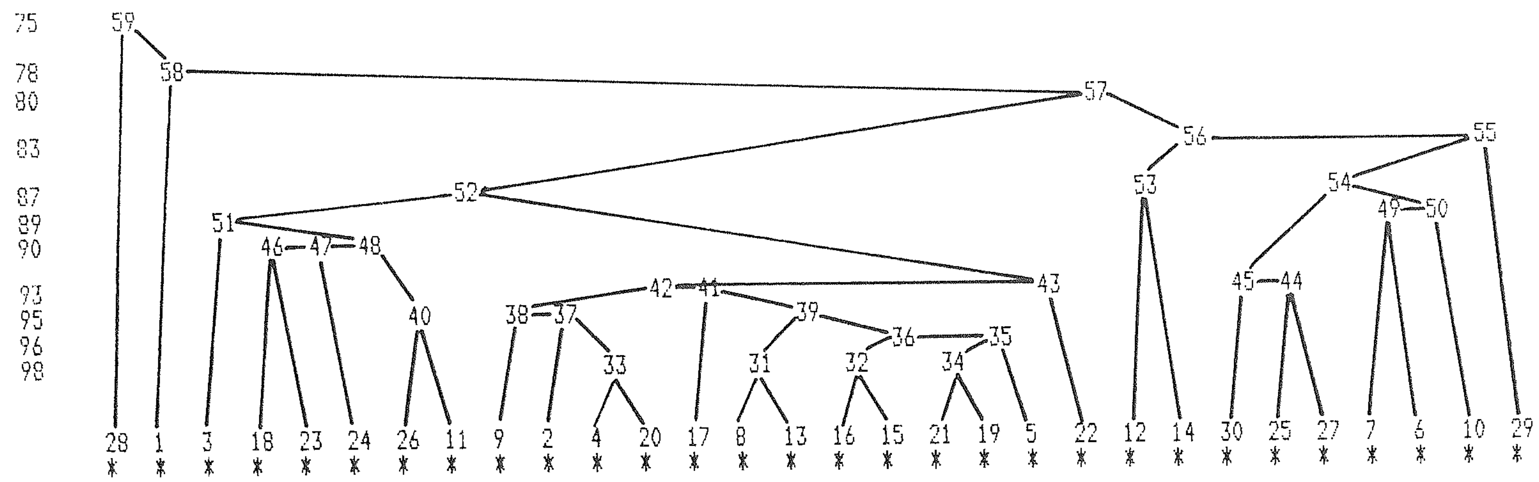
TREE FOR ELEMENTS -- GRID 12



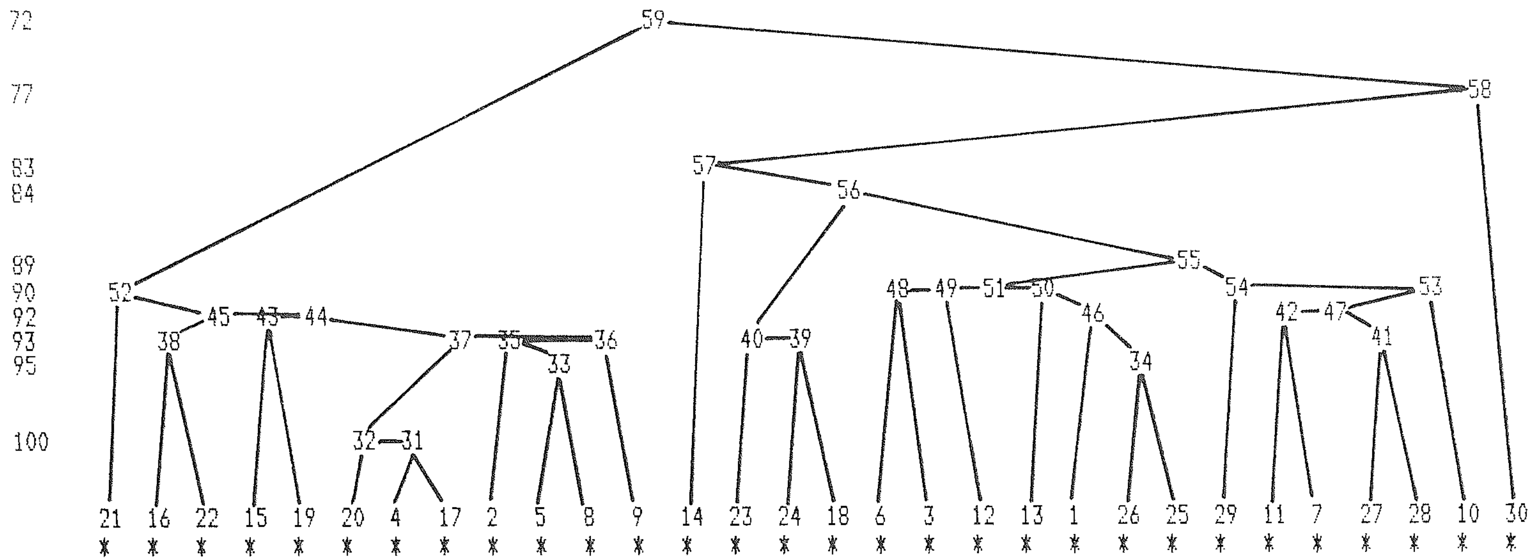
TREE FOR ELEMENTS -- GRID 13



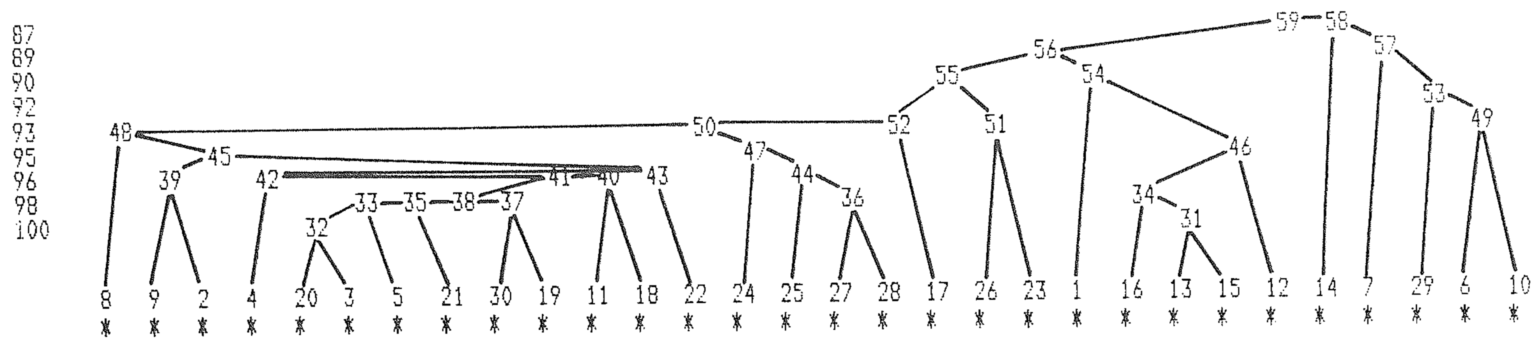
TREE FOR ELEMENTS -- GRID 14



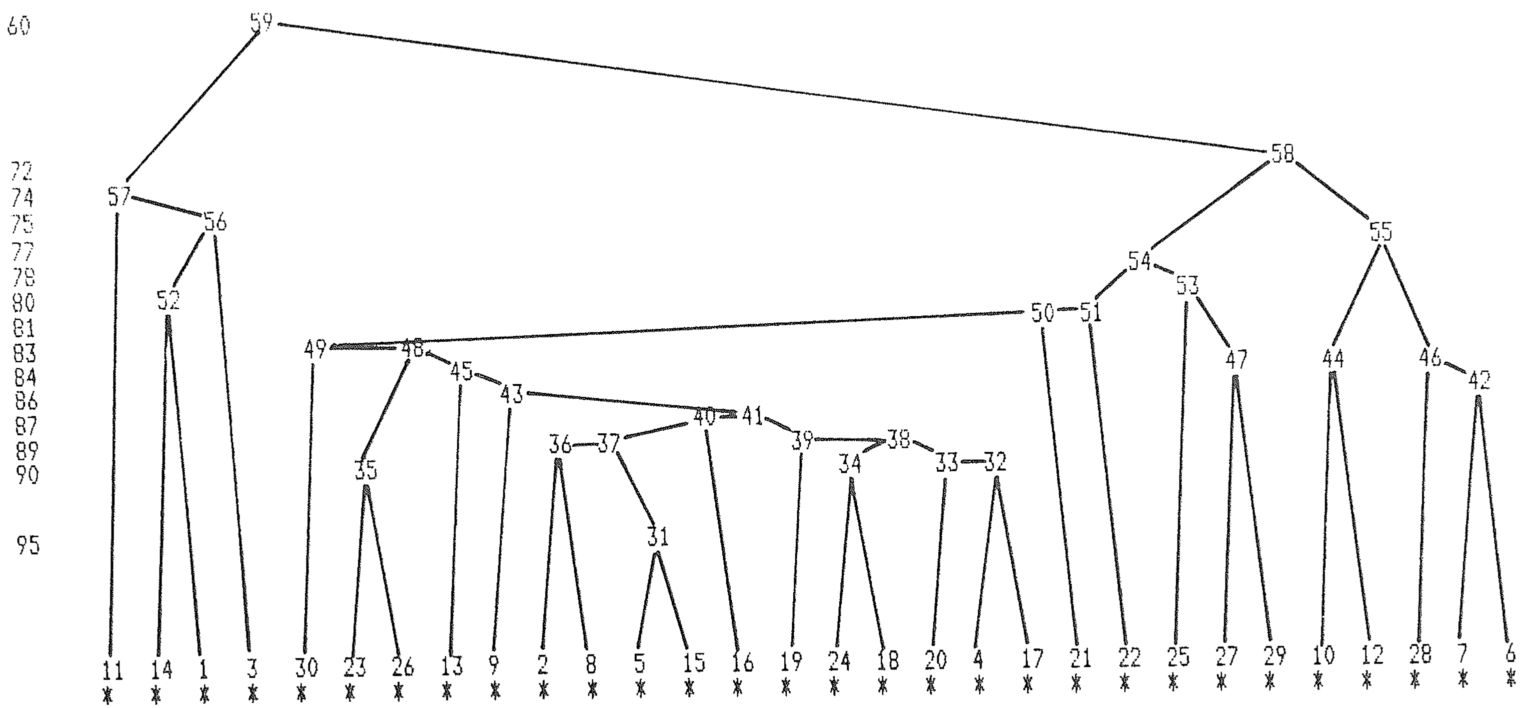
TREE FOR ELEMENTS -- GRID 15



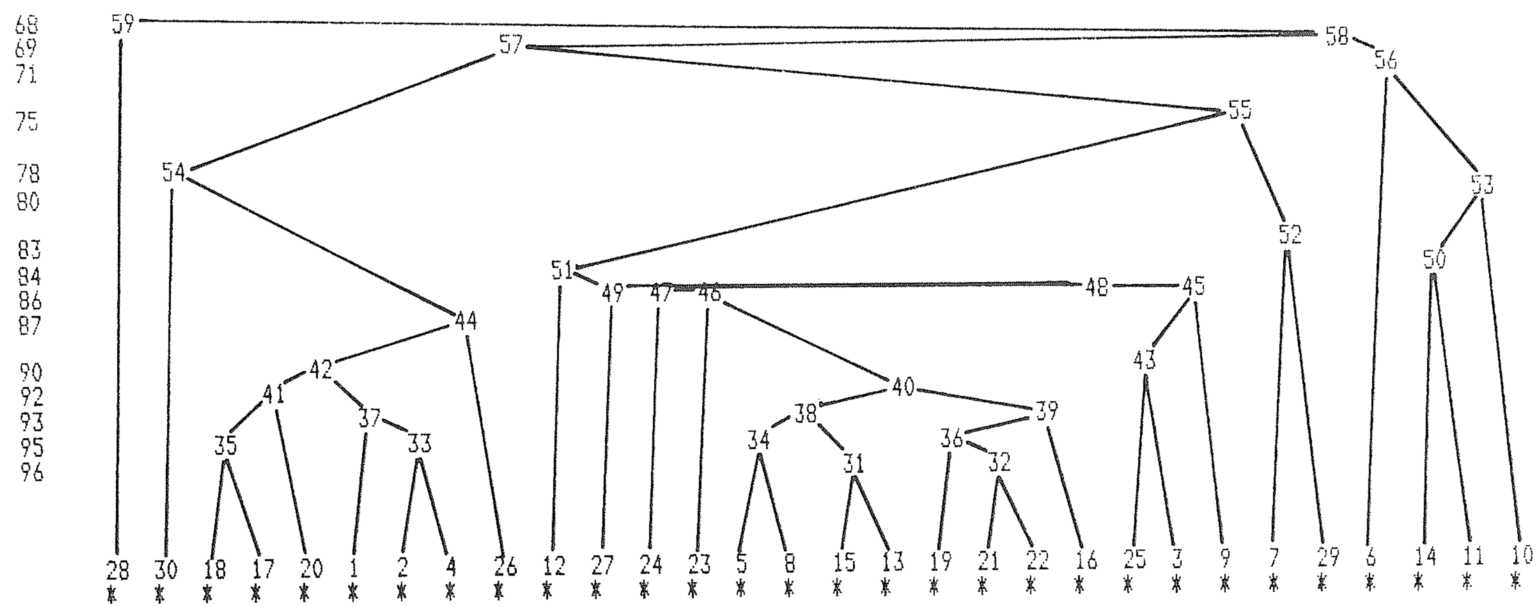
TREE FOR ELEMENTS -- GRID 16



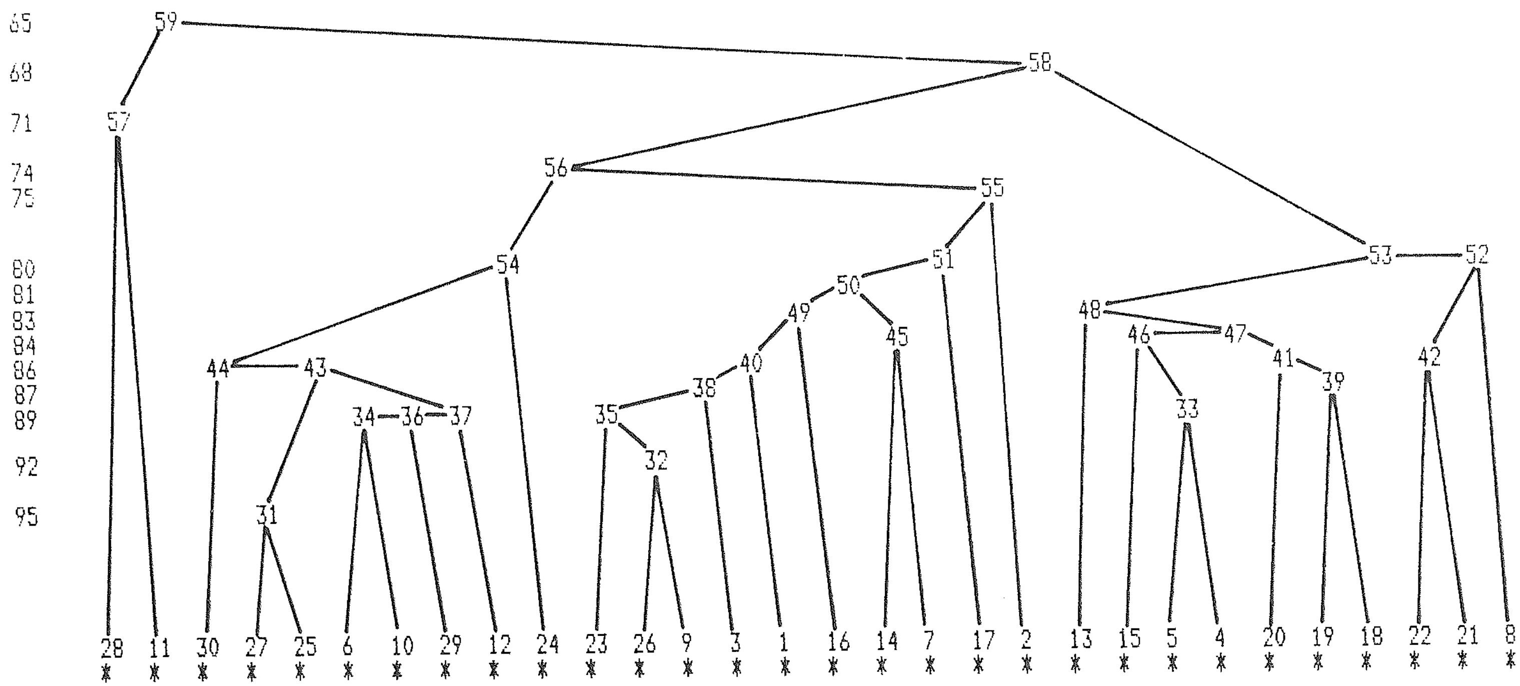
TREE FOR ELEMENTS -- GRID 17



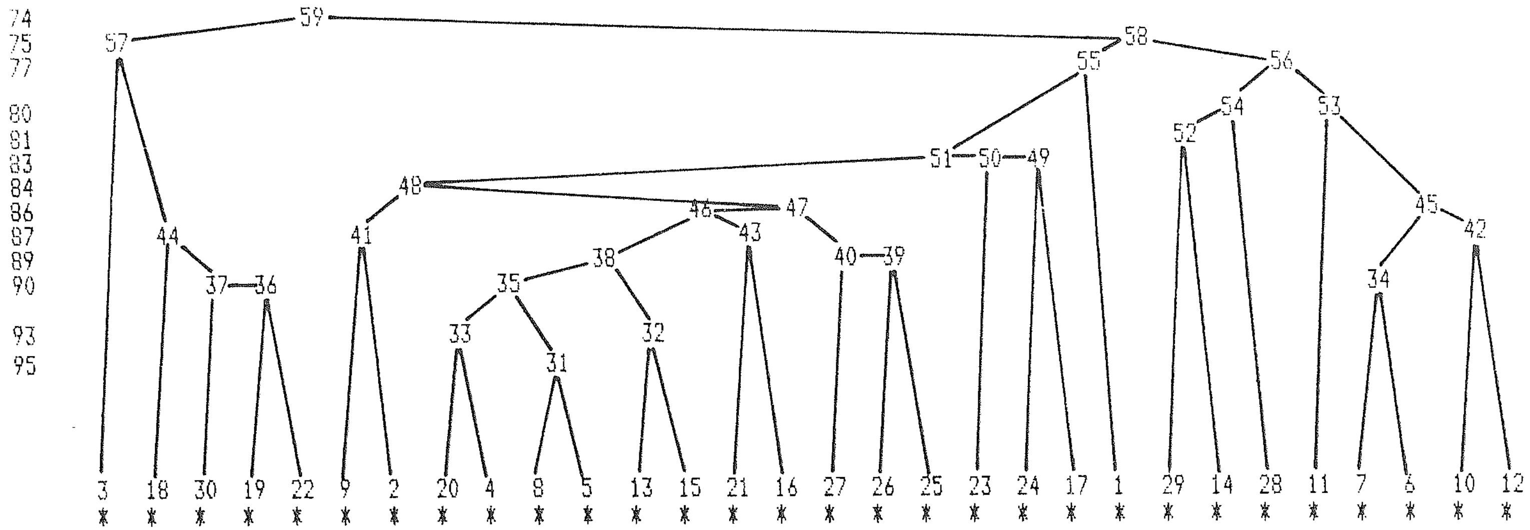
TREE FOR ELEMENTS -- GRID18



TREE FOR ELEMENTS -- GRID 19



TREE FOR ELEMENTS -- GRID 20



REFERENCES

ABRAMS, M. (1973) Subjective social indicators. Social Trends, No.3 35 - 50. HMSO.

ALDAG, R.J. & BRIEF, A.P. (1979) Task design and employee motivation. Glenview, Illinois: Scott Foresman.

ALDERFER, C.P. (1969) An empirical test of a new theory of human needs. Organisational Behaviour and Human Performance, 4 142 - 175.

ALDERFER, C.P. (1972) Existence, relatedness and growth: Human needs in organisational settings. New York: Free Press.

ANNETT, J. & DUNCAN, K.D. (1967) Task analysis and training design. Occupational Psychology, 41, 211 - 221.

ANNETT, J., DUNCAN, K.D., STAMMERS, R.B. & GRAY, M.J. (1971) Task Analysis. Department of Employment Training Information, Paper 6. London: HMSO

ARGYRIS, C. (1957) Personality and organisation. New York: Harper and Row.

ARNOLD, H.J. & HOUSE, R.J. (1980) Methodological and substantive extensions to the Job Characteristics model of motivation. Organisational Behaviour and Human Performance, 25, 161 - 183.

ATC SYSTEMS COMMITTEE (1975) Future ATC Systems - A preliminary study. AGARD Conference Proceedings, No. 188, Paris.

BABBAGE, C. (1832) On the Economy of Machinery and Manufacturers. London: Charles Knight.

BAINBRIDGE, L. (1975) The representation of working storage and its use in the organisation of behaviour. In W. T. Singleton and P. Spurgeon (Eds.) Measurement of human resources. London: Taylor and Francis.

BAINBRIDGE, L. (1979) Verbal reports as evidence of the process operator's knowledge. International Journal of Man-Machine Studies, 11, 411 - 436

BALL, R.G. (1976) Cooperative ATC using a medium-term predictive aid. in: Seminar Report: "Conflict Detection and Resolution", Eurocontrol Institute of Air Navigation Services. (Luxembourg: Eurocontrol)

BALL, R.G., LLOYD R.B., & ORD, G. (1975) Interactive Conflict Resolution. In: AGARD Conference Proceedings No. 188 "Air Traffic Control Systems" (NATO)

BANNISTER, D. (1966) A new theory of personality. In B. Foss (ed.) New horizons in psychology. Penguin.

BANNISTER, D. & MAIR, J.M.M. (1968) The evaluation of personal constructs. Academic Press.

BARTH, R.T. (1976) An empirical examination of several job attraction and job satisfaction measures. International Review of Applied Psychology, 25 (1) 53 - 69.

BEEHR, T.A. & GUPTA, N. (1978) A note on the structure of employee withdrawal. Organisational Behaviour and Human Performance, 21, 73 - 79.

BLACKLER, F.H.M. & BROWN, C.A. (1978) Job redesign and management control: Studies in British Leyland and Volvo. Farnborough: Saxon House.

BLACKLER, F.H.M. & BROWN, C.A. (1980) Job redesign and social change: Case studies at Volvo. In K.D. Duncan, M.M.Gruneberg and D. Wallis (Eds.) Changes in working life. J. Wiley & Sons.

BLACKLER, F.H.M. & WILLIAMS, A.R.T. (1971) People's motives at work. In P.B.Warr (Ed.) Psychology at work. Penguin.

BLAUNER, R. (1964) Alienation and Freedom. Chicago: University of Chicago Press.

BLOOD, M.R. & HULIN, C.L. (1967) Alienation, environmental characteristics, and worker responses. Journal of Applied Psychology, 51, 284-290.

BLUMBERG, P. (1968) Industrial democracy: The sociology of participation. London: Constable.

BOWLES, M.L. (1976) Job satisfaction: Measurement and meaning. Unpublished Ph.D. thesis; University of Wales, Institute of Science and Technology, Cardiff.

BRAVERMAN, H. (1974) Labor and Monopoly Capital. New York: Monthly Review Press.

BRAYFIELD, A.H. & CROCKETT, W.H. (1955) Employee attitudes and employee performance. Psychological Bulletin, 52 (5) 396 - 424.

BRIEF, A.P. & ALDAG, R.J. (1975) Employee reactions to task characteristics: A constructive replication. Journal of Applied Psychology, 60. 182 - 186.

BROWN, W. (1960) Exploration in management. New York: Wiley.

CAMERON, S. (1973) Job satisfaction: The concept and its measurement. Work Research Unit Occasional Paper No. 4, U.K. Department of Employment.

CAMPBELL, J.P. & PRITCHARD, R.D. (1976) Motivation theory in industrial and organisational psychology. In M.D.Dunnette (Ed.) Handbook of Industrial and Organisational Psychology, Chicago: Rand McNally.

CAMPBELL, J.P., DUNNETTE, M.D., LAWLER, E.E. & WEICK, K.E. (1970) Managerial behaviour, performance and effectiveness. New York: McGraw Hill.

CAREY, A. (1967) The Hawthorne studies: A radical criticism. American Sociological Review, 32, 404 - 16.

CHADWICK-JONES, J.K., BROWN, C.A., NICHOLSON, N. & SHEPPARD, C.(1971) Absence measures: Their reliability and stability in an industrial setting. Personnel Psychology, 24, 463-470.

CHRISTAL, R.E. (1974) The United States Air Force Occupational Research Project. Technical Report AFHRL-TR-73-75. Occupation Research Division, Air Force Human Resources Laboratory, Texas.

COFER, C.N. & APPLEY, M.H. (1964) Motivation: Theory and research. New York: Wiley.

COOPER, R. (1973a) Task characteristics and intrinsic motivation. Human Relations, 26, 387 - 413.

CRAWLEY, R. & SPURGEON P., (1979) Computer assistance and the air traffic controller's job satisfaction. In R.G.Sell & P.Shipley (eds.) Satisfactions in work design: Ergonomics and other approaches. London: Taylor & Francis.

COOPER, R. (1973b) How jobs motivate. Personnel Review, 2, 4 - 12.

CRUMP, J.H. (1979) A review of stress in air traffic control: Its measurement and effects. Aviation, Space and Environmental Medicine, 50, 243 - 248.

DAVIS, L.E. (1957) Toward a theory of job design. The Journal of Industrial Engineering, 8, 305 - 9.

DAVIS, L.E. & CANTER, R.R. (1955) Job Design. Journal of Industrial Engineering, 6, p.6

DAVIS, L.E. & TAYLOR J.C. (eds.) (1979) Design of Jobs. Goodyear Publishing Company, Inc., California. 2nd Ed.

DAVIS, L.E. & TRIST, E.L. (1974) Improving the quality of work life: Sociotechnical case studies. In J.O'Toole (Ed.) Work and the quality of life. Cambridge, Mass: MIT Press.

DECI, E.L. (1975) Intrinsic Motivation. London: Plenum Press.

DEPARTMENT OF INDUSTRY (1977) Preliminary study of long-term Air Traffic Systems in Europe. Vol. I-III. HMSO.

DUNCAN, K.D. (1975) An analytical technique for industrial training. In W. T. Singleton and P. Spurgeon (Eds.) Measurement of human resources. London: Taylor and Francis.

DUNHAM, R.B. (1976) The measurement and dimensionality of job characteristics. Journal of Applied Psychology, 61, 404 - 409.

DUNHAM, R.B., ALDAG, R.J. & BRIEF, A.P. (1977) Dimensionality of task design as measured by the Job Diagnostic Survey. Academy of Management Journal. 20, 209 - 223.

EASTERBY-SMITH, M. (1980) The design, analysis and interpretation of repertory grids. International Journal of Man-Machine Studies, 13, 3 - 24.

ELDEN, M. (1979) Three generations of work-democracy experiments in Norway: beyond classical socio-technical systems analysis. In C.L.Cooper and E. Mumford (Eds.) The quality of working life in Western and Eastern Europe. London: Associated Business Press.

EMERY, F.E. (1959) Characteristics of sociotechnical systems: London: Tavistock.

EMERY, F.E. (1975) The assembly-line - its logic and our future. National Labour Institute Bulletin (New Delhi), 1, 1 - 9.

ERICSSON, K.A. & SIMON, H.A. (1980) Verbal reports as data. Psychological Review, 87, 215 - 251.

EVERITT, B. (1974) Cluster analysis. Heinemann.

EWEN, R.B., SMITH, P.C., HULIN, C.L. & LOCKE, E.A. (1966) An empirical test of the Herzberg two-factor theory. Journal of Applied Psychology, 50, 544-550.

FAA AVIATION FORECAST BRANCH (1975) Aviation Forecasts - Fiscal Years 1976 - 1987. Report No. FAA-AVP-75-7 U.S. Department of Transportation, Washington, D.C. 20591.

FARR R.M. (1977) On the nature of attributional artifacts in qualitative research: Herzberg's two-factor theory of work motivation. Journal of Occupational Psychology, 50, 3 - 14.

FEARN, C.W. (1975) Computer Assisted Approach Sequencing for Heathrow Airport - Simulator Phase. CAA Paper 75029, Civil Aviation Authority, London.

FERGUSON, G.A. (1976) Statistical analysis in psychology and education. 4th edition. McGraw Hill.

FITTS, P.M. (1951) (ed.) Human engineering for an effective Air Navigation and Traffic Control System. National Research Council.

FLEISHMAN, E.A. (1967) Development of a behaviour taxonomy for describing human tasks. Journal of Applied Psychology, 51, 1 - 10.

FLEISHMAN, E.A. (1972) On the relation between abilities, learning and human performance. American Psychologist, 27, 1017 - 1032.

FLEISHMAN, E.A. (1975) Taxonomic problems in human performance research. In W. T. Singleton and P. Spurgeon (Eds.) Measurement of human resources. London: Taylor and Francis.

FORD, R.N. (1969) Motivation through the work itself. New York: American Management Association.

FORD, R.N. (1973) Job enrichment lessons from A T & T. Harvard Business Review, 51, 96 - 106.

FOX, A. (1973) Industrial Relations: A social critique of pluralist ideology. In J. Child (Ed.) Man and Organisation. London: Allen Unwin.

FRANSELLA, F. & BANNISTER D. (1977) A manual for Repertory Grid Technique. London. Academic Press.

GALBRAITH, J. & CUMMINGS, L.L. (1967) An empirical investigation of the motivational determinants of task performance. Organisational Behaviour and Human Performance, 2, 237 - 257.

GAUDET, F.J. (1963) Solving the problems of employee absence. New York: American Management Association.

GOLDTHORPE, J.H., LOCKWOOD, D., BECHHOFER, F. & PLATT, J. (1968) The Affluent Worker. Cambridge University Press.

GRAEN, G. (1969) Instrumentality theory of work motivation: Some experimental results and suggested modifications. Journal of Applied Psychology Monograph, 53, 1 - 25.

GRANDJEAN, E., WOZKA, G. & KRETZSCHMAR, H. (1968) Psychophysiologic investigations into professional stress on air traffic control officers at the Zurich-Kloten and Geneva-Cointrin airports. Unpublished manuscript, Swiss Confederate College of Technology at Zurich.

GRUNEBERG, M.M. (1979) Understanding job satisfaction. London: McMillan.

GUEST, D., WILLIAMS, R. & DEWE, P. (1978) Job design and the psychology of boredom. Work Research Unit, London.

GUEST, R.H. (1955) Men and machines: an assembly-line worker looks at his job Personnel, 31, 496 - 503.

HACKMAN, J.R. (1969) Nature of the task as a determiner of job behaviour. Personnel Psychology, 22, 435 - 444.

HACKMAN, J.R. (1975) On the coming demise of job enrichment. In E.L. Cass and F. G. Zimmer (Eds.) Man and work in society. New York: Van Nostrand-Reinhold.

HACKMAN, J.R. (1977) Work design. In J.R.Hackman and J.L.Suttle (Eds.) Improving life at work. Santa Monica, California, Goodyear.

HACKMAN, J.R. (1980) Changing views of motivation in work groups. In K.D. Duncan, M.M. Gruneberg and D. Wallis (Eds.), Changes in working life. Chichester, John Wiley and Sons.

HACKMAN, J.R. & LAWLER, E.E. (1971) Employee Reactions to Job Characteristics. Journal of Applied Psychology Monograph, 55 (3) 259 - 286.

HACKMAN, J.R. & OLDHAM G.R. (1975) Development of the Job Diagnostic Survey. Journal of Applied Psychology, 60 (2), 159 - 170.

HACKMAN, J.R. & OLDHAM, G.R. (1976) Motivation through the design of work: Test of a theory. Organisational Behaviour and Human Performance, 16, 250 - 279.

HACKMAN, J.R. & OLDHAM, G.R. (1980) Work redesign. Addison-Wesley.

HACKMAN, J.R., OLDHAM, G.R., JANSON, R. & PURDY, K. (1975) A new strategy for job enrichment. California Management Review, Summer, 57 - 71.

HACKMAN, J.R., PEARCE, J.L. & WOLFE, J.C., (1978) Effects of changes in job characteristics on work attitudes and behaviours. A naturally occurring quasi-experiment. Organisational Behaviour and Human Performance, 21, 289 - 304.

HAMNER, W.C. & SMITH, F.J. (1978) Work attitudes as predictors of unionisation activity. Journal of Applied Psychology, 63 (4), 415 - 421.

HARE, A.P. (1962) Handbook of small group research. New York: Free Press.

HAWGOOD, J., LAND, F. & MUMFORD, E. (1978) A participative approach to forward planning and system change. from Lecture Notes in Computer Science 65: Information Systems Methodology, Proceedings Venice 1978, 39 - 61. (Berlin: Springer-Verlag)

HEDBERG, B. & MUMFORD, E. (1975) The Design of Computer Systems: Man's vision of man as an integral part of the system design process. In E. Mumford & H. Sackman (Eds.) Human choice and computers. North Holland.
HEIDER, F. (1958) The psychology of interpersonal relations. New York: Wiley.
HERZBERG, F. (1966) Work and the Nature of Man. Cleveland: World Publishing Co.
HERZBERG, F. (1968) One more time: How do you motivate employees? Harvard Business Review, 46, 53 - 62.
HERZBERG, F., MAUSNER, B., & SNYDERMAN, B. (1959) The motivation to work. New York: Wiley.
HERZBERG, F., MAUSNER, B., PETERSON, R.O., & CAPWELL, D.F., (1957) Job attitudes: Review of research and opinion. Pittsburgh: Psychological Service of Pittsburgh.
HILL, J.M.M. & TRIST, E.L. (1955) Changes in accidents and other absences with length of service Human Relations, 8, 121 - 152.
HOBSBAWM, E.J. (1969) Industry and Empire. Harmondsworth: Penguin.
HOMANS, G. (1950) The human group. New York: Harcourt Brace Jovanovich.
HOPKIN, V.D. (1975) The Controller versus Automation. In A. Benoit (ed.) A Survey of Modern Air Traffic Control. AGARDograph No. 209, AGARD.
HOPPOCK, R. (1935) Job satisfaction. New York: Harper.
HOPWOOD, A.G. (1979) Towards the economic assessment of new forms of work organisation. In C.L.Cooper and E. Mumford (Eds.) The quality of working life in Western and Eastern Europe. London: Associated Business Press.
HOUSE, R.J. & WIGDOR, L.A. (1967) Herzberg's dual-factor theory of job satisfaction and motivation: A review of the evidence and a criticism. Personnel Psychology, 20, 369 - 390.
HULIN, C.L. (1966) Job satisfaction and turnover in a female clerical population. Journal of Applied Psychology, 50, 280 - 285.
HULIN, C.L. (1968) Effects of changes in job satisfaction levels on employee turnover. Journal of Applied Psychology, 52, 122 - 126.
HULIN, C.L. & BLOOD, M.R. (1968) Job enlargement, individual differences and worker responses. Psychological Bulletin, 69, 41 - 55.
HUSE, E.F. & TAYLOR, E.K. (1962) The reliability of absence measures. Journal of Applied Psychology, 46, 159 - 160.
INTERNATIONAL LABOUR ORGANISATION (1972) Conditions of Employment and Service of Air Traffic Controllers. International Labour Office, Geneva.
JENKINS, D.C. (1971) Psychologic and social precursors of coronary disease (ll). New England Journal of Medicine, 284, 307 - 317.
JENNEY, L.L. & LAWRENCE, K.A. (1974) Implications of Automation for Operating and Staffing an Advanced Air Traffic Management System. PB 238 423 U.S. Department of Transport, Washington, D.C. 20590.
KATZ, D. & KAHN, R.L. (1952) Some recent findings in human relations research in industry. In G.E. Swanson, T.M.Newcomb & E. L. Hartley (Eds.) Readings in social psychology. New York: Holt.
KATZ, R. (1978) Job longevity as a situational factor in job satisfaction. Administrative Science Quarterly, 23, 204 - 223.
KELLY, G.A. (1955) The psychology of personal constructs. Norton.
KELLY, G.A. (1961) The abstraction of human processes. Proceedings of the 14th International Congress of Psychology, Copenhagen, 220 - 229.

KENNHOLT, I. & BERGSTEDT, M. (1971) Attitudes towards the work and working conditions among Air Traffic Control Personnel in the Aviation Administration. Stockholm: Swedish Personnel Administrative Council.

KERLINGER, F.N. (1973) Foundations of behavioural research. 2nd edition. Holt, Rinehart and Winston.

KILBRIDGE, M.D. (1960) Reduced costs through job enrichment: A case. The Journal of Business, 33, 357 - 362.

KING, N. (1970) Clarification and evaluation of the two-factor theory of job satisfaction. Psychological Bulletin, 74, 18 - 31.

KLEIN, A.R. (1977) Examination of the Hackman - Oldham Job Enrichment Theory. Doctoral Dissertation, Illinois Institute of Technology (Ann Arbor, Michigan; University Microfilms - 78 - 867)

KLEIN, L. (1976) New forms of work organisation. Cambridge University Press.

KORNHAUSER, A.W. (1965) Mental health of the industrial worker: A Detroit study. New York: Wiley.

KUHAR, W.T., GAVEL, P. & MORELAND J.A. (1976) Impact of Automation upon Air Traffic Control System Productivity/Capacity (ARTS III) Department of Transportation, Federal Aviation Administration, FAA - RD - 77 - 39.

LATHAM, G.P. & YUKL, G.A. (1975) A review of research on the application of goal setting in organisations. Academy of Management Journal, 18, 824 - 845

LAWLER, E.E. (1969) Job Design and Employee Motivation. Personnel Psychology, 22, 426 - 435.

LAWLER, E.E. (1970) Job attitudes and employee motivation: theory, research and practice. Personnel Psychology, 23, 223 - 237.

LAWLER, E.E. (1980) Motivation: Closing the gap between theory and practice. In K.D. Duncan, M.M. Gruneberg & D. Wallis (Eds.) Changes in working life. Chichester: John Wiley and Sons Ltd.

LAWLER, E.E. & PORTER, L.W. (1967a) The effect of performance on job satisfaction. Industrial Relations, 8, 20 - 28.

LAWLER, E.E. & PORTER, L.W. (1967b) Antecedent attitudes of effective managerial performance. Organisational Behaviour and Human Performance, 2, 122 - 142.

LAWLER, E.E. & SUTTLE, J.L. (1972) A causal correlational test of the need hierarchy concept. Organisational Behaviour and Human Performance, 7, 265 - 287.

LEWIN, K. (1951) Field theory in social science. New York: Harper & Row.

LICKLIDER, J.C.R. (1960) Man-computer symbiosis. IRE Transactions on Human Factors in Electronics, HFE - 1, 4 - 11.

LIFSHITZ, M. (1974) Quality professionals: does training make a difference? A Personal Construct theory study of the issue. British Journal of social and clinical Psychology, 13, 183 - 189.

LIKERT, R. (1961) New patterns of management. New York: McGraw Hill.

LOCKE, E.A. (1968) Towards a theory of task motivation and incentives. Organisational Behaviour and Human Performance, 3, 157 - 189.

LOCKE, E.A. (1969) What is Job Satisfaction? Organisational Behaviour and Human Performance, 4, 309 - 36.

LOCKE, E.A. (1970) Job satisfaction and job performance: A theoretical analysis. Organisational Behaviour and Human Performance, 5, 484 - 500.

LOCKE, E.A. (1976) The nature and causes of Job Satisfaction. In M.D. Dunnette, (ed.) Handbook of Industrial and Organisational Psychology. Chicago: Rand McNally.

LOCKE, E.A. (1978) The ubiquity of the technique of goal setting in theories of and approaches to employee motivation. Academy of Management Review, 3, 594 - 601.

LOCKE, E.A., CARTLEDGE, N. & KOEPPEL, J. (1968) Motivational effects of knowledge of results: A goal setting phenomena? Psychological Bulletin, 70, 474 - 485.

LOCKE, E.A. FEREN, D.B., McCALEB, V.M., SHAW, K.N. & DENNY, A.T. (1980) The relative effectiveness of four methods of motivating employee performance. In K.D. Duncan, M.M.Gruneberg and D. Wallis (Eds.) Changes in Working Life. J. Wiley.

LOFQUIST, L.H. & DAWIS, R.V. (1969) Adjustment to work. New York: Appleton - Century - Crofts.

LYONS, T.F. (1972) Turnover and absenteeism: A review of relationship and shared correlates. Personnel Psychology, 25, 271 - 281.

McCLELLAND, D.C. (1961) The Achieving Society, Van Nostrand.

McCORMICK, E.J. (1976) Job and task analysis. In M.D. Dunnette (Ed.) Handbook of Industrial and Organisational Psychology. Rand McNally.

McCORMICK, E.J., JEANNERET, P.R. & MECHAM, R.C. (1972) A study of job characteristics and job dimensions as based on the Position Analysis Questionnaire (PAQ) Journal of Applied Psychology Monograph, 56, 347 - 368.

McFARLAND, A.L. & HOROWITZ, B.M. (1974) A description of the Intermittent Positive Control (IPC) concept. AD - 776111 U.S. Dept. of Transportation, Washington D.C. 20591.

McGREGOR, D. (1960) The human side of enterprise. New York: McGraw-Hill.

MACKINNEY, A.C., WERNIMONT, P.F. & GALITZ, W.O. (1962) Has specialisation reduced job satisfaction? Personnel, 39, 8 - 17.

McQUITTY, L.L. (1957) Elementary linkage analysis for isolating orthogonal and oblique types and typal relevancies. Educational and Psychological Measurement, 17, 207 - 229.

MAHER, J.R. (ed.)(1971) New perspectives in job enrichment. New York: Nostrand.

MASLOW, A.H. (1943) A theory of human motivation. Psychological Review, 50, 370 - 96.

MASLOW, A.H. (1970) Motivation and personality. (revised edition) New York: Harper & Row.

MATHIAS, P. (1969) The First Industrial Nation. London: Methuen.

MEISTER, D. (1976) Behavioural foundations of system development. New York: Wiley.

MELTON, C.E., McKENZIE, J.M., POLIS, B.D., FUNKHOUSER, G.E., & IAMPIETRO, P.F. (1971) Physiological responses in air traffic control personnel: O'Hare Tower. Federal Aviation Administration, FAA - AM - 71 - 2.

MERTES, F. & JENNEY, L.L. (1974) Automation Applications in an Advanced Air Traffic Management System. Vol. 3. Methodology for Man-Machine Task Allocation. Report No. PB - 236806/6 . U.S. Department of Transporation, Washington D.C. 20591.

MILLER, G.A.,GALANTER, E. & PRIBRAM, K.H. (1960) Plans and the structure of behaviour. New York, Holt.

MILLER, R.B. (1953) A method for man-machine task analysis. Report WADC - TR - 53 - 137, Wright Air Development Centre, Ohio, AD 15921.

MINER, J.B. & BREWER, J.F. (1976) The management of ineffective performance. In M.D. Dunnette (ed.) Handbook of Industrial and Organisational Psychology. Chicago: Rand McNally.

MUCHINSKY, P.M. (1977) Employee Absenteeism: A review of the literature. Journal of Vocational Behaviour, 10 (3) 316 - 340.

MUMFORD, E., MERCER, D. MILLS, S. & WEIR, M. (1972) The human problems of computer introduction. Management Decision, 10, 6 - 17.

MUNSTERBERG, H. (1913) Psychology and Industrial Efficiency. Cambridge: Houghton Mifflin.

MURRAY, H.A. (1938) Explorations in personality. New York: Oxford University Press.

NEALEY, S.M., THORNTON, G.C., MAYNARD, W.S. & LINDELL, M.K. (1975) Defining research needs to insure continued job motivation of Air Traffic Controllers in future air traffic control systems. NTIS No. AD - A014 719.

NICHOLSON, N., BROWN, C.A. & CHADWICK-JONES, J.K. (1976) Absence from work and job satisfaction. Journal of Applied Psychology, 61 (6), 728 - 737.

NICHOLSON, N., WALL, T. & LISCHERON, J. (1977) The predictability of absence and propensity to leave from employees' job satisfaction and attitudes toward influence in decision-making. Human Relations, 30, 499 - 514.

OLDHAM, G.R., HACKMAN, J.R., & PEARCE, J.L. (1976) Conditions under which employees respond positively to enriched work. Journal of Applied Psychology, 61 (4), 395 - 403.

OLDHAM, G.R., HACKMAN, J.R. & STEPINA, L.P. (1978) Norms for the Job Diagnostic Survey. Technical Report No. 16, School of Organisation and Management, Yale University.

PATRICK, J. (1980) Job analysis, training and transferability: Some theoretical and practical issues. In K.D. Duncan, M.M. Gruneberg & D. Wallis (Eds.) Changes in working life. Wiley.

PATRICK, J., SPURGEON, P. BARWELL, F. & SPARROW, J. (1980) Re-deployment by upgrading to technician. Vol. I. Report submitted to the Training Services Division, Manpower Services Commission. Applied Psychology Department, University of Aston in Birmingham.

PAUL, W.J. & ROBERTSON, K.B. (1970) Job enrichment and employee motivation. Gower Press.

PAYNE, R.L. (1970) Factor analysis of a Maslow-type need-satisfaction questionnaire. Personnel Psychology, 23, 251-268.

PEACE, D.M.S. & EASTERBY, R.S. (1973) The evaluation of user interaction with computer-based management information systems. Human Factors, 15, 163 - 177.

PEAK, H. (1955) Attitude and motivation. In M.R. Jones (Ed.) Nebraska symposium on motivation. Lincoln: University of Nebraska Press.

PEPINSKY, H.B. & PEPINSKY, P.N. (1961) Organisation, management strategy and team productivity. In L. Petrullo & B. M. Bass (Eds.) Leadership and interpersonal behaviour. New York: Holt.

PIRANI, M. & REYNOLDS, J. (1976) Gearing up for safety ... or these boots were made for wearing. Personnel Management, February, 25 - 27.

PORTER, L.W. (1961) A study of perceived need satisfaction in bottom and middle management jobs. Journal of Applied Psychology, 45, 1 - 10.

PORTER, L.W. & LAWLER, E.E. (1968) Managerial attitudes and performance. Homewood, Ill: Dorsey Press.

PORTER, L.W. & STEERS, R.M. (1973) Organisational, work and personal factors in employee turnover and absenteeism. Psychological Bulletin, 80, 151 - 176.

PORTER, L.W., LAWLER, E.E. & HACKMAN, J.R. (1975) Behaviour in Organisations. Tokyo. McGraw Hill.

PRIEN, E.P. & RONAN, W.W. (1971) Job analysis: A review of research findings. Personnel Psychology, 24, 371 - 396.

PUTNAM, M.L. (1930) Improving employee relations. Personnel Journal, 8, 314 - 25.

QUINN, R.P., STAINES, G.L. & McCULLOUGH, M.R. (1974) Job satisfaction: Is there a trend? Washington, D.C: U.S. Government Printing Office, Document 2900 - 00195.

RATCLIFFE, S. (1976) "Two Centuries of Navigation": System Problems in Air Traffic Control. Journal of Navigation, 29 (4) 372 - 379.

REDFERN, S.J. (1978) Absence and wastage in trained nurses: a selective review of the literature. Journal of Advanced Nursing, 3, 231 - 249.

ROETHLISBERGER, F.J. & DICKSON, W.J. (1939) Management and the worker - An account of a research program conducted by the Western Electric Company, Hawthorne Works, Chicago; Harvard University Press.

ROTTER, J.B. (1966) Generalised expectancies for Internal versus External control of reinforcement. Psychological Monographs, 80 (1), 1 - 28. (Whole number 609)

ROUSSEAU, D.M. (1977) Technological differences in job characteristics, employee satisfaction, and motivation. A synthesis of job design research and sociotechnical systems theory. Organisational Behaviour and Human Performance, 19, 18 - 42.

ROY, D. (1952) Quota restriction and goldbricking in a machine shop. American Journal of Sociology, 57 (5), 430 - 437.

RUMP, E.E. (1974) Cluster analysis of personal questionnaires compared with principal components analysis. British Journal of Social and Clinical Psychology, 13, 283 - 292.

SALANCIK, G.R. & PFEFFER, J. (1978) A social information processing approach to job attitudes and task design. Administrative Science Quarterly, 23, 224 - 253.

SCHAFFER, R.H. (1953) Job satisfaction as related to need satisfaction in work. Psychological Monographs, 67 (14, whole number 364)

SCHNEIDER, B. & ALDERFER, C.P. (1973) Three studies of need satisfaction in organisations. Administrative Science Quarterly, 18, 489 - 505.

SCHUH, A.J. (1967) The predictability of employee tenure: A review of the literature. Personnel Psychology, 20, 133 - 152.

SHAW, M.L.G. (1980) On becoming a personal scientist. London: Academic Press.

SHAW, M.L.G. & THOMAS, L.F. (1978) FOCUS on education - an interactive computer system for the development and analysis of repertory grids. International Journal of Man-Machine Studies, 10, 139 - 173.

SHEPHERD, A. (1976) An improved tabular format for task analysis. Journal of Occupational Psychology, 49, 93 - 104.

SHEPHERD, A. & DUNCAN, K.D. (1980) Analysing a complex planning task. In K.D. Duncan, M.M. Gruneberg & D. Wallis (Eds.) Changes in working life. New York: Wiley.

SINGER, R. & RUTENFRANZ, J. (1971) Attitudes of Air Traffic Controllers at Frankfurt Airport towards work and the working environment. Ergonomics, 14, 633 - 639.

SINGER, R. & RUTENFRANZ, J. (1972) Job satisfaction and job-related health disturbances among Air Traffic Controllers (German) Internationales Archiv fur Arbeitsmedizin, 30, 135 - 160.

SINGLETON, W.T. (1967) The systems prototype and his design problems. In W. T. Singleton, R.S. Easterby & D. Whitfield (Eds.) *The human operator in computer systems*. Taylor & Francis.

SINGLETON, W.T. (1971) Psychological aspects of man-machine systems. In P. B. Warr (Ed.) *Psychology at Work*. Penguin.

SINGLETON, W.T. & CRAWLEY, R.C. (1980) Changing job and job demands in Europe. In K.D. Duncan, M.M.Gruneberg & D. Wallis (Eds.) *Changes in working life*. Wiley.

SLATER, P. (1974) Cluster analysis vs. principal components analysis: A reply to E. E. Rump. *British Journal of Social and Clinical Psychology*, *13*, 427 - 430.

SLATER, P. (1977) (Ed.) *The measurement of intrapersonal space by grid technique: Volume 2. Dimensions of intrapersonal space.* London: Wiley.

SMITH, J.M. (1978) Using repertory grids to evaluate training. *Personnel Management*, *10 (2)*, 36, 37, 43.

SMITH, P.C., KENDALL, L.M. & HULIN, C.L. (1969) *The measurement of satisfaction in work and retirement*. Chicago: Rand McNally.

SMITH, R.C. (1973) Comparison of the job attitudes of personnel in 3 Air Traffic Control specialities. *Aerospace Medicine*, *44 (8)*, 918 - 927.

SMITH, R.C. (1974) A realistic view of the people in ATC. Federal Aviation Administration, NTIS No. FAA - AM - 74 - 12, AD/A - 006789.

SMITH, R.C. & MELTON, C.E. (1973) Susceptibility to anxiety and shift difficulty as determinants of state anxiety in ATCOs. Federal Aviation Administration, FAA - AM - 73 - 15.

SPURGEON, P. & YOUNG, K.M. (1981) The role of work analysis in the study of shipping accidents and the implementation of computer-based collision avoidance systems. *Human Factors in Transport Research*, *1*, 49 - 57.

SRIVASTVA, S. SALIPANTE, P.F., CUMMINGS, T.G., NOTZ, W.W. BIGELOW, J.D. & WATERS, J.A. (1975) *Job satisfaction and productivity*. Cleveland: Case Western Reserve University Press.

STAGNER, R. (1950) Psychological aspects of industrial conflict, II. Motivation. *Personnel Psychology*, *3*, 1 - 15.

STAMMERS, R.B. & PATRICK J. (1975) *The psychology of training*. Methuen.

STANDING, T.E. (1971) An application of information theory to individual worker differences in satisfaction with the work itself. Unpublished Ph.D. thesis. Bowling Green State University, USA.

STEERS, R.M. & RHODES, S.R. (1978) Major influences on employee attendance: A process model. *Journal of Applied Psychology*, *63*, 391 - 407.

SWIFT, D.F. (1969) *The Sociology of Education*. London: Routledge and Kegan Paul.

TAYLOR, F.W. (1911) *The Principles of Scientific Management*. New York: Harper.

THACKRAY, R.I., BAILEY, J.P., & TOUCHSTONE, R.M. (1975) Physiological, subjective and performance correlates of reported boredom and monotony while performing a simulated radar control task. Department of Transportation, Federal Aviation Administration, FAA - AM - 75 - 8.

THIBAUT, J.W. & KELLEY, H.H. (1959) *The social psychology of groups.* Wiley.

THOMSON, R. (1968) *The Pelican history of psychology.* Penguin.

THURMAN, J.E. (1977) Job satisfaction: an international overview. *International Labour Review*, *117* (3), 249 - 267.

TRIST, E. (1971) Critique of scientific management in terms of socio-technical theory. Prakseologia, 39, 159 - 174.
TRIST, E.L. & BAMFORTH, K.W. (1951) Some social and psychological consequences of the long-wall method of coal-getting. Human Relations, 4, 3 - 38.
TRIST, E., HIGGIN, G. MURRAY, H. & POLLOCK, A.P. (1963) Organisational choice. London: Tavistock.
TURNER, A.N. & LAWRENCE, P.R. (1965) Industrial jobs and the worker. Boston: Harvard University Graduate School of Business Administration.
UMSTOT, D.D., BELL, C.H., & MITCHELL, T.R. (1976) Effects of job enrichment and task goals on satisfaction and productivity: Implications for job design. Journal of Applied Psychology, 61 (4), 379 - 394.
VERNON, H.N. (1921) Industrial fatigue and efficiency. New York: Dutton.
VERNON, H.M. (1924) On the extent and effects of variety in repetitive work. Industrial Fatigue Research Board, Report No. 26. London: HMSO
VICKERS, J. EDWARD (1978) A Popular History of Sheffield. E.P. Publishing Limited, Wakefield.
VROOM, V.H. (1964) Work and motivation. New York: Wiley.
WALKER, C.R. (1950) The problem of the repetitive job. Harvard Business Review, 28, 54 - 58.
WALKER, C.R. & GUEST, R.H. (1952) The man on the assembly line. Cambridge. Harvard University Press.
WALL, T.D. & STEPHENSON, G.M. (1970) Herzberg's two-factor theory of job attitudes: a critical evaluation and some fresh evidence. Industrial Relations Journal, 1, 41 - 65.
WALL, T.D. CLEGG, C.W. & JACKSON, P.R. (1978) An evaluation of the Job Characteristics Model. Journal of Occupational Psychology, 51, 183 - 196.
WANOUS, J.P. & LAWLER, E.E. (1972) Measurement and meaning of job satisfaction. Journal of Applied Psychology, 56 (2) 95 - 105.
WARR, P. & WALL, T. (1975) Work and well-being. Penguin.
WEICK, K.E. (1965) Laboratory experimentation with organisations. In J.G. March (Ed.) Handbook of organisations. Chicago: Rand-McNally.
WEISS, H.M. & SHAW, J.B. (1979) Social influences on judgements about tasks. Organisational Behaviour and Human Performance, 24, 126 - 140.
WHITFIELD, D. (1978) Real-time simulation studies of a concept for conflict resolution. Symposium: Society for Applied Learning Technology, 2nd International Congress. University of Aston in Birmingham Publication, AP 141.
WILSON, A.T.M. (1979) Quality of working life: an introductory overview. In C.L. Cooper & E. Mumford (Eds.) The quality of working life in Western and Eastern Europe. London: Associated Business Press.
WINER, B.J. (1971) Statistical principles in experimental design. McGraw Hill.
WYATT, S. (1927) Rest pauses in industry. (A review of the results obtained) Industrial Fatigue Research Board, Report No. 42, Great Britain.
WYATT, S. FRASER, J.A. & STOCK, F.G.L. (1928) The comparative effects of variety and uniformity in work. London: HMSO

NOTE 1

DAVIES, D.R., SHACKLETON, V.J., & PARASURAMAN, R. 'Monotony and Human Performance' Draft chapter of book to be published. The first two authors may be contacted at the Applied Psychology Department, University of Aston in Birmingham.