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From Engineer to Manager:

The careers of technical managers in high technology industry

by

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ABSTRACT

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This thesis examines the process through which engineers move into technical management. Movement into management has been considered a part of "normal" career progression for many engineers. But this "normal" career pattern does not necessarily imply that engineers want to become managers when they are educated for, or initially employed in the engineering industry. The thesis adopts a qualitative approach, analysing the subjective, individual careers of thirty technical managers in high technology industry. The field work was carried out in twelve organisations in central southern England.

The thesis traces the career orientations of engineers back into their education and upbringing. It establishes an orientation to practical creativity - a technical orientation which in most cases persists through out all career stages, even into management. The thesis also proposes a distinct type of technical work termed "technical leadership" as part of the career establishment stage. On why engineers move into management, the thesis concludes that they are typically forced into choosing a managerial role through organisational constraints and the onset of technical obsolescence.

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"[My employer's] policy is, like a lot of companies in Britain, ...they take engineers and if they're good at their job they turn round and call them managers; they expect them to be able to fulfil the management role. But, I mean, a good engineer is not necessarily a good manager."

(respondent 25, Product Group Manager, Organisation K)

"Especially people management is not easy. When you're technically trained, everything conforms to formulae and you know exactly where you're going. And suddenly you're up against people and they don't function in the same way; you can't program them the same!"

(respondent 27, Engineering Group Manager, Organisation H)

Chapter 1 Introduction

The aim of this thesis is to examine how and why engineers become managers. More specifically, its aim is to examine the process through which engineers move into technical management. To achieve this I develop two themes:
i) the career orientation of engineers,
ii) their career transition into managerial work.

The purpose of this introductory chapter is to outline why the subject is worthy of research, and to locate it in the broad literature on technical labour and careers; identifying the need for investigation of the two related themes. I then propose the framework of analysis and briefly introduce the key terms and concepts.

In this chapter I also briefly outline the research design and the methods employed. The chapter concludes with an outline plan of the thesis.

1.1 Aim of the thesis

This thesis aims to examine the process through which engineers move into technical management. That is, how they move from working as technical specialists involved in one sector of engineering, to being employed as managers of other technical specialists. This involves not only an analysis of the differences between the two roles, and the stages passed through to move between them, but also an examination of why such a movement takes place.

Movement into management has been considered a part of "normal" career progression for many engineers. But this "normal" career pattern does not necessarily imply that engineers want to become managers when they are educated for, or initially employed in the engineering industry. Movement into management is often seen as a "forced" movement - but little known about the process by which this takes place, or changes in career orientations which this movement involves. It is clear that any change, however it may be described, from an engineer to a technical manager takes place within a series of life events called the career, the study of which has different definitions and approaches. Further, over time, the career is constructed by choice, struggle and negotiation inside and outside the workplace (Child, 1984b).

"Engineering" and "management" require different skills and abilities. Obviously the engineering industry does not provide the opportunity for every engineer to take on a managerial role even if he or she originally envisaged this. I intend to provide an examination of the processes involved in the development of an engineer from the school classroom to technical management (and potentially at least, to the company boardroom) by analysing the opportunities, choices and constraints on the career at various stages.

Movement from "engineering" to "management" arguably entails change of occupational identity. Therefore I propose an examination of the orientation of engineers to particular types of work or skills, and to see whether their expectations of engineering and what engineers "normally" do changes over time.

To look at these questions on the formation of engineers and their careers is not new in Britain. Since the Finniston Report on the engineering profession in 1980, there have been a variety of sociological studies of technical labour in Britain. These studies have included a growing interest in cross-national perspectives (see Smith, 1990). Yet in 1987 Glover and Kelly still felt compelled to comment that "the interchange of ideas between sociology and engineering remains limited" (1987 p6) partly because the findings of research were not widely enough available. Sociologists have nonetheless found plenty of scope to examine engineers place in theories of work, organisation and society. British engineers remain in the news in recent years; for example reports on the declining numbers of UK engineering graduates, declining standards of engineering education, and poor standards among engineering managers (reports by McLain, 1990; by Garnett, 1989 and I.V.P, 1989; and by Dixon, 1989 and Griffiths, 1989 respectively). This thesis adds to that work through its analysis of technical managers' career orientations, and by proposing a distinct type of technical work - technical leadership.

1.2 Research design and methodology

This study seeks to explore engineers' career orientations and the process of job change through detailed interviews with thirty technical managers. These technical managers are all employed in Research or Design and Development (R&D/D&D) departments in twelve "high technology" companies located in central southern England. The choice of one specific sector of engineering, and of one geographical location, is for a set of three reasons as follows. First, high technology industry - which is broadly electronics and related industries such as parts of aerospace - has particular problems of managing technical specialists with diverse skills in an area of rapid technological change. Secondly, it is useful to focus on one quite distinct sector of engineering to maintain comparability within a sample. Third, it is more straightforward to gain access in a discrete area, and links in with existing research at New Technology Research Group, University of Southampton. It has been in the environment of this research group (note a) that the work has been carried out, but the content of this thesis is entirely my own work (note b).

The research focus is upon the individual career: processes of career choice and career transition by which movement from engineering to management took place. It is also focussed on the subjective career: the career orientations of individuals, and factors which individuals making the transition see as having shaped their careers.

There are various methods of gathering data on the individual subjective career. I have adopted a qualitative approach, sampling technical managers from twelve high technology companies (note c). I have used questionnaires to gather some objective career details, and interviews to explore the individuals' responses to career change, their orientations and aspirations. These interviews yield data on the individual technical managers' current work and responsibilities, together with a chronological trace of their career path from education, through technical and leadership work, to their current post.

1.3 Structure of the thesis

This section concludes the introductory chapter by summarising the structure of the thesis.

The starting point in chapter two is the need to consider the central concept of "career" and its associated concepts. In this chapter I establish the level of analysis and approach adopted. I examine career stages and patterns, adopting a model to structure discussion of career events and job changes at the various stages. The chapter also contains detailed consideration of career choice and constraint surrounding career movement. It concludes with an analysis of career orientation stemming from basic values and professionalism.

Chapter three defines the professional engineer by what he or she does and stresses the emphasis on design and creativity. The chapter applies the concept of career orientation to the engineer and outlines the basis for engineers' discontent with lack of authority and status. I then move the chapter on to an examination of existing research on entry to the engineering industry and the study of engineering careers in general. I cover in turn the areas of technical specialisation, the possibilities of obsolescence, and movement into the margins of engineering. I focus particularly on engineers and management, describing the alternatives to management offered in a few organisations. I present an "option plan" charting the possible career movements in engineering, and use this as a basis for asking how and why engineers are "pushed" or "pulled" through these options into technical management. I also explore in some depth the existing research into engineers' career orientations and the potential for conflict within or between them.

For chapter four, I present a description of the research design and methodology in greater detail than that above. I outline existing research on high technology industries and their patterns of work organisation and career structure.

The first empirical chapter is five, in which I present basic data on characteristics of the sample of technical managers selected from the cohort of organisations.

Then in chapter six I present more detailed analysis of the sample's social background and education. I focus on the career growth and exploration stages, examining initial career orientations and categorising the educational routes by which engineers come into the industry. This categorisation gives an indication of the relative options available to different entrants. I describe the new engineers' integration into industry and where (in hindsight) they hoped their careers would go at that stage.

Chapter seven looks at what is actually meant by technical work for engineers, the skills it requires, and how they change. The chapter examines how incremental job change away from direct technical involvement towards technical leadership, supervision and administrative functions takes place in practice. It adds to the understanding of what supervisory work entails in this stage. I identify technical leadership as a distinct type of technical work which is based on technical expertise, not on ability to manage human resources. My emphasis is on individuals' experiences of the change, the choices and constraints they may have recognised, and the significance of their reflections on why it happened in this way.

Technical management is investigated in some detail in chapter eight. Having examined what the career change process is, and how it works, the focus of chapter eight is on why the overall movement to technical management, and in some cases higher managerial levels, takes place in practice. The terms "push" and "pull" factors are used to categorise the different motivations found. I return to the orientation principle (in the light of professional identity) and look at whether expectations held by the individual have been fulfilled by their career, why, and where they intend to go next.

The conclusion, in chapter nine, summarises the findings of the thesis under the heading of the twin themes of career orientation and career transition, and suggests scope for further research.

Chapter 2 - Career Movement and Career Choice

The purpose of this chapter is to focus on what is meant by the term "career" and the associated terms and concepts mentioned in chapter one. In this chapter I attempt to narrow down the focus of the research through the following five sections utilising a wide range of literature on careers. The first three sections concentrate on the concept and structure of careers, and of jobs within them:

i) the definition of the concept of career,
ii) career stages and patterns,
iii) the process of job change.

The final two sections explore individual career experiences surrounding career events and patterns:

iv) the concept of career choice and constraint,
v) career orientations and professional identity.

2.1 Concept of "career"

The use of the term "career" itself is potentially ambiguous. Different analysts have constructed or used different definitions of what a career includes according to the aims of their research. Frequently definitions of career have only taken account of positions held at work in an organisation. The concept of career tends to imply a stereotype of systematic progression in a vertical direction, smoothly climbing a hierarchy which can be mapped out, and on which movements can be planned. A "career" is often perceived as something which some (mainly "professional") people have, and others do not. The term "career" can be seen in use as a measure of what "should" happen in a persons's working life.

Nicholson and West's (1988) research into how managers' careers actually change over time leads them to comment on the usefulness of the concept of "career":

> "The notion of career,... needs to be redefined away from the stereotype of smooth continuous and planned development, an image that is promoted by the media, fiction, schools, professional associations, careers advisory services and paternalistic organisations. If we look at what managers actually experience, the notion of 'career' is best broadly defined to mean work histories." (Nicholson & West, 1988 p92)

And yet, as they demonstrate, a wealth of subjective experience also surrounds those mere work histories (p73). "And it would not be surprising if many managers ... feel some anxiety about why their own experience fails to conform" to the stereotypes they see around them (Nicholson & West, 1988 p93). Watts (1981) rightly points out that a normative career pattern model is restrictive when discussing the individual. The emphasis of such career models on the objective and vertical movement of careers

> "has little or no relevance for a substantial proportion of the population, and in any case is able to reflect few of the rich and varied ways in which individual careers develop - whether that development is viewed objectively or subjectively." (Watts, 1981 p244)

Hugh Gunz (1989) distinguishes the differences between the organisational and individual levels of analysis of careers. He notes that while both levels of analysis must be viewed in the light of each other, they are distinct:

i) the organisational level sees careers as the process by which organisations renew themselves.

ii) the individual level sees careers as a series of choices made by people between different opportunities presented to them. (Gunz, 1989 p226)

Some of the ambiguity in the use of the term "career" can also be overcome by identifying two differing ways of looking at the career: the objective career and the subjective career. The objective career is a set of positions moved through. This may yield data on the sequence of jobs in organisations, but not on perceptions, behaviours or aspirations which accompany them. Gunz (1989 p235) notes that if research is restricted to objective career data, it may be impossible to get "below the surface" of those facts alone to examine external influences on key events in a career.

For this research it is important to get below the surface of the objective facts of career movement, to examine the meanings attached by individuals to these movements. These meanings constitute the subjective career. In this thesis, the role of the objective career is to provide a framework on which the subjective career data can be built up. The objective career is an assembly of both the explicit and implicit career events experienced by an individual. Also, data on the objective career may be used to assess and cross-check respondents' perceptions of the subjective career. This is particularly important in studying careers which are in the process of change, to see the actual outcomes of certain movements and aspirations.

I have adopted the individual level for this research, as the most appropriate for analysis of job change and career progression. Gunz builds on the grades of meaning of individual career distinguished by Hall:

i) The career as advancement, which sees a career as involving essentially vertical movement between jobs.
ii) The career as a profession, which associates the idea of a career with vertical movement between jobs in certain types of occupation only.
iii) The career as a life-long sequence of jobs, which regards any individual's set of jobs as constituting a career.
iv) The career as a sequence of role-related experiences, so that the experiences of a house-wife, a mental patient or a dying person can form a career. (Hall, 1976, 1986)

Mindful of the distinction made by Gunz, these move from i) through to iv) increasingly emphasising the individual over the organisational view of the career. All these elements are valuable in this study of the individual career, not least because individuals, as well as researchers, may adhere to one of these views of their own career.

Hall (1976, p200) suggests that the common view of the career as advancement is gradually being overtaken by the concept of a lifelong set of experiences. There may be a pattern evident in that set of experiences, which appear to make it a stereotypical "good" career. But as Watts (1981) suggests, a pattern evident in an individual vertical series of jobs may be by chance, or it may be that it fits into a pattern which might be expected in one particular organisation. Neither is absolute evidence that the organisation shaped the career without subjective elements as important factors.

In the light of the debates on how to approach career studies, the definition of the career I use here is that constructed by Hall (1976). His definition expands on the notion that careers are an individual experience and behaviour in an organisation:

"The career is the individually perceived sequence of attitudes and behaviours associated with work-related experiences and activities over the span of the person's life." (Hall, 1976 pp2-3)

At face value this definition seems to cover a whole range of activities which may be related to work. The strength of this definition is not just in its emphasis on the individual; even though it only covers work related behaviours it excludes the notion that careers are simply constructed in organisational terms. The definition facilitates analysis of:

i) perceptions of the career as well as objective career movement data;
ii) the career as a sequence of activities which may be related together, not simply isolated jobs;
iii) attitudes and behaviour patterns rather than perfect and informed career choices;
iv) work as an experience rather than isolated activities;

v) extension of the concept of career into education, unemployment and retirement as well as periods in a place of work.

The aspects above are essential in researching individual career changes and choices. They offer an opportunity for individuals to express why their certain career pattern has emerged, rather than the researcher attempting to deduce this from objective career data, of a type which could be supplied by organisations on their employees.

This section has arrived at a definition of career, having addressed the various levels at which careers can be analysed and adopted the most appropriate approach: to focus on the individual, subjective career avoiding judgements on the success of career achievements or planning. On one hand, in this conception of career, I attempt to avoid reifying the career, constructing it as a thing when it only exists in the minds of people (Gunz, 1989; Evetts, 1992 p2). But on the other hand, a structure needs to be adopted to examine careers within an all-embracing definition such as Hall's. I develop this in the next section by looking at models of career structure in detail.

2.2 Career stages and patterns

Whatever level of analysis is used, careers display certain common characteristics, or structures, which have been examined by different researchers. I suggest there are two scopes of approach which have been adopted. One is analysis of what can be termed "career events" or "career movements", whether these are large or small scale, within or between organisations, or relate to tangible changes of job or less tangible changes in attitude to the career. The other is to attempt to model the whole career, showing common patterns and stages.

On the narrower scope, research has produced the following theories on career "event" factors which potentially disrupt or stabilise career movement. Cyril Sofer (1970), for example, explores characteristics of the subjective career in "mid-life". This has produced interesting work on unstable periods of career discontent which interrupt a stereotypical smooth career progression, revealing the possible outcomes of an individual rejecting the career progression expected of him/her by an employer. The "mid-career" disruption is unlikely (as the review by Collin, 1977, suggests) to affect every individual but is important in challenging the stereotype view of career. It provides an accepted summary term for some individual career decisions or aspirations.

Carnazza et al (1981) have looked at "plateauing". This is a career stage at which an individual is dissatisfied with their career because there is no prospect of moving anywhere as a result of a narrowing hierarchy reducing opportunities. Often this is related to "mid-career" characteristics, although the two terms have not been linked in the literature. Taken together, this work summarises the subjective career experiences which may be expected during a period of career movement from technical specialism up a hierarchy towards management.

More specifically, some external social factors are of such great importance that they invariably affect career progression. For example Baxter (1975) identifies marriage and its attendant responsibilities as an important factor in stabilising a career at whatever age it takes place. For women in particular the stages of child bearing and rearing may serve to interrupt the career at any stage. Watts focusses on another career event, job changing between organisations, and points out (1981, p232) that role try-outs through frequent job changing in the early twenties are unlikely to have detrimental long term effects on the career, but may indicate an initial inability to come to terms with work *per se*. Apparently haphazard job-changing, even in the establishment or maintenance phases, may have a purpose to the individual, even if simply providing variety. The findings of these and similar research projects have useful input into the analysis of movement into management because they reveal influences on a career which are difficult to predict or plan for.

The wider scope of approach, modelling the whole career, shows patterns to be noted in their construction. The career model of Super and Jordaan (1973) spans the whole life of an individual, rather than just economically active years. First, they identify career types, which incorporate Super's earlier typology of objective career advancement. These types are not arranged in any order over time, but summarise the overall characteristics and pattern of individual careers:

- *stable*, consistent following of one career from qualification to retirement, as in the case of many professional and managerial workers, some skilled and a few semi-skilled and clerical workers;
- *conventional*, where a worker includes initial temporary and trial jobs before settling into the stable pattern;
- *unstable*, in which a trial-stable-trial cycle takes place as the individual moves from one field or line of advancement to another;
- *multiple-trial*, in which the individual changes employment frequently and does not achieve stability in any field.

(Super & Jordaan, 1973)

Super and Jordaan's model breaks down the career into stages at which certain career characteristics are typically seen. These stages link to age bands in chronological order:

Super and Jordaan's Career Stage Model (1973)

i) *Growth* (ages 0-14), during which the self concept develops through identification with key figures in the family and at school. Needs and fantasy are dominant in the early parts of this stage; interest and capacity become more important with increasing social participation and reality testing.

ii) *Exploration* (ages 15-24), during which self-examination, role try-outs, and occupational exploration take place in school, leisure activities, part-time work, and later in a first full-time job.

iii) *Establishment* (ages 25-44), during which, having found an appropriate field, efforts are made to establish a permanent place in it. As the career pattern becomes clear, effort is exerted to stabilise it through advancement: for the majority of people the ages 31 - 44 are the most creative years.

iv) *Maintenance* (ages 45-64), during which the concern is to hold on to the place that has been established in the world of work; little new ground is broken, but there is continuation along established lines.

v) *Decline* (age 65 and over), during which physical and mental powers decline, and the pace of work slackens and finally ceases. (summarised from Watts, 1981 p230)

The career stage model represents a typical pattern without career breaks or major changes of career direction. It is intended to be applicable to all types of career, not just those of professionals; although some characteristics of the model such as the relatively late onset of the establishment stage show its suitability for the study of professional careers. Although the model suggests ages at which movement from one stage to another may take place, this does not suggest these should apply to any particular career or that the change is clearly seen. It would be misleading to suggest that all individuals pursue this model if they are able to, even though it represents a typical pattern.

There have been alternative attempts to link life stages to career stages such as the "work/career" perspective of Schein (1978) or the three stage managerial career model for ages 29 to 64 of Veiga (1983). Super and Jordaan's model has particular strengths as a broad framework for this thesis when compared with these alternatives. When compared with Schein, Super and Jordaan's model provides a relatively straightforward single set of stages for the economically active years through which an individual may advance or stabilise his or her career. Super and Jordaan also make a distinction between establishment and maintenance stages, the age and circumstances of movement between these two stages being particularly important here. And also importantly for this study, Super and Jordaan model the period of growth and occupational exploration which shapes the career aspirations and pattern of every individual, but of which Veiga takes little account.

In this section I have explored some of the theoretical approaches to certain career events or career stages. This has introduced some new terms from the literature to describe either these events or stages, but the most important part of this section is the adoption of the Super and Jordaan career stage model as a broad framework for ordering data on the career. The next section focusses in on the subject of "job change", that is, the way in which during the working career, individuals move between or within identifiable jobs which may mark out movement between career stages.

2.3 Career and job changes

In this section I examine the career event termed "job change": mobility in the career, or the desire to "move on". Job change is inadequately defined in the literature, so first I intend to define what I mean by job change. A doubtful assumption is that it just entails a move to another organisation or at least a promotion to a new position and title in the same organisation. In the same way as it cannot be assumed that boundaries between career stages in Super and Jordaan's model can be easily defined, job change does not always take place through recognised "moves".

I see the real picture of job change as far from this simple inter- or intra-organisational movement. Nicholson & West (1988 pp 72-3) look further into the complexity than Watts and other earlier writers by rejecting the notions of simple push and pull factors in the careers research focussed on the exploration stage. They look at the decision processes experienced by managers in the establishment stage. "These reveal a much more shifting, contingent set of relationships between needs, circumstances and actions" (p73).

Job change cannot always be seen clearly as a decision, or mobility to a different post. I propose that job change may also be a gradual, incremental alteration to work that may only be perceived by the individual in hindsight. In this transition process, choices can still be identified as presented to the individual, implicitly and explicitly. Nicholson and West's 1981 study used longitudinal data to compare managers' expectations of job change with their subsequent experience of and satisfaction with it. It revealed that while managers would like to have foreknowledge and control over their job changes, they rarely do so. However, a career that apparently lacks any plan does not necessarily lack form. A totally unplanned career may very well conform to the stereotyped smooth sequence of positions which would generally be regarded to form a good or successful career. While Nicholson and West (as mentioned in ch. 1) do find the use of the conventional term "career" relevant, it seems from their research that our understanding of the processes of job change is crucial to its relevance. The influences of choice and attitudes to work or careers are in turn crucial to the understanding of that job change.

So in summary, the term job change will be used to mean the alteration of work patterns and responsibilities over time, whether sudden or transitional; whether individually planned or unexpected. Job change is a process of incremental change within jobs as well as movement between jobs.

In summary of the first three sections of this chapter, I have conceptualised the career as:

i) made up of objective career movements and subjective career experiences and attitudes.

ii) an individual series of identifiable events and behaviours;

iii) divisible into five stages over the whole of a person's life:
- growth
- exploration
- establishment
- maintenance
- decline

which group those events and behaviours.

iv) marked by job changes which may be within or between jobs.

An individual's career pattern, and particular job changes, are a product of a process of implicit or explicit choices and surrounding constraints. In the next sections I go on to examine subjective career experiences. First I focus on the choices and constraints faced by individuals as they move through a set of career stages.

2.4 Career choice and constraint

In this section I consider the subjective career in terms of individual attitudes to career events and stages. First I examine the choices or actions an individual may take at different career stages to promote their career development. I also present approaches to the constraints around such choices, and to the complexity of the process of career movement.

At different stages of their career individuals make choices or take actions which are more or less explicit, but which have an impact on the direction their career subsequently takes. Choice is broadly about how opportunities are perceived and acted upon, and not just a preference for a certain hypothetical outcome. At their most explicit, these opportunities are clear options which can be chosen between. At their least explicit they can be ill-defined paths which lead to unclear outcomes but about which decisions never the less have to be made.

The first and most obvious career decision is typically at the point of transfer from the growth to the exploration stage. This is the much researched point of "occupational choice" when a career path is supposedly selected on the basis of education and aspirations. Choices are made at many other points in a career, such as in the subsequent acquisition of qualifications, job applications and performance appraisals in which career aspirations may be identified and acted upon. These points in the process by which occupational choice takes place are synthesised by Musgrave (1974) and criticised by Ford and Box (1974) and Coulson et al. (1974) in an attempt to arrive at a sociological theory of the choice process both at initial entry into employment and in subsequent career stages.

Coulson, Ford and Box argue that occupational decision making is probably best regarded as a largely continual choice process in that it is often the result of interaction over a protracted period between aspiration, preference, self-discovery, influence, opportunity and experience (Sofer, 1974 pp 21 & 44). This, I feel, is a more satisfactory and detailed attempt at explanation of choices than Van Maanen (1976), for example, who proposed that educational, employment and social structures shape an individual's expectations of which career choices are open or closed before they even see them as potential opportunities. This may be so in terms of whether an individual becomes a street cleaner or a brain surgeon, because some social groups have hardly any access to some career opportunities for those reasons. But for the present study, which is concerned with changes within professional jobs this sort of "closure" approach does not begin to offer any explanations for why individuals make a choice between, say, technical and managerial work within engineering.

At any career stage, choice may be constrained by a variety of factors. These include the availability of career opportunities, awareness of such opportunities, suitability of an individual's qualifications, and the experience required for entry or movement in a certain career. Sofer (1970) exposes the structural constraints placed by organisations on careers, even those of their most highly paid "professional" employees. There are only a limited number of positions at each stage of an organisation hierarchy, and competition ensues in which potential post-holders rely on various strengths to ensure success. A mismatch emerges between the individual's aspirations and what is achievable in an organisation structure, not just in terms of promotion, but in relevance and interest of the work itself. This is a particular career phenomena at "mid-career". (Bailyn, 1977, 1982) Furthermore, the work of Scase and Goffee (1989) suggests that throughout a career an organisation may impose career choices on an individual. For example, this may take the form of enforced relocation, or an individual being "squeezed out" of a particular career path.

Choices or career movements made at any one career stage can be seen in turn to act as a constraining factor on future career moves. When a decision is made and a particular option chosen, then a certain series of further opportunities, choices and constraints apply; if a different decision is selected, a different series of potential consequences can be expected to follow.

A framework for this process can be conceptualised in different ways. The framework may be conceived with the characteristics of a path or ladder, on which each decision has only a limited range of follow-on options, which may not in the end lead to where the individual initially hoped. More realistically, it can be represented with more dimensions. Haystead (1974) expresses this with her "decision tree" analogy. Gunz (1989) prefers to talk about career "climbing frames" rather than career trajectories or paths, which imply being pre-defined. These climbing frames consist of a range of inter-linked career options and roles as the career progresses. This seems the most useful and accurate conception of inter-linked career decision making, which at the outset of a particular career could be termed its "option plan". Musgrave (1974) similarly presents the choice process over the whole career as movement between linked roles. He represents the life-cycle as a large number of alternative pathways theoretically available to individuals. Decisions made at each stage limit the possible pathways along which an individual may travel in the future.

The growth and exploration stages of a career significantly shape career preferences and narrow an individuals's range of choice through the action of family, school and peer group before they start work. Musgrave suggests that the first post achieved in the exploration stage may not suit an individual, who may therefore change jobs to find one more suited to his or her preference. An individual may also change jobs through changes forced upon them by technological or organisational change. What Musgrave fails to bring out is that information on career choice is far from complete, and that a career path may initially suit an individual's preferences, skills and abilities, but that suitability may change over time as a result of role changes through moving up a hierarchy within the same job. This may entail roles and responsibilities which were not foreseen by the individual upon entry into that line of work, and remains distinct from wider structural factors affecting his or her choice process (see Coulson et al, 1974 and Sofer, 1974 p45)

Coulson et al. (1974) principally criticise Musgrave on another count, however. Their critique emphasises that the choice process is not a smooth one and (I presume even if career stages can be clearly delineated) the phases of career decision making are not always neatly linked with each other. They rightly argue that socialisation is simply a mixture of processes involved in social learning by previous social experiences, which may lead to certain value orientations in the career (1974, pp126-7). This is opposed to Musgrave's suggestion that the internalisation of social norms leads to clearly defined career aspirations.

Movement in a career is therefore an outcome of complex and on-going processes of choice and constraint over a long period. Particularly in the last paragraph, I have already mentioned career orientations which surround and underlie such processes, most notably in the careers of professional groups. These orientations form the other major area to be explored in this chapter.

2.5 Career Orientations

Underlying the choice and decision making process which surrounds career movements, is the question of what prompts an individual to choose one option on a career "climbing frame" rather than another. However rational this process is assumed to be, there must be values or orientations which will shape how different decision situations are perceived by different individuals. Ford & Box (1974 p112) and Sofer (1974) assert that these value orientations are a relatively static, "given" factor in career choices. Hage (1977, pp5,7) notes that what constitutes a choice for one person is not perceived as a choice for another. Either they do not recognise the scope for a choice *per se* or do not react to a choice situation because they perceive any likely outcome as a positive one; ie they will go along with whatever happens. Through different career orientations, another individual may perceive the same choice situation differently, and spot the scope for decision-making, or more importantly perceive one or more of the potential choices as having a negative effect on their career.

Gunz (1989) identifies orientations as "needs". The starting point of the individual level of analysis he terms the "micro-view", which commences with individuals entering a system of education and then employment, having certain needs, only some of which can be generalised. These needs may change over time, and the career continues to satisfy these needs to a greater or lesser extent. The employer also has certain needs in terms of education, skill and expertise which individuals either bring with them or develop on the job. (Gunz, 1989 p227, from Schein, 1977, 1978) Gunz sees an individual as always looking forward - their "future orientation" and suggests that individuals work out "career logics" to enable their needs to be met (Gunz, 1989 pp239-242). An individual faces a series of choices, both implicit and explicit, to meet their needs throughout the career. When faced with constraints in the structure of their employer or society, or from within their own values, they may have to deviate from a "normal" career path to continue to meet their own particular needs.

Other researchers have attempted to categorise career orientations. Derr (1986), for example, proposes a framework of five values or orientations underlying the career. Unfortunately Derr rather takes competence in an occupation as read, whereas in any career where there is a clear difference between the work and/or skills required technically and those required managerially, I suggest that competence is going to be important. In other words, if an individual feels they are unlikely to become competent as a manager, they are unlikely to even want to become one, let alone achieve such a position.

So although the term "orientation" seems most appropriate for this study, I turn further back to work by E.H. Schein

(1977, 1978) who describes "career anchors" which are "a syndrome of motives, values and self perceived talents which guides and constrains the person's career" (1977). Schein's work is particularly useful for this study because it focusses on the career values likely to be held by professional employees. He takes account of two types of competence in work, and identifies five career anchors:

i) managerial competence,
ii) technical or functional competence,
iii) security,
iv) creativity (creating something of one's own),
v) autonomy or independence.

These anchors may be found in combination - for example technical creativity - but are generally intended to identify the one or two major satisfactions or aspirations which an individual gains (or intends to gain) from work.

Career orientation is a useful concept to describe the motives and aspirations of the individual, taking into account skills held, which are carried into and through a career. As such, for my categorisation of career orientation I adopt Schein's five "career anchors".

I have already noted the term "professional", and I suggest that the identification of an individual with a professional group more clearly defines their career orientation(s). The term "professional" has limitations and potential confusion lies in the fact that "the word profession is used to refer both to concrete historical occupations and to an intellectual construct or ideal type, without consistent attention to the relationship between the two." (Freidson, 1977 p15; cf. Habstein, 1963) Here I use the term "professional" in the latter sense. Increasingly diverse occupations claim professional status (Evans, 1979) and writers such as Freidson (1983 pp35-6) cannot arrive at a single definition of professionalism which covers bother the "free" professional such as the medical doctor, and the organisation based professional such as the engineer.

What is important to note here is that some professional characteristics (drawn from Greewood, 1957) are common between free and organisation professionals. These are primarily a basis of systematic theory; an authority and depth of knowledge in a certain speciality; and a professional culture. It is these attributes which make an individual identify a certain professional group as his or her own. Indeed there are many professional institutions to formalise that sense of belonging. It matters less whether these attributes are actually achieved by professionals working in organisations. What is important is professional identity; that many highly skilled employees of organisations *aspire* to those ideals, whether they are attainable or not (Horobin, 1983).

This means that certain career orientations are appropriate to professional groups. Moreover, some of Schein's categories may be specific to certain professional groups. Technical professionals can be expected to identify most with orientations to technical competence, and perhaps to creativity, security and autonomy. But to have an ongoing orientation to management might be seen as moving away from the authority and depth of specialist knowledge which effectively defines that professional group.

I suggest the position for the professional in an organisation may take the following form. Individual professional authority is undermined by the assembly of a large number of (usually) fairly equally qualified professionals in an organisation hierarchy which is bureaucratically structured. An organisation will value certain "non-professional" or non-technical skills, to direct and manage the organisation's profit making. An individual's professional authority may gradually become derived *not* from a knowledge of any systematic theory, but a working knowledge of the *organisation*. Yet that individual is still recognised as a part of the original professional group, up to a point. He or she will still command a great deal of "speciality" knowledge over the "layperson" but not necessarily over other professionals with whom he or she works.

So derived from this point I see an interesting possibility: whether a professional moves outside the strict limits of his or her profession when taking on work which is less explicitly technical. Building on the basic assumptions of the profession literature, a profession based in organisations may not have tightly closed ranks. This may work in two directions. Most obviously the qualifications to practice may not be strict, or at least routes of entry may be varied. Alternatively the professional may have the choice, or even be in some way compelled to advance his or her career by means of taking on new skills which are outside their original field, or which are common to many professional bodies such as managerial skills, or which may even be identified as part of another profession. Management is, after all, one of the many occupations which claims professional status in its own right.

In this section I have identified career orientations which are carried through the events of a career and help to shape up the decisions made. I have argued that these orientations matter to professional employees, and that identity with a particular professional group should heighten an individual's awareness of their career orientations.

2.6 Summary

In this chapter I have examined the concept of the career and adopted frameworks to study the individual, both in its objective patterns and stages, and in the subjective career experiences surrounding career events such as job changes. I have moved on in the chapter to establish the process of choice and the orientations which can be identified as part of the career decision making process over time. In summary I argue that a career is:

i) made up of objective career data and subjective career experiences and attitudes;

ii) an individual series of identifiable events and behaviours;

iii) divisible into five stages over the whole of a person's life:
   - growth
   - exploration
   - establishment
   - maintenance
   - decline

   which group those events and behaviours;

iv) constructed by a process of choice and constraint around available career opportunities

v) built up on growth and exploration stage orientations, which may then be modified over time and emphasised by professional allegiances.

I have identified the main concepts and structures to organise the data in the thesis, and outlined how I wish to use them. In the next chapter I move on to apply these career concepts to technical and managerial aspects of careers in engineering in general, and in high technology industries in particular.

Chapter 3 - The Careers of Engineers

In this chapter I define an engineer for the purposes of the thesis, I define what is meant by technical work and how managerial work differs. The chapter then relates the concept of career to the engineer, by looking at the engineer's career stages, patterns and orientations. I start with examining work orientations, and then review evidence of the factors which may lead to the choice of a career in engineering. I trace the routes taken to enter the engineering industry and describe the career patterns and influences to be noted in the first few years of employment.

Then I examine what management involves in engineering, and what happens when an engineer climbs a typical organisation hierarchy into technical management and beyond. Finally I summarise the research agenda for the study of career choice in the path through technical management.

3.1 Definition of the engineer

Professional engineers can be defined both by what they do, and also by their qualifications. First I examine what engineers do, and then describe the roles of function and qualifications in defining engineers for the purpose of this thesis.

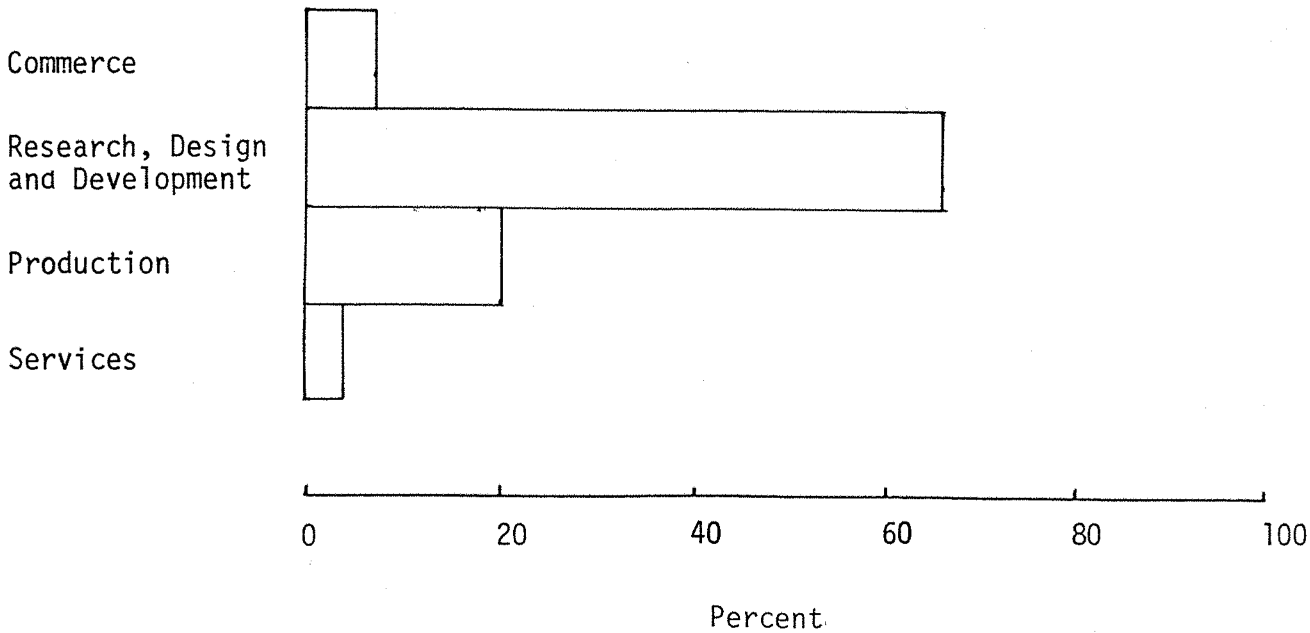
Engineers are workers applying technical knowledge, but that does not mean engineering is the same as technology, or science. This is because engineering generally outputs three-dimensional objects which are not only normally useful but are produced with a commercial or practical aim in mind. Science, by contrast, produces two-dimensional outputs in the form of papers and articles in the pursuit of truth. Engineers do use scientific knowledge as an input together with various types of technical knowledge and including markets, finance and people (Fores, 1972; Glover & Kelly, 1987).

The involvement of science and technology in the work of engineers means that in all sectors of engineering a high proportion of engineers are not directly involved in the production of engineered items for sale, but instead their work is in the research, design and development of new or updated products or processes. Key emphasis must be placed on design, which defines engineers from scientists even when working alongside one-another in the same organisation

(Venning, 1975 p50). This is the case from initial entry into the industry as a student apprentice or graduate at the career *exploration* stage.

Venning (1975) provides a large quantity of data on engineers (and scientists in industry). She shows the variety of engineering subject specialisms, but although an engineer is always originally trained in one sector, such as mechanical, civil, electrical, electronic engineering, some interplay between these sectors takes place over the course of some individuals' careers. Figure one (below) breaks down professional engineers by their function within engineering industry.

Figure 1 - Professional engineers analysed by function



Source: Venning, 1975 p24

Two distinctions must be made to define professional engineers in general. These can be perceived as vertical distinctions in an organisation hierarchy. The first distinction is between professional engineers and technicians, or engineering support staff. The engineering institutions make quite a clear distinction here, considering that it is essential for professional engineers to possess an engineering degree (or until the 1970s an HNC/D) or a professional institution qualification in some cases, otherwise they are technicians (Berthoud & Smith, 1980). This distinction is therefore by qualifications, but as Peter Whalley points out, the "identification of engineers by qualifications - while useful for certain purposes - says little about occupancy of positions in the division of labour" (Whalley, 1986 p64). Definition by function is more useful because it can be assessed at any point in time throughout a person's career.

Functionally, professional engineers can usually be distinguished from technicians by the non-routine nature of the work of an engineer, as well as by a greater involvement in, for example, design of projects rather than routine testing of prototypes. Engineering technicians typically work under the direction of engineers. There is potentially some grey-area in this distinction, however, because some engineers may spend some time on relatively repetitive testing work in certain stages of an engineering project.

Engineers also need to be distinguished from managers directing the work of other engineers, but not involved in technical work themselves. Attempts have been made to clarify this upper end of the spectrum of professional engineers' work. Venning (1975), in a survey for the Engineering Industry Training Board in 1969-70, deliberately excluded managers from the category of engineers, but in this she implies a dichotomy and dividing line which simply does not exist. It was easier for Berthoud and Smith (1980) to find that a significant proportion of those with engineering qualifications move into non-engineering jobs, for example "general management". But they say less about the new position of those who remain very much within the engineering industry but move to the margins, wholly in sales for example, or so far up into the management of engineering firms that they have effectively become general managers.

So there is a greater potential grey area in defining the professional engineer - the distinction between an engineer and a manager. The engineering institutions assume that anyone qualified as an engineer, and therefore fulfilling their entrance criteria, is forever an engineer, regardless of subsequent function within an organisation (Whalley, 1986 p20). This stance seems to defy the reality of the careers of some engineers, and this area will be further discussed in section 3.2 on engineers' career orientations.

A similar grey area exists in terms of function: do engineers always remain as engineers throughout their careers? This is a potential source of conflict amongst engineers (rather than between professional and organisation) because a personal career path may no longer be technical and to an outsider it may be perfectly obvious that the individual has become more of, say, a manager or a salesperson than an engineer; but when they became so is harder to pinpoint. This question is further addressed in sections 3.4 and 3.5 on engineers and management.

So for the purposes of this thesis, professional engineers can be defined first by holding a minimum level of qualification, and then by the type of work that they do. There are no precise boundaries to be drawn in this distinction, but on the technical managerial level at which respondents are sampled for this thesis, these distinctions are of less importance than for research sampling younger/less senior engineers (note a). Two questions implicitly arise out of the distinctions I have drawn in this section. The first asks: do professionally qualified engineers remain as engineers throughout their careers? I expand on this in the next section examining engineers' career orientations. The second asks: when does an engineer become a manager - what marks out the differences and the change?

3.2 Engineers' career orientations

There is evidence from the literature that engineers demonstrate certain career orientations throughout their careers, and typically gain greatest job satisfaction from certain areas of their work. Some original research into engineers' careers indicates that engineers are usually characterised by a strong work commitment, or an attachment to intrinsic occupational goals (Gerstl and Hutton, 1966; Kerr, Von Glinow and Schriesheim, 1977). These intrinsic goals are best summarised in terms of Schein's (1978) model as anchored in *technical or functional competence* and *creativity*. This technical competence is based upon being able to design products and solve complex problems, while the creativity is more practical than artistic. (Glover & Kelly, 1987 pp179-82).

Certainly it seems true to say that the intrinsic rewards for an engineer lie in performing technically, while a desire to perform well managerially is not so universal through the span of a career. American research demonstrates some orientation to management among some engineers. For example, Allen & Katz (1986) break down career orientations into technical, project oriented and managerial orientations (note b), finding respondents distributed in proportions of 22%, 46% and 33% respectively. The percentage preferring a project orientation increased significantly with age. In her study, Bailyn (1986) found the distribution between the three orientations almost equal. It is important to note that the technical and project categories together incorporate Schein's technical or functional competence and creativity, remaining clearly separate from managerial competence. In both cases it is clear that across the Atlantic, management is *not* the aspiration of at least 66% of engineers, and there is no evidence to suggest it is any less in Britain.

This may be fine. After all, not every engineer can become a manager, so it is perhaps fortunate that two-thirds of them do not want to. However, as I have already mentioned, the only "way up" in many engineering careers is through movement into management over time. By contrast, all engineers start their working career in a technical specialism, not in a position of quasi-technical management in which management is the natural progression. It is a career orientation to technical competence, coupled with a bias to service provision, product and technology, which characterises engineers while primarily engaged in technical work. The satisfaction gained from the intrinsic rewards offered by technical work itself may vary according to how far the engineer has moved away from his or her original area of technical expertise. A number of structural constraints within an organisation are likely to channel the individual working career from early on, away from technical to more administrative and managerial roles, whether their orientation is towards management or not. So while Allen & Katz (1986) and Garden (1990) correctly state that not *all* technical engineers are being "forced" against their will into managerial roles, there is plenty of scope for some moving into these roles without them being their career aspiration.

Glover & Kelly (1987 ch9) present the arguments concerning engineers' position in the professional-organisation debate. The implication of the research findings outlined in the preceding two paragraphs is that engineers show a bias to providing a service rather than a profit. To some theorists this has suggested a conflict in one form or another, between the professional aspirations of the engineer (with his or her technical expertise and desire for autonomy) and the employing organisation (with its desire to make a profit). Whalley (1986) and others dismiss this, seeing British engineers as "trusted workers" whom employers allow a fair amount of freedom, status and other privileges compared with other employees. They see engineers as in some ways a part of the management structure, and yet in some cases insulated from it, to forestall conflicts. What is interesting here is whether being "part of management" is part of the engineer's career orientation, when by contrast, an engineer is more likely to be product/technology orientated rather than people/client orientated. These orientations are unclear, because being "part of management", contact with customers and any financial involvement with the firm is likely vary widely. Specifically these influences on technical or managerial orientations are likely to be a function of:

i) the size of the firm,
ii) its range of customers,
iii) the width of the technical area in which it works.

An increase in the size of the firm may contribute to its engineers' bias to product/technology because less customer contact may be required, and there may be more opportunities to stay with an orientation to technical competence. On the other hand, Garden (1990) found in software engineering that an orientation towards a managerial career was more common in larger organisations, but the average wanting a managerial career was only 1% higher than the findings of Allen & Katz (1986) quoted above. Relationships in ii) and iii) require research but it may be that opportunities to explore different sidelines on the margins of technical work may pull an individual's career in that direction, if only for variety. If the nature of an organisation does not enable it to offer these opportunities, it therefore does not offer the chance to see and sample this potential job change. The themes emerging here are developed further in sections 3.5 and 3.6 on the relationship and career development between engineering and management.

So at this stage, it is interesting to note that in some career circumstances at least, the engineering institutions may curiously be right all along: "once an engineer, always an engineer", whereas in others an orientation to managerial work may be evident and nurtured by the employer. There is other wider evidence of the orientations of engineers. For example comparative research has suggested that, certainly in relation to German counterparts, British engineers valued achievement and "challenge" in their work, perhaps less straightforwardly than the German engineers' value of clear objectives, orderliness and (most notably) *authority over others* (Mant, 1978; Lawrence, 1980). Bamber and Glover (1975), in a case study in British Steel, found that interesting and challenging work were valued by those working in a narrowly defined technical capacity. Those engineers who had taken on a project leadership or managerial role of some sort tended to also emphasise the "exercise of authority" and "relationships with others" as their principal sources of satisfaction (also Glover & Kelly, 1987 p179).

Just as important in discussing orientations is what engineers were most dissatisfied with. At workplace level, Bamber and Glover found that their respondents on any hierarchy level were typically dissatisfied with a lack of authority, control and status, as engineers (not as managers, where appropriate) (Bamber & Glover, 1975; Glover & Kelly, 1987).

A great deal has been debated and written on the image of engineering as a whole, largely in connection with debates on skill shortage. Thurley and Swarbrick (1986 pp31-3) quote evidence from Berthoud and Smith (1980) showing nearly half of the engineers in their survey to have complaints about their lack of status. Papers compiled by Bladon (1989) implicitly suggest, as always, that the "image problem" of engineering is wholly the fault of misconceptions by the world outside. Many of the general public, and most importantly general school leavers, have these misconceptions on two areas: the wide range of engineering disciplines, and the difference between professional engineers and manual engineering workers (NOP Omnibus Survey, 1978, O'Neill, 1990).

This low status of engineers is unlike the patterns in other European industrial nations (Glover, 1978) and Child, et al (1983) argue that the status problem is based on the differences between vocational higher education courses offered in Britain and West Germany, for example. That may be so, but it seems that young engineers have a better conception of engineering as their professional identity than older engineers. The institutions emphasise engineering's technical components and responsibilities rather than the managerial side. The Finniston Report (1980) identified a body of technical knowledge and public responsibility as central to engineers' professionalism and proposed registration of all engineers, under a central, unified body. Finniston also recommended greater authority for an umbrella institution and the provision of professional services and representation for engineers, which many members had otherwise had to seek in unionisation. This technical professionalism is effectively closed by the system of chartering. Engineering is not widely regarded as very successful in its professionalisation, which in turn is tied up with image questions (Glover & Kelly, 1987 ch10; Bladon, 1989).

It can be said that engineers have rejected the technical professionalism of the institutions because only about half those in Britain eligible to join them have actually done so, mostly joining when they are students. At least some of those who have joined have a lukewarm attitude to the institutions, seeing them as "sources of slightly enhanced qualifications and as ways of keeping in touch with wider developments which are on the whole more interesting than useful" (Glover & Kelly, 1987 p195).

However, the apparent rejection of institution membership is compensated for by unionisation, and Glover and Kelly quote 1983 data showing 41% of all chartered engineers as belonging to a union (1987 p185). Few are likely to belong to a union and an institution. They argue that many engineers have recognised that their skills are not statutorily defined, and they do not have the same autonomy or domination of clients enjoyed by other professions such as accountancy. Most engineers, they argue, would accept the best description of them is as highly qualified and skilled salaried employees (p195). But I argue that they are still identifying themselves with a profession, or at least a set of skills, which are primarily technical, whether a member of an institution or of a union. This professional identity forms an indicator of career orientation, and one which is clearly challenged over the course of a career in which an individual gradually takes on more managerial responsibilities.

In summary, it matters less for my thesis whether the image/status problem is in relation to other professionals in the UK or in relation to engineers in other countries. What is salient here is that evidence exists for widespread dissatisfaction with engineering as a professional identity which may give rise to constraints on the individual's career movements and lead to a change in career direction by taking on new responsibilities. Coupled with the different possible career orientations towards either technical or managerial work in different organisation circumstances, there is evidence to suggest the technical creative orientations of the young engineer will be seriously challenged in the first few years of working life.

3.3 Initial career choices

There are a number of factors which contribute to a positive choice of engineering as a career (or at least, perhaps, as a course to study at university), however low an individual's aspirations may be in that career. In relation to the career anchor and orientation theories, the basic attitude of a child in the career *growth* stage is most important. Engineers' technical/functional and creative orientations show in a combination of the following specific areas:

- interests in technical things through pastimes or hobbies,
- the anticipation of a rewarding career in engineering,
- motivation through the study of engineering-related subjects at school,

and less importantly:

- the advice of friends and relatives,
- the advice and influence of teachers and careers officers.

The British education system has been shown to direct the most able children away from practical subjects throughout their school careers. This occurs directly through certain options being closed to the most able pupils. It also works indirectly as school children often received advice in school which indicated that a place at university studying a pure discipline should be the ultimate aim of all school-leavers. The few technical courses which are provided in schools are not particularly attractive to pupils. (Tubman and Lewis, 1979; Glover and Kelly, 1987 pp99-104, 110-2). Therefore the chances of even three out of the five factors outlined above being present together is statistically remote. On this basis it can be argued that chance is important regarding the numbers of people who do make engineering their positive subject or career choice (Glover, 1973).

Study of social influences on the choice of engineering as a career reveals a fairly constant situation: at age 11, 20% of engineers have a father associated with engineering, 9% being a professional engineer and 11% being a skilled manual worker in engineering or a related industry (Berthoud and Smith, 1980). Engineering has been seen as the route to a good career for "bright working class boys", though Berthoud and Smith identify children from the middle class to be more likely to enter engineering than those from the working class. They also found that this middle class background was lower than that of other professional groups, and much lower than the middle class background of doctors or lawyers. (Glover and Kelly, 1987 p112; Berthoud and Smith, 1980 p11)

Moving on from school, the gaining of qualifications by part-time study had been dominant until the 1960s in all branches of engineering including mechanical and electrical.

It is still a recognised route but far less popular; the pattern of recent years has been for an absolute increase in the sheer numbers of people graduating in engineering subjects (Glover and Kelly, 1987). Berthoud and Smith's study (1980 figs 2.1, 2.2, pp7-11) brought out the pattern of change over the then-current spread of engineers. Their survey sampled only institution members but did include members at technician grade, and revealed the following situation in September 1978:

31% - "Academic" route: holding a degree with no intervening post-school qualifications;
69% - "Practical" route: invariably with post-school qualifications, possibly with a degree added later

In the second category 13% had then gone on to gain a degree as well, 15% had no degree but had passed professional exams, 27% had passed HNC, HND or FTC but no higher qualification, and 14% had none of these.

A dramatic increase in the number of people entering via the academic route was demonstrated and the trend continues. A problem, however, has been that this has tended to be at the expense of technician engineers. With the rise in the number of degrees in engineering there has been a decline in entry by the full-time HND route and an even sharper fall in the numbers coming in through the part-time HNC route. The result has been that the technician level is being starved of its best candidates as they are tempted away to degree-level studies and the possibility of Chartered Engineer status later on. Chartered status used to be obtainable by HND and HNC holders until 1985 (Glover and Kelly, 1987).

In the trend towards entry by degrees, engineering is no different from other comparable professional careers such as accountancy, and Glover and Kelly (1987 p103) also suggest that it is symptomatic of the high value placed on a non-technical education in Britain. Berthoud and Smith (1980) suggest that the trend may imply more academically-minded school pupils are attracted to engineering, but the wider availability of sixth form places, the general expansion of higher education and other factors cloud the picture. It is difficult to determine with confidence whether or not the same group of young entrants are coming in via universities and polytechnics rather than apprenticeships.

One outcome which Berthoud and Smith do substantiate from their data is that engineers with higher academic qualifications do tend to be more successful, if that success is measured by salary, and by the speed with which managerial positions are reached. It may be that those with degrees are better at their work, but a causal link cannot be made here because those with ability in the workplace may also have risen just as naturally in education. A more concrete suggestion by Berthoud and Smith is that the differential in success between graduates and non-graduates were less noticeable in 1980 than 20 or 30 years previously.

The Finniston Report (1980) focussed much of its attention on how engineers careers are shaped at the education level. The report is concerned with the encouragement of school-leavers and graduates to enter engineering in the first place to overcome perceived shortages, rather than how to tackle the types of "mid-career", obsolescence and promotion problems experienced by engineers later on. But the report lacks the perception of social researchers of the way engineering has itself underlined the degree route.

In summary of this section, education and training are obviously an important "sieve" process by which certain young people are able to choose a career in engineering, or at least to train for one. But compared with those who are presented with the opportunity to choose engineering, there are a greater number who have been filtered out by the structural constraints of the education system. Ability to choose is constrained by far more than academic, or creative abilities. It is a matter of being in the right class, gender and other circumstances at the right time, and often, it seems, ignoring advice from parents and teachers which may influence a young, enquiring, potential candidate. This process has a crucial effect on who becomes an engineer, and on what their level of ability and future aspiration (including any bias to technical or managerial role) is likely to be.

3.4 Engineering careers

The career path of an engineer is initially set up through their choice of degree or other qualification, or the work of the organisation in which he or she found a place to do an apprenticeship. Peter Whalley emphasises the importance of the engineer's career in the workplace. He saw it was not the characteristics of the job which distinguished, for example, test engineers from operatives, but the fact that the engineers were tied to a career ladder with good expectations, and the operatives were not (Whalley, 1986 p38). If that were true of test engineers, whose actual work is closest in nature to technicians of all the qualified engineers, then it is certainly true of other engineers. Wickham's (1988) study of Irish engineers found that over a third of his sample (mean age 28 years) expected to progress their careers by moving to another organisation in the next three years, and of the remainder, most expected promotion from their existing employer in that period. Nothing suggests British engineers' aspirations differ.

Engineers' career progression varies in detail between different branches, but in most cases the individual will work in teams of varying size and duration, building up a technical experience in whatever specialism is either being worked on at the time or is required by the company. A graduate may take part in a graduate training scheme to equip him or her for certain practices or techniques used by the new employer. Typically this includes career *exploration* in the form of "doing the rounds" of several departments for a few weeks each. Some organisations may employ postgraduates specifically for the certain narrow technical skill they possess. (Gerstl and Hutton, 1966; Glover and Kelly, 1987) By age 25, 72% of the engineers in Berthoud and Smith's study claimed to be "practising engineers" but of those only 36% had achieved the institutions recognition as "professional". Again of the practising engineers at age 25, 43% were involved in research, design and development work, with 36% supervising operations and 21% unclassified (Berthoud and Smith, 1980 pp18-9).

Promotions above graduate or junior engineer grades vary not only between branches of engineering, but also between organisations according to the way their hierarchy is constructed. A standard arrangement is a bureaucratic, rather than professional system, in which a variety of grades of engineer all directly report up to one manager (Whalley, 1986 p37). Typically, the young engineer will have potential opportunities during career *establishment* to take on supervisory functions alongside greater technical responsibilities, as the trust of his or her colleagues builds up. If sufficient aptitude is shown, the engineer may have further opportunities for promotion, though these may come before or after the actual work to which they relate has been started.

Some American research suggests that as the individual stays in engineering over the first few years, technical skills increasingly become locked into one specialised sector, though not necessarily into a specific organisation. This can be seen as a product of the tendency of many organisations to force the most able professionals into a clearly pre-defined slot in a framework; it may lead to increased vulnerability to processes of obsolescence (Rothman and Perrucci, 1970). The specialist confined to one narrow sector may enjoy relatively rapid promotion or higher rewards, as the skills he or she offers are in great demand within the organisation. However, as time goes on, and a possible job change is thought about, the engineer may also find that his or her mobility between organisations is limited by their over-specialisation or over-reward/promotion (McLoughlin, 1983 p198; Kanter, 1984; Winstanley, 1989 p53).

A rather limited amount is known about why engineers move into managerial positions. Are they motivated to choose management, and see it as an essential engineering career stage? Or at the opposite extreme are they constrained structurally by the organisation, and end up pushed into management? The process is central to my thesis and complicated by the issues described in the previous sections so it cannot be considered in isolation. Past research has shown no conclusion, even on the factors involved in the choices or constraints, but there are several possibilities, outlined below.

An individual may conceivably have always intended to use engineering as a "springboard" into general management, using the project supervision and technical management training to develop necessary qualities for a managerial role. According to Schein (1978) this would reflect a career anchor in a *managerial competence*, but as I have already noted empirical evidence does not suggest that more than one third of engineers *ever* aspire to be managers, and this orientation is likely to be significantly lower in the early career stages. On the other hand Glover and Kelly suggest this apparent choice of management may not be any "free" choice at all. Such a move towards general management may be a coping strategy for those unable to contend with the low status of engineering (1987, p115). Whether it is viewed as a "cover-up" strategy or whether it is freely admitted by those who choose it, this theory seems equally as feasible as the "springboard" idea. What is needed is to ask engineers about to enter the maintenance career stage for their honest reactions, for neither idea has been tested.

Alternatively it has already been mentioned that if an engineer has developed a dissatisfaction with intrinsic rewards from his or her work over time, a less usual process of job change may occur. This may be by the choice of heading out of engineering altogether or to the margins of engineering, such as wholly into a sales function. This happens to many engineers in a gradual process, which was noted by a Personnel Officer in data recorded by Causer and Jones (1990) who observed that 17 out of his 21 electronic and mechanical engineers were under 35 years of age:

> "...we still haven't worked out what happens to all the 35 plus engineers! (laughs) I don't know what happens to them. But predominantly engineers are under 32, 33, I would guess. I think what happens is that they move off into engineering support functions, so that they're not solely involved with engineering or design. They do other things. For example, they may well go into the commercial world. Most of our marketing staff are ex-engineers. So once they've got a background behind them, they've got a lot of experience, they can then go and sell things." (CJ - interview 1.24 for Causer and Jones, 1990)

That is, they can go and sell things if they think it will be rewarding. If the individual's anchor in technical competence deteriorates (through obsolescence or any other means) then such a move may be enforced. But assuming such sanctions are not necessary, and assuming an organisation can provide a suitable opportunity, the engineer may choose to move on to a technical management function to find new challenges, (Glover and Kelly, 1987 p138) even after a spell in the margins or outside.

Slightly differently, an engineer may become motivated by the extrinsic rewards offered by managerial positions; a straightforward choice. Berthoud and Smith (1980) in common with most other engineers and indeed most of society find themselves measuring success in terms of extrinsic rewards. Hence, of course, the "springboard" idea proposed above. However, there is a danger of a social researcher, along with others outside the world of engineering, overplaying the financial attractions and forgetting that most engineers earn a salary adequate to maintain a nuclear family and so frequently and clearly find sustained motivation from intrinsic rewards throughout their career *establishment* period.

On career prospects, Whalley (1986) demonstrates that some engineers pursue their careers mainly internally to one organisation, while others take a "cosmopolitan" view and are more prepared to make inter-organisational career advances. Underlying all this, though, is that the career may be constrained by post-education factors from the first job onwards. There are clear constraints surrounding possible career choices all the time. Whalley asserts that organisations deliberately motivate engineers in their desired direction. It is logical to expect this to work in positive and negative ways. As well as bringing up enough managers, the right number of technical staff with the right skills are still required. As one of Whalley's respondent's pointed out, it is easy to get "left behind" by quietly getting on with technical work (1986 p113).

In the 1970s a rather low total of 40% of engineers believed that engineering was "the best career route" in their organisation. A clear majority stated they would encourage their children to become engineers, but the 33% who would said they would "somewhat" or "strongly" discourage their children from following in their footsteps must give cause for concern (Beuret & Webb, 1983; Glover & Kelly, 1987 p176).

An assumption in the Finniston Report (1980) is that engineers will be captivated by the industry and remain in it, (possibly trapped in it) with only minimal attention being given to their career progression; in fact the handful of recommendations on this topic consider only the need to remain updated in technical matters alone. Yet the paragraphs above show there are obviously more questions asked by engineers, and choices to be made by them, over the course of their careers. Fundamental amongst these is the decision of whether to make the transition into managerial positions or not, and in this context an important alternative route requires description.

In some engineering organisations there is an opportunity to pursue technical work at a level of salary equivalent to management but without managerial responsibilities. The need for this is commented upon by Child: "The question ... arises as to how far engineers can be provided with a combination of technical work and personal advancement. The attempt to satisfy these combined expectations through the establishment of a separate status ladder additional to the managerial hierarchy - the "professional" or "dual" ladder - does not go far towards resolving the problem. Promotion opportunities up the professional ladder are often made available to a few select engineers only. Perhaps more significantly, a separate status hierarchy runs the risk of removing engineers from possession of that very influence within the organisation which enhances the weight of their engineering opinion and the chance of their projects securing adequate backing." (Child, 1982 p225)

The "dual track" or "dual ladder" opportunity may be a regular hierarchical track, or a "niche" track for an individual. Aside from the criticism made by Child (1982), there are other objections which may be raised by engineers in firms in which this type of position is offered, as follows:

i) the dual ladder does not in fact eliminate all supervisory administrative and budgetary responsibilities, only the personnel management tasks;
ii) the dual ladder exists only up to a certain point on the salary scale and a decision must eventually be made again about a switch to management, if an individual wishes to keep on climbing.

Bailyn (1982, 1985) points out that by remaining in a technical career ladder, an engineer may have similar rewards to colleagues who entered managerial work, but the organisation may ensure that he or she does not enjoy anything like the same level of autonomy as those colleagues. Other researchers such as Gunz (1980) raise doubts about the effectiveness of dual ladders in satisfying and motivating engineers who want to remain in technical work, and doubt how widely they have been, or are being applied. Miller (1986) found that in practice, mobility between the two career tracks at any level is unlikely. For an engineer on the technical track, mobility to an organisation without any dual track structure is just as unlikely. Large organisations may adopt the method formally, smaller ones may use "niches" for technical specialists supported by special reward packages.

The option of a dual track career ladder is by no means widespread, or particularly successful in all instances. In looking at technical managers, I will obviously not produce much data on those who have stayed on a technical track, or on the effectiveness of the idea. But it is a significant career event in the lives of some engineers which needs a clear career decision, and as such is very interesting for this study. The option of a technical career ladder gives a potential insight into how an individual considered their career should be shaping in the *establishment* stage. The decision to take a technical track has far reaching career consequences, not least of which are other engineers' prejudices to the idea. The choice typically seems to have presented early on in the career. If respondents were offered the choice, at any time, and turned it down, this may yield useful data on their career orientations and how they may have changed. Respondents may also be able to reflect on the decisions made by colleagues who were offered the choice. But before being able to analyse what that choice precisely entails, I present debates on what is already known about management in engineering.

3.5 Engineers and Management

In the previous section I concentrated on the structure and patterns of engineering careers, and discussed the basic incentives for career movement which researchers have found. Having already mentioned managerial work in engineering, in this section I identify what I mean by the term, and exactly what technical management involves. I then go on to discuss some of the deeper reasons why engineers move into management.

It is too easy to conceptualise "technical" and "managerial" work as totally dichotomous, distinguished by a dividing line. A number of facets of engineering, particularly the technical aspects of it, have already been briefly explored. Yet technical work often includes components which could be categorised as administrative or managerial (Faulkner & Wearne, 1979; Shenev, 1988). There are also, perhaps more subtle, facets to management which require definition. It is useful in this context to draw on the literature of what managers actually do (as opposed to wider literature on what they are *supposed* to do) and to provide a working definition of managerial work with which to distinguish it from technical work.

From the work of Henry Mintzberg (1973), who aimed to "derive valid generalisations from observation of industrial phenomena" (Jenkins, 1978 p32) rather than prescribe, management in any context can be defined as composed of ten roles:

i) interpersonal roles as figurehead, leader and liaser;

ii) informational roles as monitor, disseminator and spokesperson;

iii) decisional roles as entrepreneur, disturbance handler, resource allocator and negotiator. (Mintzberg, 1973, 1979)

This set of managerial skills and responsibilities is comprehensive, and contrasts with the technical aspects of an engineer's work in terms of the orientation, qualifications and personal skills it requires. But there are stages on the path to managerial positions in engineering, as I have already outlined in the previous section. Any clear dichotomy often suggested between technical and managerial work is not readily apparent in the work engineers do, if anywhere. Rather, Bailyn (1980), McLoughlin (1983), Whalley (1986), Steiner and Farr (1986), Nicholson and West (1988), Causer and Jones (1990) and others have described in detail the process of transition through stages of supervisory and managerial responsibility, as more a continuum than any clear division. I will identify the stages as I find them useful (and later exemplify the processes by which they operate from the data presented in chapters 6, 7 and 8).

The form of the movement of an engineer towards management is well summarised by McLoughlin:

"The conventional structure of engineering careers demands that in order to achieve higher remuneration and greater responsibility the individual engineers have to progressively relinquish more and more of their direct technical involvement. That is, the technical work role of the practising engineer is progressively replaced by administrative and quasi-managerial tasks, where at best the engineer is using engineering knowledge rather than putting it into practice." (McLoughlin, 1983 p196)

Before examining this process I will define the terms I use. The term "supervision" is used here distinctly to mean the control of low numbers of other engineers and/or technicians in the daily hands-on work in a project team of two or more members. Some attributes of managerial work start to emerge at this stage, such as leadership, liaison, and dissemination of information, but this work takes place in a technical capacity in which achievement is measured by technical criteria (note c).

It is from this "technical leadership" level that engineers move up to take on greater responsibility for co-ordinating technical work of more than one team, adding further responsibilities to their role as monitor, resource allocator and spokesperson. Typically this means being deeply involved four areas in engineering: in the strategic technical planning of a project, to control budgets for projects, and eventually to also handle the full administrative work-load and personnel management functions of a large project team or a department.

It is only at this stage with all four lines of responsibility in place that the engineer can be termed a "technical manager". That is:

i) strategic technical planning of projects,
ii) controlling budgets for projects,
iii) administration of a project team or department,
iv) personnel management of a project team or department.

Technical knowledge is still required by a technical manager as a background resource in informational and decisional roles (Berthoud & Smith, 1980 p44). The transition may continue to the point where the work undertaken has extremely little regular decision-making involving technical knowledge, and certainly no contact with hands-on work or its supervision.

For Peter Whalley (1986) there was no evidence that initial education or any other factor marked out those who would climb, or were prepared to climb to technical managerial responsibilities. Whalley views the movement to management to be part of engineers' "trusted worker" status. Managers at various levels are needed by organisations and therefore engineers' motivation is moved in the desired direction deliberately. Management, at least first through technical management, is the most obvious course open to engineers, and so, once in industry, they are "happy to oblige" (Whalley, 1986 p108) and go along with the organisation's career climbing frame mapped out for them. Whalley states that although engineers are originally predisposed by their training to seek job satisfaction, "they can readily be persuaded to seek it in managerial positions. Engineers have to respond to a market dominated by the interests of employers. Technical orientations are not so fixed as to be impervious to employers' distribution of rewards and advantages, particularly when conditions of work, task autonomy and so on, vary as part of the rewards being offered" (Whalley, 1986 p109).

So Whalley essentially brings it down to the combination of rewards offered to lure engineers through organisation structure into management. While the basis of Whalley's argument is consistent with his view of engineers and holds good, it is not the whole story and leaves unanswered questions. Is it really possible to change the orientation of an engineer so far away from their original technical work, and expect a consistent satisfaction with the job? And as some engineers' technical specialism (put together as a combination of education and range of work experience) is very narrow, can they be expected to perform well enough in a technical management position; a position which may entail a technical shift or an understanding of a wider range of techniques such as Mintzberg describes? Whalley's explanation requires further investigation; these questions are addressed in the analysis of transitional job change in chapter seven.

Motivation to seek the next stage in the transition may be positive, or negative to avoid potentially unwelcome changes (Nicholson and West, 1988). At this point the technical manager's career has taken him or her more into "general management". Peter Armstrong (1987) explores a number of reasons why very few engineers make it to become high level managers, pinning the "blame" on a view amongst senior managers that technically trained and orientated engineers in general are not well equipped or adept at dealing with financial and personnel management issues. Armstrong's starting point for this research is an assertion that "the majority of professional engineers are very keen indeed to become managers" (Armstrong, 1987, p422); quoting Berthoud and Smith, 1980 and Gerstl and Hutton, 1966 in support of this. The truth of this statement is in itself highly debatable, as demonstrated by data in the work of Allen & Katz (1986) or Scase & Goffee (1990).

As highly qualified individuals, engineers have quite a wide range of potential career opportunities, but to translate these into the options from which they are realistically likely to choose, I present figure two:

Figure 2 - <u>Potential career paths - an "option plan"</u>

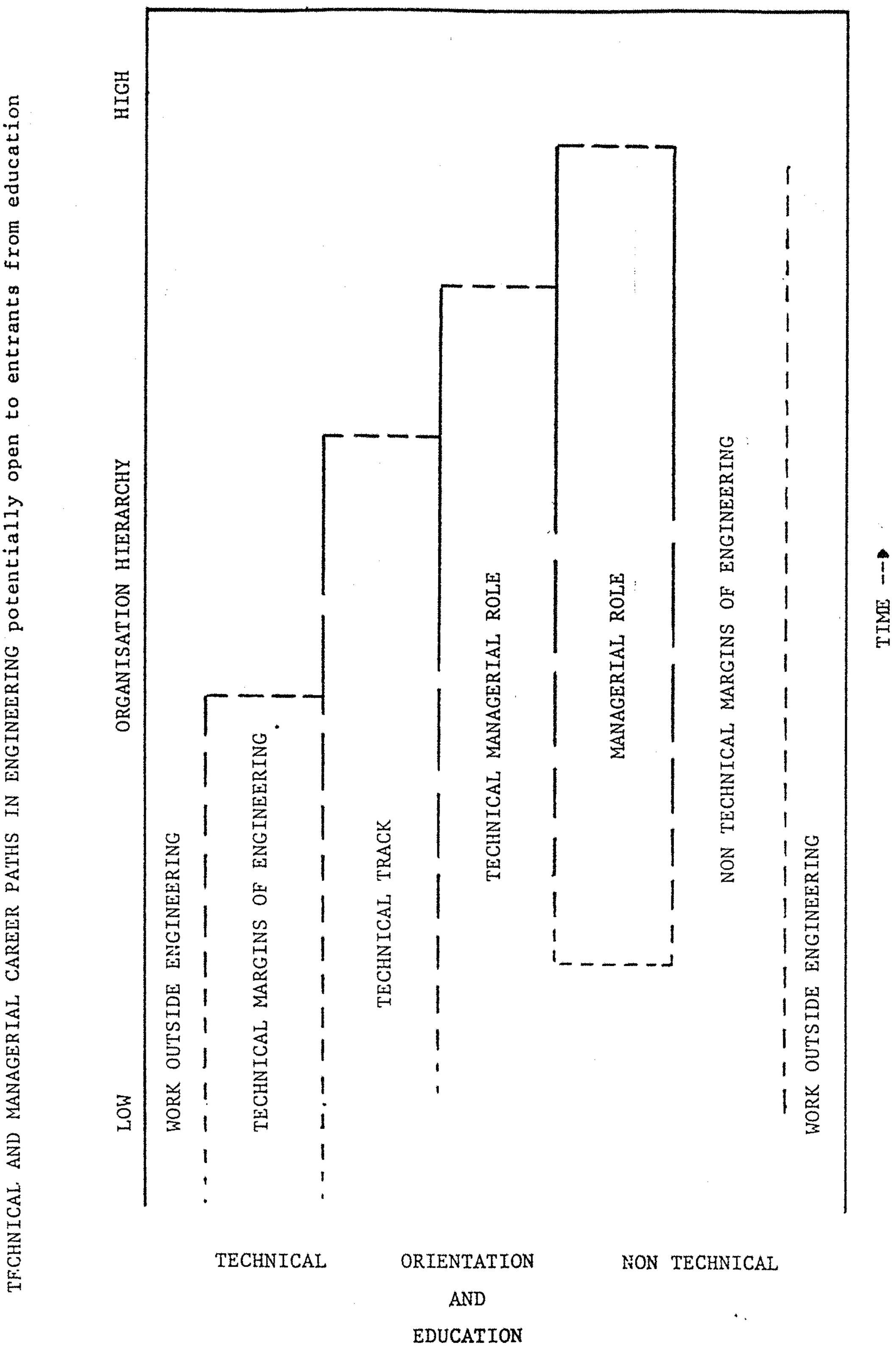


Figure two represents the structure of a typical "option plan" for an engineer's career, in which I have attempted to summarise the career paths in and around the engineering industry which are open to an engineer inter-relate. On the figure, the time axis may be subdivided into career stages representing the typical years of employment - the exploration, establishment and maintenance stages, although no likely boundaries are indicated on the figure as it intends to show work types in general, not directly related to stages. The dotted lines indicate notional boundaries between "tracks" which are easier to cross than solid lines. The tracks exist as a body of career opportunities within the total professional/service class labour market captioned "work outside engineering". This includes the option of starting up a new small company, perhaps not for the reason of wanting to return to technical work itself, as suggested by Turbin & Rosse (1988, quoted in Garden, 1990). The inclusion of a technical track does not necessarily imply a dual track career structure, which is far from universal, but obviously such a track determines the relative length of the path available up a hierarchy on a technical track.

This figure represents a hypothesis of work types from available research, and I suggest that the pattern of career choice open to an individual at any stage on the figure can be quite precisely identified. Therefore I hope to be able to add understanding to a diagram which in its present form is basically descriptive. In short, I intend to present data to show how and why engineers are metaphorically "pushed" or "pulled" across the figure.

Even if engineers would choose to move into higher level management, organisation needs and structures ensure that few succeed. But many engineers move into technical management, through a process of job change which requires some explanation. They then have few opportunities to go further. I suggest that possibly as a result of their educational background or the type of person encouraged to enter engineering, the original technical orientation of most engineers ensures that they do not want to. I develop this further in the next section.

3.6 Technical - managerial conflict and orientations

Engineers recognise tangible technical skills, but the skills required for personnel management tasks, if not others of the four lines of responsibility listed above, are in practice largely learned on the job by experience not through education and training (Bailyn, 1980). Meanwhile it seems to be implicit that the nature of technical knowledge required to perform daily tasks will change. The narrow training of engineers in electronic, electrical, mechanical, chemical and other branches of engineering may not be adequate for the project management of work involving more than one branch. Also even in the earliest stages of project management responsibility an engineer is concerned less with doing and making and more with planning and costing. Clearly every manager has had to come from somewhere, via some technical or quasi-technical background even if it is from sales or accounting. What is at issue is how the skills from the technical years of a career are used in the managerial years, if they are recognisably used at all.

The very complex set of human relationships which Glover and Kelly (1987 p137) found pose problems for British engineers are at their sharpest here. A move to away from technical towards managerial work marks a change in identities and loyalties to professional groups, and to groups in the organisation. This is likely to be true even if the individual regards supervising the work of others and the eventual role of a technical manager to be an essential, natural part of engineering. It is also true even though as "trusted workers" the engineers are not part of a wider conflict between the professional workforce and the organisation (Whalley, 1986).

Although it is not possible to mark a clear division between technical and managerial work in engineering, Child et al (1983) assert that direct conflict exists between engineers and managers aspiring to form their own dichotomous professional groups. Child et al take the view that this undermines the status of each when compared with Germany, for example, where there is no (need for) such a proposal. This complicates any explanation of the transition from technical work to managerial work because it asserts that somehow "pure" technical and "pure" managerial work are so separate that an individual can have loyalty to only one profession. Although the dividing line may be blurred this idea implies that as individuals move through the transition, a middle ground of technical management involves internal, personal conflict of identity, not two sets of skills harmoniously used together.

From some empirical research it seems there are going to be a set of conflicts at work, which individuals may be able to pin down to specific objections to managerial responsibilities, or specific times when pressures mounted to make a move, such as Whalley found in interviewing several of his engineers in both cases (1986, ch5).

In this thesis, then, my intention is to explore some questions, uncovered by existing research, about the nature of this identity conflict, the choices it presents, and how constraints act upon the career as an individual passes through the transition to management. What exactly are the options available to the individual who aspires to climbing up the career ladder? How do engineers in technical management roles see the professional groups themselves? What do they see the technical management work based on: (possibly notional) original expertise, on newer technical skills, on newly acquired management skills, or on which combinations of these? The data collected and the analysis in chapter eight attempts to examine these questions.

3.7 Summary

So having unpacked the components of engineers' careers in some detail, where has this taken us? I have defined what I mean by an engineer, and how managerial work is different from technical. I have also presented the results of previous research on engineers' career stages and patterns. I propose an analysis of the individual, subjective career. I consider how this progresses in the structure of the career stage model by Super and Jordaan (1973) together with useful concepts from other researchers.

From existing research on engineers I argue that their movement through career stages and across figure two will not be straightforward. This is because unlike "free" professionals, engineers find work within organisations. Therefore it appears that in order to move up the organisation hierarchy to achieve greater reward and status, an engineer must inevitably move away from his or her career orientation to creativity and technical/functional competence. This is because moving up means: moving out of the technical design side of engineering, moving into the margins of engineering, moving out of it altogether, or most commonly moving on to managing other engineers. This must mean conflict in career orientation and conflict in terms of leaving one professional group for another. How is this movement achieved? I suggest that it seems to take place as a transition which hides the underlying process, whereby an individual takes on more supervisory and technical managerial functions over time. Thus at the opposing ends of the technical - managerial work spectrum I see distinct differences in skill, task and responsibility. But in between, in reality there is no great dichotomy to be bridged in a single job change. An engineer does not become a manager at once, but through a transition, and I intend to present data to explain exactly how this process works throughout the course of the career, from education and the career exploration stage.

This transitional process of career changes need new skills and experience of different levels of technical work if the individual is going to succeed in making the transition to a technical manager. The changes take the form of a series of implicit or explicit choices in an incremental process, operating within the structural constraints of the organisation, and the individual's social circumstances. The impact of professional ideals on the engineer's career may be slight, but each has an identity and aspirations which are shaped by organisational factors. Engineers may be lured into management by their employers and learn to like it, or at the other extreme they may have aspired to management since becoming engineers.

I endeavour to address these issues with data from a detailed examination of one type of management level in a specialised technological field of engineering, which I look at in the next chapter, on methodology. In chapter five I present basic data on characteristics of the sample selected from this field. Then in chapter six I focus on the career growth and exploration stages, examining initial career orientations and categorising the educational routes by which engineers come into the industry.

Chapter seven looks at what is actually meant by technical work for engineers, the skills required, and how they change. The chapter examines how the incremental job change away from direct technical involvement towards technical leadership, supervision and administrative functions takes place in practice, and adds to the understanding of what supervisory work entails in this stage. My emphasis is on individuals experiences of the change, the choices and constraints they may have recognised, and the significance of their reflections on why it happened in this way.

Having examined what the overall process is, and how it works, chapter eight focusses on why the overall movement to technical management, and in some cases higher managerial levels, takes place in practice. It returns to the orientation principle (in the light of professional identity) in looking at whether expectations held by the individual have been fulfilled by their career, why, and where they intend to go next.

Chapter 4 - Methodology

The purpose of this chapter is to describe the research design and the methodology used to collect data on individuals who had moved through successive career stages towards a managerial role. There are three main sets of data to be collected:

i) in the growth (and exploration) stages - the social and educational background of engineers who have been promoted to technical managerial positions.

ii) in the exploration stage - the initial work experiences of those engineers.

iii) in the establishment and maintenance stages - the team work and management experiences of those engineers.

To describe the method of collecting this data, I structure the chapter in the following way. First I explain the focus of the study on one sector of engineering: high technology industries, and explore particular characteristics of this chosen sector. I then outline the research design and the selection of the sample of respondents. Lastly, I describe the data gathering procedures themselves.

4.1 Identifying the area for research

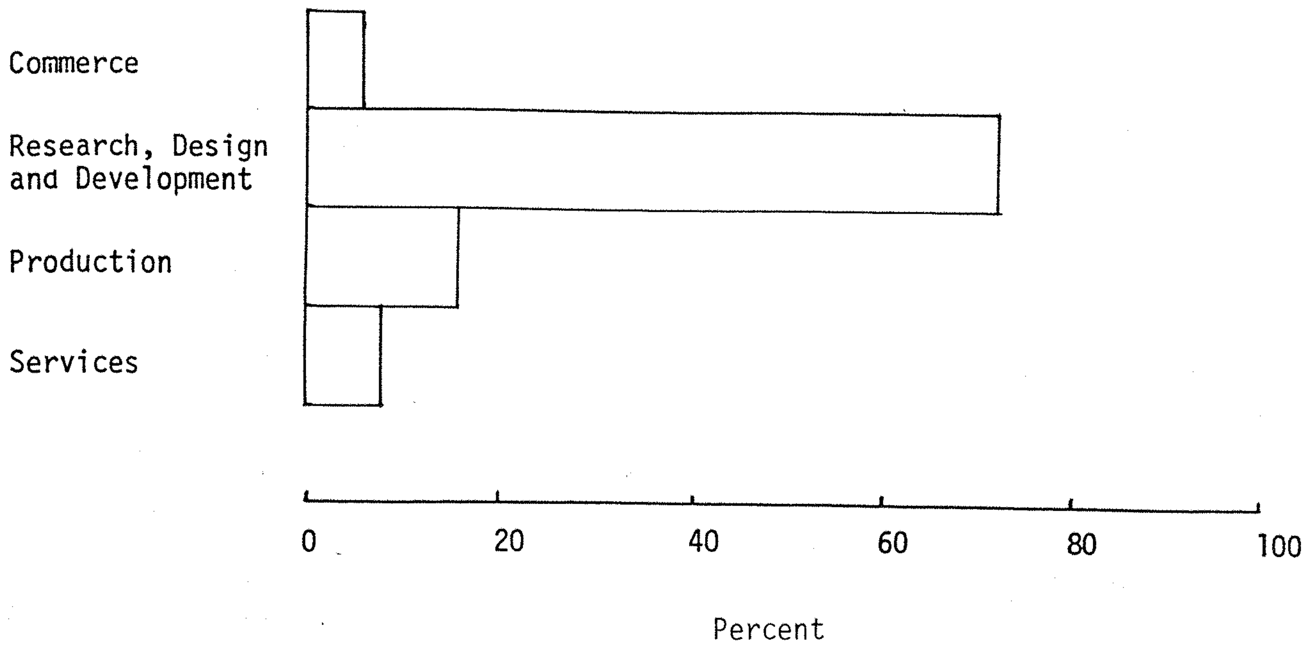
To gather data on the questions outlined at the end of the previous chapter, I have adopted the approach of in-depth interviews, with thirty technical managers, to explore their individual subjective career experiences during the movement from technical to managerial work. So far in the conceptual chapters of this thesis I have talked about engineers and technical managers in general, and less about the various sectors of engineering or about work in particular parts of the engineering industry. But identifying the research area involves a decision to focus on technical managers in specific sectors of high technology industry. The reasons for doing so are threefold. Firstly there is a need to focus on a limited area of engineering to maintain comparability within a sample of respondents. The second concerns accessibility of suitable organisations in the region around Southampton, and compatibility with existing research in the New Technology Research Group. Last, but far from least, there are particular characteristics within high technology industry which make the study of career movement of particular interest. These include the problems of managing technical specialists with diverse skills in an area of rapid technological change and the potentially greater effect of obsolescence processes on career development. The remainder of this section is devoted to outlining the characteristics of work and careers in high technology industry and relating these to the research design.

High technology industries are characterised by the high percentage of engineers employed in research and development, and/or design and development work. Most, but by no means all, of the engineers in this sector are electronic engineers. These electronics engineers have diverse specialisms within the broad heading of electronics. The terms "high technology" and "electronics" are not synonymous, and my working definition of "high technology" industries covers the following sub-sectors as identified in Hampshire by Knight (1984):

i) computers
ii) electronic systems and capital goods
iii) software development
iv) scientific and industrial instruments and systems
v) research and development
vi) aerospace equipment

The work carried out in these sub-sectors will have a high electronics content, but may take a variety of forms in its R&D/D&D. This will typically take the form of electronics engineers in technical departments carrying out research work for a new product, or in basic research for a new line of products. As a comparison with figure one, figure three below shows some small differences between the functional breakdown of engineers in electronics and a similar breakdown of all professional engineers in industry.

Figure 3 - Electronics engineers analysed by function



Source: Venning, 1975 p23

Comparing this figure with figure one (section 3.1) it can be seen that in the electronics sector there is a marginally greater percentage of engineers employed in research, design and development, and in services, than the average. There are proportionately slightly fewer engineers employed in commercial and production functions, but in general figure three shows similarity to engineering industry as a whole, when compared to other sectors (see Venning, 1975 ch3). In other sectors of engineering, such as electrical engineering, there are many more production engineers and their managers in line functions, compared with engineers in technical departments (Whalley, 1986). So the electronics sector has a particular emphasis on R&D and is an important sector of engineering for the employment of professional level staff. This is illustrated by the example that in 1975, although the electronics sector only accounted for approximately 9% of the engineering industry's total employment, it employed 30% of all professional engineers and scientists within the industry (Venning, 1975 p22).

Most "electronics" includes other related work, and it is difficult to distinguish what "pure" electronics research work in an profit motivated organisation might be. Basic research into material properties, for example, will still be driven by and budgeted against a potential product. Also, most hardware and software is an intrinsic part of the operation of a product with its origins in other branches of engineering, therefore designers and manufacturers are concerned with the method of application, not just how to put together electronic components. As a result, the professional engineers found in an electronics technical department may come from a variety of backgrounds in electronic engineering (or electrical engineering before the former was widely offered in higher education); pure sciences such as physics; applied subjects such as software engineering (whose practitioners in particular may have diverse first degrees before moving into software), mechanical engineering and chemical engineering. A close liaison with marketing and customer contact is usually necessary in the initial design stages at least. This diversity of technical background reflects the design requirements of many electronics based projects, and is likely in turn to show up in the technical background of their technical managers.

So high technology industry is largely treated here as electronics and related engineering concerned with the design of hardware and software. Sometimes the work is the "free-standing" product of an organisation such as office computing facilities, or alternatively as one department's contribution to a larger engineering project involving the electronic control systems for a mechanical or marine engineering product, for example. Either way, high technology firms do not just employ electronic engineers (defined by qualification and/or experience); but they can be defined by the work they produce.

Whalley (1986) notes the potential tensions underlying engineers from different technical specialisms working alongside each other, but does not actually decide whether there were fewer or greater incidences in high technology work where specialisms were more likely to be mixed. However, technical departments in electronics seem to be characterised by less direct contact or team work with technicians, draughtspersons or production staff than in more traditional industries; so prospective career status may be more equal across a department and therefore of lesser importance than current work derived status.

A work characteristic Whalley (1986) noted amongst high-tech engineers was that they do a lot of "bench" work themselves.

> "R&D engineers, for example, carry out some of their own assembly. The first working prototype is generally put together in the R&D lab and though there is some help from technicians, most of the work is done by the engineers themselves." (Whalley, 1986 p67).

Whalley found that in his electronic engineering case study firm ("Computergraph") only 55% of the engineers had ambitions to move into management. Only a third were prepared to pursue these ambitions outside technical departments. "The valued technical specialist who is not considered 'management potential' or who does not want the job, is a fairly frequent phenomenon" (Whalley, 1986 p103) This stood in direct contrast to the other case ("Metalco") where amid a more traditional engineering environment, promotion to management and then higher management was seen as the best measure of success. It was perceived as the natural progression there, Whalley states, partly because the engineers were already set up as an elite, further above the manual workers at Metalco than at Computergraph. Obviously the ambitions at Metalco were usually frustrated by the lack of technical or higher management opportunities, and if they got there it was assumed they would drop their engineering background as far as possible.

Meanwhile some of Computergraph's engineers were able to identify some aspects of a managerial job they may like, or cope with (p105), and some aspects they would not. The principal objections from the quotations Whalley offers are to loss of technical involvement and taking on administration.

Institution membership in electronics and related organisations is no higher than the situation outlined for engineers as a whole. Jones and Causer (1990) have found that technical departments in electronics are not unionised in place of engineering institution membership. The role of, and attitudes to, institution membership needs particular clarification as a range of technical backgrounds is likely to have led to membership of a wider range of institutions than would be typically expected in engineering.

Causer and Jones (1990) comment on the overall mechanisms of management used in technical departments. The mechanisms stress differences between small and large departments, not in terms of trusted worker status, but in details which have a marked effect on the individual career. Only the largest organisations (but not necessarily the largest departments) have anything but a fairly *ad hoc* training programme for change in responsibilities. There is less correlation to organisation size in terms of whether a dual track career structure is offered. Positions and reporting structures tend to be less rigid and formalised in smaller organisations (but, again, not necessarily departments) as might be expected.

Electronics technical departments characteristically encourage a rapid pace at which employees rise through a career ladder, while still in the career *exploration* stage. Comparison with Bailyn (1980) for example, however gives an impression that the parallel USA situation is more extreme, but rapid promotions in British electronics (usually on technical merit while technical work is still dominant in the individual's working day) are not uncommon. Hence the individual may be expected to pass through a series of changes in the transition into management in a shorter period than engineers in other sectors. A pattern of rapid promotions has methodological advantages in terms of recall; but its most significant feature is that on the road to becoming technical managers, these engineers may be pressured to make a rapid series of career choices from a limited range of alternatives. This suggests that "mid-career" may arrive early, and issues outlined above - intrinsic interest in technical work, perception of a career, training, etc. - will have become more explicit as a result.

4.2 Research Design

This section describes the research design, in part drawing from literature on approaches to similar studies. As a study of the individual, subjective career, I adopted a qualitative approach as the most appropriate method for considering individual rather than organisational responses to career stages and patterns. The qualitative method has disadvantages, in that much data on career movements can be gathered in a quantitative method more effectively, for example the survey for the Finniston Report (1980) by Berthoud and Smith (1980). But in relying only upon quantitative methods, the opportunity for building a contextual picture of the choice processes surrounding those movements is almost totally lost. The gathering of basic data in numerical format has not been avoided, but it has been interpreted within a qualitative methodology. Despite the extensive contact with respondents to generate data for this method, I have tried to remain objective about it, but as Mills (1959) asserts, it is impossible to also remain detached from it.

The method I employed is basically that described by Bryman (1989, p152,7-8) as a multi-site study (Bryman's type four) exploring several individuals in at least six firms using a balance of observation and interview as appropriate. In this case the interviews took place with thirty technical managers in twelve organisations.

The use of non-participant observation (or "shadowing") was considered, and may have brought out a great deal of data on the current work of the technical managers. However, the individual's estimates of their division of work was accepted as the basis on which they were selected for the sample. The fieldwork continued, sampling and gathering data from interviewees, until patterns had been tentatively identified and similar responses were re-occurring (note b).

In the remainder of this section I describe the way in which the cohort of organisations and departments in which the respondents were found was arrived at. I term the group of organisations in which the research was carried out a "cohort" rather than "sample". It would be useful to be able to generalise from the research to other organisation groups and their employees, but as Bulmer (1988) points out, any "sample" of organisations is inevitably an assorted group of firms who happened to agree to co-operate. As Bryman (1989) states, a diversity of organisation types in a study may at first sight make generalisation from it more valid, but as in this research, the confusion of organisation types, including, say, a mixture of research and manufacturing engineers, may obscure the true focus on work and careers. Indeed, drawing on most recent suggestions of Bryman (1990), I suggest that the cohort of organisations may be more akin to a case study of a people in a particular organisation function and type in a constrained area, with scale and cultural characteristics as the only variables. This may then be used to explore issues generated in that cohort and test emergent theories from it. In any case, the salient aspects of the working environment and organisation structure can be related to career progression where appropriate.

The organisations in the cohort intentionally cover a range from single site independent companies to large multi-national enterprises. The working definition of an organisation here is a sector of a large company which specialises in a particular product (note a). Each organisation fits within the sectors of high technology industry, as identified by Knight (1984) above. Each organisation is involved in activity which employs at least one technical manager who was an electronics engineer, or is managing a group of engineers engaged on projects with a high electronics content. The cohort of organisations comprises a balance between small and large scale firms which were reasonably accessible from Southampton. Within those firms can be found departments of various sizes, which may affect opportunities for career advancement. Departments can be divided into large, medium and small categories, which I define as follows:

Small - 9 engineers or less

Medium - 10 to 29 engineers

Large - 30 engineers or more.

Among the larger ones, I have sought contrasting corporate styles and national ownership.

Important in the larger organisation is the selection of a suitable department in terms of activity and size. A department is defined as the research, design or development facility located wholly on the site in question, the engineers assessed being only those full-time within that department, not drawn onto project teams from marketing or manufacturing facilities even if on the same site. Contract engineering staff, technicians and clerical staff are not counted in the totals for the purpose of assessing size. Within the small departments the number of potential respondents is therefore limited to only one or possibly two individuals. To ensure diversity of experiences, the maximum number of respondents in any one organisation has been limited to three, on two levels of technical management responsibility where possible. Therefore no organisation accounts for more than 10% of the sample (note c).

Having described the design of the research and aim of the fieldwork in organisations, the next section goes on to examine the definition of appropriate technical managers in each location.

4.3 Defining respondent sample

The purpose of this section is to outline how the technical manager "population" was defined and a sample selected from it, to interview in each location. As indicated in section 3.5, technical managers can be defined primarily by their function in the workplace, which can be assessed at a point in time. However, in practice a problem arises because function is not simply measured by an individual's title or hierarchical position. Titles vary according to the "ranks" of which the hierarchy is composed, and according to the size and nature of work of the department, and the detail (even accuracy) with which it is described by these titles. Changing technology and organisation ownership mean that these titles can change over time. Further, an individual may have made career movements between organisations with different internal divisions of labour, which adds to the difficulties of comparing jobs over time (Gunz & Whitley, 1985).

The target population was defined loosely as heads of departments or sections in organisations which qualify as "high technology". Function in a technical managerial post includes managerial responsibilities in four forms as detailed in section 3.5. Managerial function has therefore been assessed, to distinguish whether an individual has sufficient managerial responsibility in their current post to qualify for inclusion. The criterion of function excludes engineers who have moved into the "margins" of engineering as conceptualised in section 3.6. In order to narrow the field of function I secondly exclude engineers working outside the research, design and development of new or existing products, or those not concerned with high technology projects. Therefore production engineers or those who are primarily involved in technical sales functions are not considered.

However use of the function criterion is only completely reliable if an estimate of the division of a postholder's time between managerial and technical functions can be made before going to collect data in detail, or if data has already been gathered on their team responsibilities in the past. Therefore it has been necessary to approach individuals partly on the basis of their position in their organisation hierarchy.

On the basis of what was known about the likely technical/managerial components of certain named posts, some posts have in general been included in the population and others excluded. In the light of the potential problems highlighted above, the notional horizontal lines drawn across the hierarchy of organisations are slightly artificial and not universally applicable, but have allowed certain grades in the population to be targeted for sampling.

Chief Engineers are the lowest grade sampled, but the great variation which exists between organisations means that the individual had to have sufficient team leadership experience to qualify. Likewise at the top of the scale, the population of technical managers has been delineated by the balance of technical to managerial responsibility; the individuals still had to have some technical interest or involvement in the design of current projects.

When making new contacts, typically the targeted titles have been "technical manager", "technical director", "research director" or similar. Providing the idiosyncrasies of job titles such as these are overcome, it has been possible to assess who would be best to talk to from outside the organisation, with minimal prior information.

4.4 Fieldwork methods

The fieldwork I describe in this section can be divided into three general stages which in part ran concurrently:

i) Identifying organisations for research sites, making contacts, and identifying respondents.

ii) Gathering objective career data by questionnaire and conducting the interviews.

iii) Transcribing the interviews and analysing the data.

Firstly in this section I describe the procedures used to identify organisations to form the cohort and potential respondents to make up the sample from a technical management "population". Secondly I describe the method of approaching these respondents and conducting the interviews.

A large number of organisations in a geographical area within easy reach of Southampton had already been contacted by previous New Technology Research Group projects. Specifically, the fieldwork area of my research is slightly enlarged beyond the range of previous projects due to additional knowledge of high technology industries in the "M4 corridor". A great diversity of activities and organisation scales and structures are to be found in the area in question, which covers the "M3/M27 Corridor" or "south coast concentration" from Bournemouth to Portsmouth, then forming a triangle north to

Reading and Wokingham on the "M4 corridor". Characteristics of this concentration are outlined briefly in chapter five.

Within the criteria outlined above, a cohort of organisations have been identified through three routes:

i) previous NTRG contact.

ii) suggestions from engineers already interviewed.

iii) business directories, "Yellow Pages" and Knight's (1984) survey of Hampshire County Council area.

The former two routes provided some information on whether an organisation was likely to fit the criteria, but the latter required further research into what activities and staff are on the site in question.

Activities actually carried by an organisation/department do not necessarily reflect the title of that organisation/department. Aside from the use of technical terms I found the job and department titles such as "engineering group", "engineering research", "systems engineering", "research and development" and "desk family and image management" needed to be visualised carefully in the context of what was already known about the structure of the organisation, before deciding on how relevant they were for inclusion. Occasionally reporting lines gave evidence of personnel overlaps with manufacturing and marketing departments, particularly in the late design or re-design stages of large scale projects.

It has been my intention not to over-sample from any one organisation. Therefore an approximate limit was set from the outset that no single organisation should contribute more than ten percent of the sample respondents, so that a variety of cultures were reflected in the career experience data collected. It was also the aim to assemble a sample representative of the age-ranges and backgrounds available within the confines of the population, rather than to secure a purely random sample which attempted to represent the population on a numerical basis rather than also seeking out the range of career experiences to be found. In particular I intended to seek data from those who had:

i) educational backgrounds which ranged in subject and grade from HNC/HNDs to PhDs and MBAs, not just concentrating on three year electronic engineering degree graduates.

ii) career histories which only included moves in one organisation, as well as those who had made a number of organisational, technical or geographical moves.

iii) opportunities for decisions on the technical-managerial composition of their careers, such as by a dual-track option, and possible pressures of enforced movement.

After initial contact by phone or letter, a statement of the research objectives (Appendix 1) either accompanied the first letter of contact or a questionnaire. This questionnaire (Appendix 2) collected objective career data: a factual framework of dates, education, employers, positions and locations; a type of information which proves difficult to collect at interview. This was a substitute for a CV, and in fact a few respondents chose to send a current CV instead of completing section B on the questionnaire (note d).

The questionnaire data provided a guide to the interviews and I was able to ask certain questions about career choices and direction with factual knowledge of the outcome of the relevant decisions on the table in front of us. Some of the objective career information from the questionnaire responses is presented in chapter five.

The interview strategy adopted falls between the "depth" interviewing and "semi-structured" interviewing techniques. Interviewing mainly gathered data on a respondent's subjective career: their attitudes to past, present and future career events and movements. The data collected covered their educational and social background, their first employment and subsequent job changes. Less successful questions concerned the technical and managerial skills used over their career to date. Questions on training and professional identity were more successful in gathering the data required. The opportunity was taken to learn more about the manager's current working environment and technical or managerial responsibilities while the interview took place. More general data has also been gathered in this way on the structure of each organisation and the potential opportunities for career choice in project teams or managerial work.

Time pressures on interview opportunities in the workplace, an access block noted by Buchanan, Boddy & McCalman (1986), led to the use of an interview schedule (Appendix 3) and an upper limit of ninety minutes. This schedule contained a range of direct and indirect questions. The sections of the schedule were followed in sequence but the questions within each were not rigidly fixed in order. However, I found it most useful to be able to hold the interview as a conversation into which the questions could be worked. When certain points needed to be explored in depth, the schedule was flexible enough to allow this, but ensure nothing was missed. Some suppositions were made on what broad topics were likely to arise, unlike depth interviewing proper (as defined by Jones, 1985) but rigid *a priori* limitations were avoided.

Care was taken not to use terms and concepts from career studies which the respondent would not be familiar with. The combination of continued observation of working environment, including language, and the intention to make each interview as much like a conversation as possible led to the appropriate use of terms picked up from engineers (note e). Not all the interviews were conducted in the respondent's own office; in practice some took place in borrowed offices, meeting rooms or laboratories on the premises; over lunch in a public house on neutral territory; or in my office at the university. This appeared not to influence the data, except that observation of the working environment and reference to documents in the course of the interview was prevented.

All the interviews were tape recorded for two reasons:

i) to ensure accuracy in recording data in limited time.

ii) to obtain direct quotes including voice intonation.

Basic notes were also made at each interview. The tape recorder was used at my discretion and with the consent of the respondent. Some comments were not recorded on tape, however, for one of two reasons:

i) the respondent seemed nervous or inhibited from disclosing certain confidential or sensitive information.

ii) the respondent raised an item before or after the interview had taken place.

Some respondents had difficulties talking about their careers during the interviews, for a number of reasons unconnected with the mechanics of the data collection method used. These included an inability to disconnect discussion of their career from detailed description of technical projects. Also noted was a poor recall of job changes in the establishment stage, although this related to the specific dates, not their actual sequence. The work of Duncan &

Mathiowetz (1988) among the unemployed shows that people recall aspects of their career history as markedly positive or negative. I found the same with the engineers. There was no direct evidence that any respondent tried to conceal any part of their career history, though. If a question on the possible outcomes of previous career choices proved difficult, a vignette technique was employed (note f).

Confidentiality was an important issue to several respondents, with reference either to the technical work they were doing or the details of their own careers. An assurance of confidentiality had been given in the statement (Appendix 1) sent to each respondent on seeking their co-operation. The exact nature of this confidentiality was questioned in about one third of the interviews, but generally the respondents seemed to feel free to divulge a great deal of information about problems in their departments, their future career progression, and other sensitive topics. I did not, however, aim to discuss finer points of salaries and fringe benefits at interview.

Potential doubts about confidentiality were also overcome by the method of gaining access to one technical manager or director and then moving down a stage to one or two further respondents. The latter were informed that their boss had already participated in the study and would not be seen again.

Therefore data could be given by the majority of the respondents without fear of the details filtering upwards.

After recording the interviews, the tapes have been transcribed *verbatim* in whole or in part. This data has been matched up with the results of each career questionnaire, and the salient points and quotes drawn out. Each section of the interview schedule relates to a career issue, and in turn relates to an empirical chapter.

4.5 Summary

This chapter has narrowed the focus of the research to the high technology sector of the engineering industry, and has justified and explored this chosen sector. The remainder has been mainly descriptive of the research design and methods used in data collection. The product of this methodology is a body of data on individual, subjective careers of 30 technical managers in high technology industry. The interview and questionnaire data provides a detailed assessment, in retrospect, of how these careers have changed over time, and the identity and attitudes of the individuals concerned.

Chapter five moves on to present overall sample characteristics from this data. A more detailed analysis of career orientations and job change follows in the empirical chapters which follow.

Chapter 5 - Sample Characteristics

The purpose of this brief chapter is to describe the characteristics of the sample of respondents and the cohort of organisations in which they work, and to present some of the data from the questionnaires and interviews in basic form.

In this chapter I first present data on the spatial location characteristics of the cohort of organisations. I describe the features of their geographical concentration, their size and structure. I justify the departments selected for the cohort, identify distinctive features and rank them according to size.

The chapter then moves on to consider the sample of 30 technical managers under study. I present here demographic data on their age, marital status, and so on. Thirdly, I examine the characteristics of the sample in the workplace: their current working patterns and division of responsibilities between the technical and managerial aspects. Finally, the patterns of the working career are presented, supported by quotations from respondents. The number of job changes and different employers for each individual is tabulated and analysed. I conclude the chapter by briefly drawing together this basic data with the concepts and questions discussed in chapters two and three.

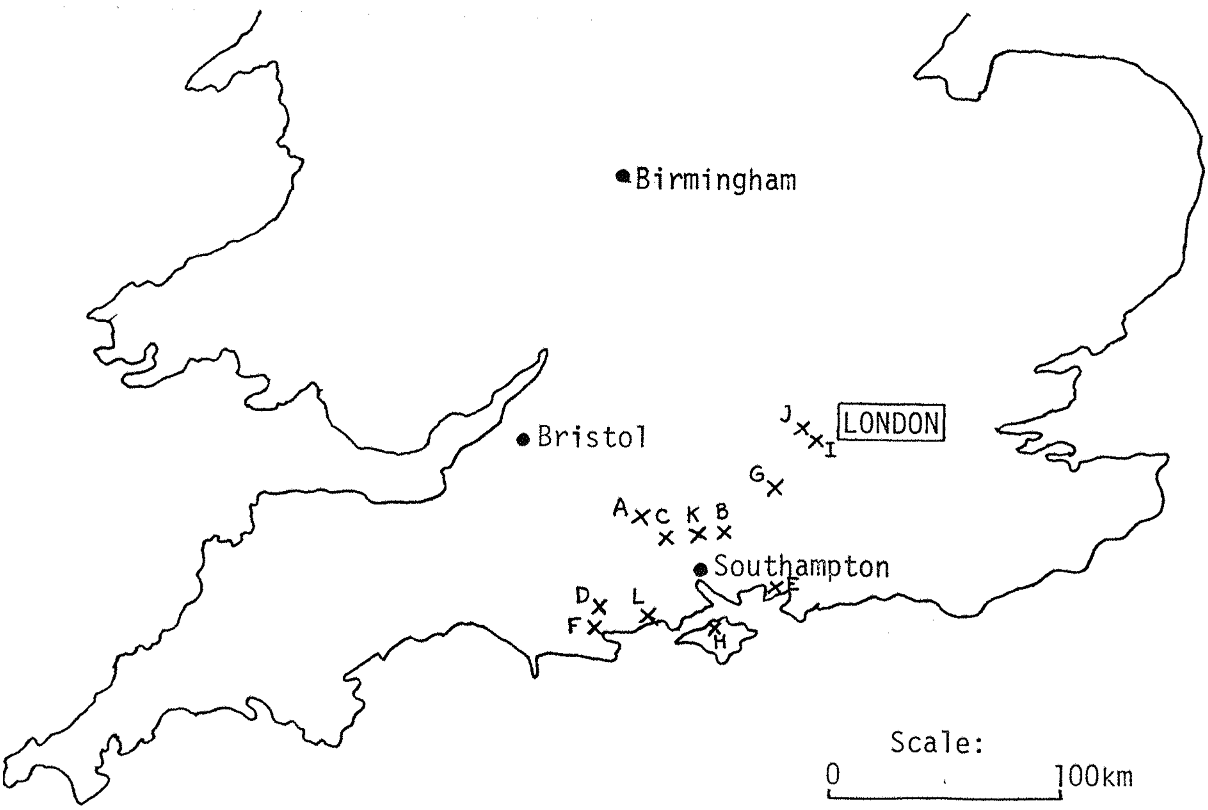
5.1 Organisation cohort

This section outlines the spatial location and other characteristics of the organisation cohort. This builds on the characteristics of high technology industry described in section 4.1.

Geographically, the city-region of Southampton stands in one of the concentrations of high tech electronics and related industry identified, although sometimes loosely, by academic researchers, journalists and property developers. These concentrations entail the location of headquarters and research and development functions, sometimes also with manufacturing functions, in a particular common region. One of the principal reasons for this tendency is the high rate of technological innovation in the electronics industry. This rapid pace of change makes it essential that firms recruit and retain a pool of highly trained technical and scientific workers. (Breheney, et al, 1985; Keeble, 1988) The concentrations of high technology industry have been identified in particular areas of southern England, often along motorway axes. Prime examples include the so-called "M4 Corridor", the "M11 Axis" especially around Cambridge known as "Silicon Fen", and the "Guildford Crescent" located astride the M25. The latest of these high technology axes to be identified is the M27/M3 Corridor which at its western end includes the Southampton city-region and the area immediately along the south coast. (Mason et al, 1991)

The area in which the cohort of organisations was identified has been drawn from the eastern end of the "M4 Corridor" in the Reading area, and the south coast concentration at the end of the M3 and the M27 from as far west as Bournemouth urban area, to Portsmouth at the east, and north to Salisbury also. The actual locations in the cohort were in or around the urban areas of Southampton, Portsmouth, Salisbury, Bournemouth, Reading and Wokingham shown below.

Figure 4 - Geographical distribution of research sites



Mason et al (1991) identify three significant differences between the high technology industries in these two concentrations. First, unlike a tendency perceived in the M4 Corridor around Reading (Keeble, 1988), government research establishments do not seem to have been an important catalyst for the development of the electronics industries around Southampton. Secondly, the whole of the M4 Corridor seems to have had important stimulus from defence expenditure, whereas the south coast concentration is split in this respect, in that Portsmouth has received defence stimulus but Southampton largely has not in recent years (Mason et al, 1989). Thirdly, whereas in the Reading area there have been spin-offs of small enterprises from the larger organisations in a process of vertical disintegration, in the Southampton region research, development and manufacture continues to be concentrated in relatively large establishments that are vertically integrated into the operations of their parent multinationals (Mason et al, 1991 p701). However, there is a link in both concentrations between the timing of the growth of the electronics and related sector and the social structure of the Reading and Southampton regions, and they complement each other as a fieldwork region while exhibiting some organisational differences which may reflect in a diversity of career experiences among the population of technical managers to be found there.

A range of organisation sizes are represented in the cohort, but there is no direct link between size of organisation and size of department; for an apparently large site can have few engineers because most employees are concerned with production, likewise a small site can be almost entirely staffed by professional engineers engaged on research design and development but with only prototype or one-off production taking place there. And similarly there is no link between scale of owning organisation and size of department in the cohort. This is particularly notable in the case of site D. It is also notable that on one research-only site, one section alone has been studied as part of the cohort (site C) but this is still large enough to count as a large department on its own. Similarly in the case of sites I, K and L only one discrete organisation has been treated as the research site, even though others under the same overall ownership trade from the same building with their own complement of engineers.

There are twelve organisation identified as research sites. Subject to the notes above, departments divide into large, medium and small categories as follows:

Small (9 engineers or less) - sites D, Bournemouth
E, Portsmouth

Medium (10 to 29 engineers) - sites A, Salisbury
F, Poole
K, Eastleigh
L, Christchurch

Large (30 engineers or more) - sites B, Eastleigh

C, Romsey

G, Basingstoke

H, Cowes, Isle of Wight

I, Wokingham

J, Reading

The departments of these organisations are summarised in Appendix 4.

5.2 Respondents' demographic characteristics

This section examines what may be termed the demographic characteristics of the sample: their age, marital status &c. The age range of respondents within the sample covers 26 years; figure 5 below shows their age distribution (note a).

Figure 5 - Age distribution of sample

```
Age     Number of respondents                         (references)

        0     1     2     3     4

(yrs)   |-----|-----|-----|-----|


28
29      |-----|                                                 27
30
31
32
33      |-----|-----|-----|                               6, 13, 26
34      |-----|                                                 25
35      |-----|                                                 23
36      |-----|-----|-----|-----|                     8, 11, 15, 28
37      |-----|-----|                                        5, 10
38      |-----|-----|-----|                              16, 20, 24
39      |-----|-----|-----|-----|                    12, 14, 21, 22
40      |-----|-----|-----|                               3, 31, 32
41      |-----|                                                 17
42      |-----|-----|                                       19, 29
43
44
45
46      |-----|-----|                                        2, 30
47
48      |-----|-----|                                         4, 9
49
50
51
52
53
54
55      |-----|                                                  1
56
```

As figure 5 shows, the youngest technical manager is an Engineering Group Manager aged 29 years, and the eldest a Technical Director aged 55. 83% of the sample fall into the career *establishment* stage, trying to establish a permanent place in their chosen field. The remaining 17% in the later *maintenance* stage, continuing along lines already established earlier in their careers. The 55 year old Technical Director, in particular, may be seen as an outlier, having remained in a similar post in a medium size department with dated technical expertise, but who still qualifies for inclusion on all criteria.

With the exception of respondent 30, who is still a Chief Engineer, the respondents in their late forties or fifties hold posts at the highest hierarchical point of the technical manager criteria as stated in section 4.3, at which point technical responsibilities become minimal and managerial responsibilities dominant. The mean average age of the respondents is 39 years 1 month.

All the respondents are married except one (respondent 22) who had not married. Most had married when in employment rather than in higher education, with the notable exception of respondent 25 who married while attempting to complete a higher degree.

Twenty eight of the respondents had at least one child, except respondents 5 and 22, and although the age of these varied they were typically at or just past secondary school age. Therefore the possible career stabilising effects caused by marriage and/or bringing up children, identified by Baxter (1975), are likely to be in place for 93% of the sample. The effects of family ties on career choice are explored using the data available, primarily in chapter 7.

Data was also gathered at interview on the social background of the respondents, with particular reference to the influences upon them in the career growth and exploration stages which may have led to the initial choice of engineering as a career or the development of certain orientations within it. This data is presented entirely in chapter six.

5.3 Respondents' work characteristics

This section focusses briefly on the current work characteristics of members of the sample. It includes some of their perspectives on their work as technical managers, but these are generally explored in greater depth in chapter eight.

All the respondents have a basic 37½ hour week to work as a minimum and enjoy various degrees of flexibility around that, but their working pattern is structured by the bureaucracy of their employing organisation. So for example, almost all the respondents seem to regard reading as an important part of their technical updating. For those later in their career, reading journals is also important for their ability to manage a project effectively by tracing trends in the marketplace and new product developments. However, all these respondents who mentioned the importance of reading did not manage to find enough uninterrupted time for it in a working day, and took it home, often along with technical or personnel problems to mull over. Design Engineering Manager respondent 10 is quite typical in his estimate of 45 to 50 hours a week spent at work and 2 or 3 spent at home, particularly dealing there with post and material for presentations:

"But I think I am very inefficient, that's my problem." (respondent 10)

He had also not taken up his full quota of holiday leave for the past five years. Respondent 12, an Engineering Group Manager had previously got into a habit of taking a lot of work home and summed up the typical situation and his specific recent circumstances. When asked how many hours he works he said:

> "I think it is about the fifty [hours a week] mark; I try to keep it down to that. ... during study for my MBA I actually stopped taking work home for a period of three years apart from very odd occasions. I found it extremely pressured to try to fit everything into life. But as a result I'm not really back in the habit; I'm now taking work home and not doing it! It's mainly reading that I take home; I prefer to stay here rather than take things home because I have a family". (respondent 12)

These employees are committed to putting in time beyond their stated hours, usually to complete something for a particular deadline, or for their own satisfaction. This confirms a "trusted worker" status in that they can almost be expected to work hard on particular projects, although the responses I found strongly suggest that their efforts will be greater on a project which they are particularly interested in or poses a special challenge. A typical example is respondent 31, who had a coronary scare a few months before I interviewed him, and was wary of taking so much work home because he felt doing about 120 hours overtime a month on three new projects had brought on his heart worries. His orientation to the technical side is also implicit here:

"I have phases of taking work home... It's not just a question of thinking about your own particular products here, you think about all of them, all sorts of new ideas you keep turning over in your mind. You end up taking a pad home, and that pad becomes a file! (laughs) You start sketching and working things out. Plus there's paperwork to sort out. It's self interest; I mean, I work on the basis that whenever I take work home - which is basically unpaid work - I'm not doing it for the firm's benefit, I'm doing it for mine. It's personal satisfaction that it's done, or that it's something that I've got a bee-in-my-bonnet about, perhaps a new idea I want to play with and I don't want to let it go. Well ultimately it is for the firm's benefit, but first it's for my technical satisfaction that I can do the job as well as I can... being a bit more thorough than perhaps I can at work." (respondent 31)

Without exception, all the technical managers enjoyed engineering, particularly the creative and the technical problem solving aspects of it, even if they don't do much of that type of work now. But working hours and division of time are an issue to be wrestled with among the engineers particularly those involved in taking on leadership and managerial functions, because the calls upon their time are more varied, as explored below and in chapters 7 and 8.

The division of time between technical, managerial and administrative functions in a technical manager's current work are presented in more detail in chapter 8, but their rough estimates of the division varied widely. This was due not only to their different posts and ever shifting responsibilities for projects week by week, but also to how rigidly they defined technical work; either as only "hands-on" or the use of technical knowledge in "hands-off" design and decision making. However, this potential discrepancy was explored with most respondents, for example with this Chief Engineer:

"I would think about 60 or 65% managerial and about 35 or maybe 40% technical. But its a bit of a fuzzy divide because I might get something like this [picks up and flicks through a 30 page document full of tables of figures, text and diagrams] to read through, which is a specification of something, now arguably that is technical. I tend to review these at a fairly top level. Is that managerial, is it technical? ...One could argue it is part and part really."

Q: "So are you including that in the technical side?"

"Probably am, yes...

Q: "...because that requires particular specialist knowledge to understand?"

"Indeed so, yes. Some of it is more top level and others, leading on from documents like that we have other documents related to various groups which would cover the manpower and time-scale requirements. There you're moving more onto the resource and management side of things." (Respondent 3)

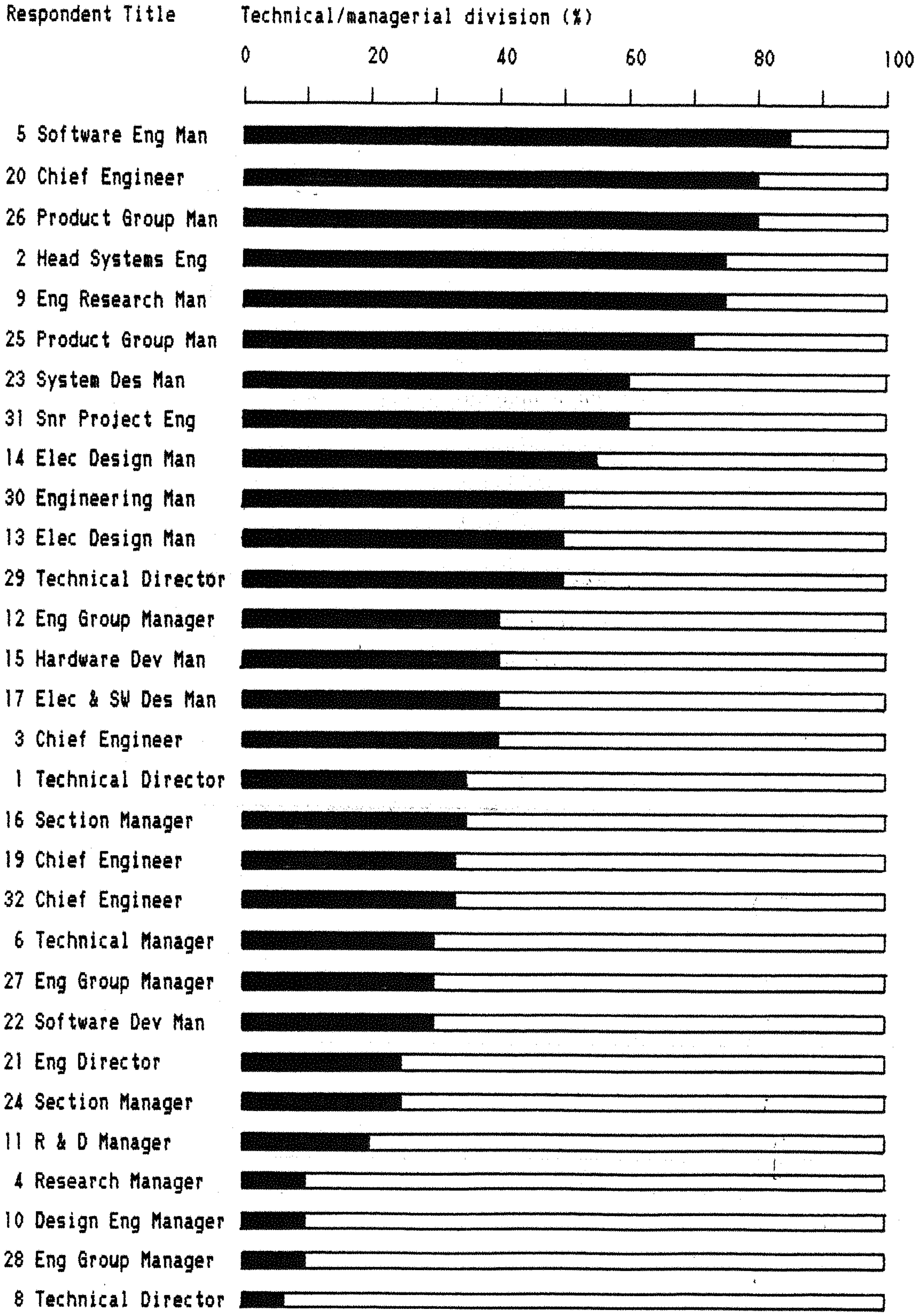
Current estimates range from one Software Engineering Manager (respondent 5), still with 85% technical and 15% managerial responsibilities in a small department, to a Technical Director (respondent 8) who estimated:

"98% managerial? It's obviously a grey area and very subjective, but my technical involvement is minimal. I mean the technical involvement is primarily either criticising or praising ... the advice and input that has been offered by the engineers." (Respondent 8)

However, this respondent's technical input appears, from data in the remainder of the interview to be still significant in a knowledge base sense, and his remark is perhaps a slight exaggeration of, say, a 10% or less proportion. Indeed it is similar to respondent 12 who estimates 40% of his time is spent on technical responsibilities, but 5% only is "hand-on" technical in any form, and that 35% is really technical management of specialist technical activity. Although he pointed out that half his job does not need any technical background at all, this part certainly does.

The technical/managerial division of the respondents' current work is presented in figure six below. The figure shows a scale of declining technical responsibilities in their own perception, technical responsibilities being represented by the black blocked line to the left, and managerial responsibilities by the white block to the right. The mean balance of technical to managerial responsibility is 42.8% to 57.2% respectively. From figure six I conclude at this stage that although the respondents were fairly clear about what is technical and what is managerial, indeed they could identify dichotomous groups of responsibilities in their job, the problems are in the boundary between them and particularly in the technical aspects which underlie certain apparently managerial tasks. Where an individual noted a "grey area" mentioned by respondent 8 and could not decide exactly where their boundary lies I have averaged their range of estimates.

Figure 6 - Technical/managerial responsibilities of sample



The inclusion in figure six of job titles held by each respondent indicates that there is no direct correlation between certain hierarchical levels and perceived level of technical responsibility retained. So for example not all Chief Engineers are at the top of the table and not all Technical Directors are at the bottom. However, the general trend is what one would expect, that the higher the post the lesser technical responsibility, in terms of technical knowledge applied to managerial or "hands-on" tasks, is required.

Important factors determining split of responsibility seem to be department size, and how many engineers or groups of engineers an individual has some sort of managerial responsibility for. Out of two respondents with apparently similar managerial responsibilities on paper, one may have far less opportunity to do any hands on technical work or even much detailed technical decision making because they have twice as many engineers reporting to them, taking up their time with "bogs and bicycle sheds" matters (note b). In terms of figure two in section 3.5 the engineers' career path can be seen to move across from the technical track to encompass a technical managerial role to a greater or lesser extent. However, a couple of engineers observed that in their particular organisation and post, their work included also taking on functions from the non-technical margins of engineering. For example respondent 11 had noted that his technical role is being transformed into a technical marketing activity, providing necessary data for sales functions. Such posts are widely available as a marginal career opportunity (note c) but are not typical of the experiences of the sample as a whole.

In chapter 3 I laid out the defining characteristics of a technical manager as an individual who had progressed from technical leadership and had four lines of responsibility in place:

i) strategic technical planning of projects,
ii) controlling budgets for projects,
iii) administration of a project team or department,
iv) personnel management of a project team or department.

Each respondent met these criteria to some extent, but as the data already presented above begins to indicate, there are wide differences in how these lines of responsibility come together in practice in different organisations. So while it is possible to look at each individual and see these areas of responsibility in place, and record their experiences of them, organisation size and structure, and individual perceptions tend to obscure any clear relationship between the technical and managerial components, making them difficult to measure in any objective way.

5.4 Respondents' career histories

Next in this chapter I present complex data on the number of organisations worked in, and the number of posts held in each, for every respondent. There are potential problems in presenting data such as this for comparison. First, different respondents have had working careers of different lengths to date. This is not just a product of the spread of ages in the sample from 29 to 55 years. Due to the variations in school systems attended and qualifications obtained, the actual working careers of two respondents aged 39 may be of up to six or seven years difference in duration, for example because one entered work at age 18 and studied for an HNC part time, whereas the other completed a first degree and a higher degree before even looking for work in the engineering industry, though they are likely to enter with different prospects. Fortunately in practice, with the sample I have, this is not an acute problem, and figure seven overleaf attempts to compensate for these differences by measuring actual working years rather than respondents ages. Therefore nought is the year at which the individual left full time education and started work; the length of the total working career being indicated on the right of the figure.

Figure 7 - Employing organisations and posts held

Respondent Title	Employment to 1990 (years) 0 5 10 15 20 25 30 35	[working career total]
1 Technical Director	la lb lc ld lelflg	l[32ys]
9 Eng Research Man	l l2 l3 lBBBBBBBl4 l5 l	[30ys]
4 Research Manager	ll2a l3l2b lc ld l	[25ys]
30 Engineering Man	la lb lc ld le lf lg lh l	[28ys]
2 Head Systems Eng	l l2 l3l4 l5 l	[21ys]
29 Technical Director	la lBBBlb l2a lb lc ld le l	[23ys]
19 Chief Engineer	la lBllb lc l	[20ys]
17 Elec & SW Des Man	la lb l2l3 l4l5 l6l7a lbl	[20ys]
31 Snr Project Eng	l l2l3 l	[23ys]
32 Chief Engineer	la lblc ldlelf lg l2 l	[19ys]
3 Chief Engineer	la lb l2l3 l	[17ys]
12 Eng Group Manager	la lb lcld lel2 l3alb l	[19ys]
14 Elec Design Man	l lBBBBBBBBBl2 l	[18ys]
21 Eng Director	l l2l3l4 l5l6a lb lcld l	[17ys]
22 Software Dev Man	la l2 llb l3a lb lcl	[15ys]
24 Section Manager	lalb lc l2alb l3a lb l	[16ys]
16 Section Manager	la lb l2a lb lc l	[17ys]
20 Chief Engineer	la lb lcld lelf l	[16ys]
10 Design Eng Manager	la lb lcl	[15ys]
5 Software Eng Man	la lb lc ld lel	[13ys]
28 Eng Group Manager	la lblcld l2a lb lc l	[18ys]
11 R & D Manager	l l2 l3albIc ld lel	[15ys]
8 Technical Director	la lb lc ldl2 l	[12ys]
15 Hardware Dev Man	ll2a lb l3a lb l	[12ys]
23 System Des Man	la lb lc ldlelfl2 l	[12ys]
25 Product Group Man	l lBBBBl2a lblc ld l	[12ys]
13 Elec Design Man	la lb lc l2 l	[12ys]
6 Technical Manager	la lblcld l2alb l	[12ys]
26 Product Group Man	la lb lc ldl2l	[11ys]
27 Eng Group Manager	la lblcldlel	[6ys]

In figure seven the respondents are arranged in strict descending order of age, illustrating the differences between the relative ages of some respondents and their period of employment in the engineering industry. Their working career duration commences with the point they left full time education, but in the case of the HND/C qualified respondents, that is not necessarily the point at which they became a professionally qualified engineer, because they may have been serving an apprenticeship initially.

The employing organisations in figure seven are numbered from 1 upwards. Posts within each organisation are identified as 1a, 1b, 2a, 2b, 2c and so on. They are considered to be in the same organisation for the purpose of this figure even if the respondent moved to a different plant or country (though that move typically represents a new post). Occasions where a company has been taken over by another (eg respondent 1) are not considered a change of organisation, because the individual has not chosen to change employer. Five respondents show breaks for educational courses of one year or more, or for work outside engineering, which are signified by the code "BBB". However, to clarify, *working* at an educational institution in a technical or technical managerial capacity is not regarded as a break.

The length of time spent in one employing organisation ranges from thirty two years to one year, but the mean overall is just under six years nine months. Respondents tended to stay with their first employer (who in seven cases had been their only employer) for rather longer than average, the mean duration of employment with first employer being just over 9 years four months.

The length of time spent in any one post varies from just under one year to over sixteen years. The mean period spent in one post was only just under three years. The distinction between different posts can be of limited use particularly in the early years of an individual's career when lower grade titles may be ascended through quite quickly. As an example respondent 27 spent just over two years as a Graduate Engineer but only 10 months as Senior Engineer, 14 months as a Principal Engineer and only 8 months as a Lead Engineer as technical leader for 10 colleagues before assuming his present technical managerial post over 24 engineers. However, the general trends of career movement for each individual are revealed.

As the youngest technical manager in the sample, the example of respondent 27 is extreme, but the figure also shows the typical patterns of the objective career. So for example respondent 13 had a typical degree route in electronics and worked for Plessey between August 1978 and February 1985, quickly moving through the grades of Engineer, Senior Engineer and Principal Engineer in a number of hardware projects. Then he left to join his present employer (organisation E) in 1985 as an Electronic Design Manager, a significant promotion to a technical management role which could not be achieved so readily in Plessey at that time. In general the posts identified as a, b, c, &c. are the respondent's own assessment of a significant change in responsibility and/or title within the same organisation, as outlined in the questionnaire data and clarified in the interviews.

Figure seven also shows unusual patterns in the objective career. In mid-career there may be interruptions as already mentioned above, such as respondent 9 who left industry to re-enter education, and respondent 19 who initially made an abortive attempt at school teaching. In the case of respondent 9, he returned to his previous employer again, as did respondent 29. Respondents 4 and 22 are also notable for having returned to their previous employer after a period in another company which did not prove as fruitful in terms of job satisfaction or prospects as they had hoped.

Inter- and intra-organisation mobility is revealed by detailed examination of figure seven. For example, respondents 13 and 31 are now settled for a long period in one post or organisation after periods spent moving quite rapidly; and respondent 10 has started achieving promotion after a relatively long period of career stability. Greatest contrast is seen between, say, respondent 1 who has held seven different identifiable positions in one organisation, enduring many changes and a takeover of that organisation, whereas respondent 17 has worked for seven different organisations for short periods of time in only one or two posts, and in a working career of less than two-thirds the duration of respondent 1's.

So study of the objective career data suggests that engineers become managers by a variety of methods, either staying in the same organisation or by moving around, and at different rates. There are, of course, bound to be some variations in career paths in reality between individuals, even if they somehow had an equal level of drive and ambition to achieve promotion, because there are only a limited number of potential positions to occupy in technical managerial work. Although the respondents are not at quite the same level of technical managerial responsibilities as each other, the differences in how they reached their current positions are not adequately explained by that. Particularly noticeable is the variation in inter- and intra- organisational mobility, and the typically longer period spent with the first employer, or in particular posts. The question to be addressed in chapter seven in particular is how do these engineers choose to make these moves to different employers and/or to different posts and for what reasons? I suggest that the answer to this question is complex, and lies partly in the orientations developed from childhood and partly from career experiences during the working career in the exploration and establishment stages.

5.5 Summary

This chapter has described the basic characteristics of the cohort of organisations and the sample of respondents who work within them. Data presented on the former is straightforward; I have described their spatial location and concentration and identified their principal features. Data presented on the latter has been more complex and at this stage I have noted some patterns in the characteristic of the respondents' backgrounds and career movements.

The data in this chapter has largely been drawn from quantitative material on objective career movements collected by questionnaire. At this stage, combining the data I have started to present in this chapter with the concepts and issues discussed in chapters two and three, I have many questions surrounding "How and why do engineers become managers?"; I have observed and described some emergent patterns but can so far offer few answers or conclusions. In the next chapters I argue what this material means from the qualitative data gathered by interview on the career experiences of the individuals in the sample. I suggest that the salient issues here, for which I have laid out the theoretical background in chapters two and three, are the influences, changing work patterns, and aspirations of engineers. Underlying these issues is the continual question of career orientation, which recurs in both the influences and the aspirations of the respondents, and which can only be explored in any accurate or meaningful way through use of the qualitative data. This material seems to break down into three distinct areas which translate into the following three chapters, six to eight:

i) what are the influences on young people to make or enable them to choose engineering as their intended future career?

ii) how does the work these engineers do initially change over time to incorporate a managerial component?

iii) do engineers want to become managers; what are their career aspirations related to, and can they change?

In structuring these next three chapters I have stuck to a temporal framework, following the engineer's career through to technical management, but the theme of career orientation underpins two of the three chapters, the first and last. Taking chapter six, I start by analysing the formation of career orientations in the engineer. These are committed employees, who particularly seem ready to rise to the technical challenges of individual projects by working extended hours, often for their own job satisfaction. I examine the process, showing two categories of entry, by which these orientations come about, and how they are initially shaped in first employment.

My focus on the characteristics of the sample in the workplace preludes a more detailed analysis in chapter seven of the process by which they reached their current post. I have noted that there is a broad spread of technical and managerial responsibilities held by the technical managers in the sample, and that to reach those responsibilities they have passed through several job changes and different employers. Here there are also two (different) categories; the respondents who typically tended to move through a single organisation, climbing the hierarchy in measured steps; and the ones who switched from one employer to another (and occasionally back again) as they ascended to a technical management post. I also examine the nature of the process of job change itself, by which all the engineers in question are "pushed" or "pulled" across the career option plan which was presented in figure two.

In chapter eight I continue to explore why these moves have come about as they have, and relate these to both initial orientations from social background and education, and to professional orientations. These orientations, I suggest, have reached a potential crisis in the role of a technical manager, and I put the respondents' perspectives on this role into the context of looking forward on their future career as well as backwards.

Chapter 6 - Entry into Engineering

How do people become engineers? The purpose of this chapter is to provide answers to this question by examining data on the early educational and societal influences on the engineer's career providing evidence of career growth and exploration stage experiences. It goes on to examine the evidence for engineers' possible career orientations. In this chapter I make a causal link between these orientations and the way they influence choices faced in the career. The patterns of explicit and implicit choice faced by prospective engineers are described. In particular this chapter relates the data on individuals' social class and educational experiences to the route they took into a career in engineering, and I present a typology of the typical social background and entry routes of young people coming into engineering.

The chapter also presents data on the types of skills which were initially developed in the career exploration stage. The latter have relevance in two areas; the unity of all the engineers around the ability to design; and as a foundation for an analysis of changing skills in chapters seven and eight. The analysis of orientations is also carried forward to chapter eight.

6.1 Social background and career orientations

This section presents data on the social background, class origins and parental occupations found within the sample of respondents. In this section I examine the influence of social background on the specific educational and career expectations of individuals. I also look at the development of engineering related interests and hobbies as an input to the technical orientation of engineers.

It is important to stress that the respondents cannot be dismissed as simply influenced to become engineers because their parents were in engineering, or even because their parents were in professional work. The data shows a range of class backgrounds and more complex patterns of choice in the career growth stage. Social class was assessed by the data on parental occupations at age 11 (the age of the "11 plus" examination in the English education system) and other indications which the respondents volunteered. The parental occupations encompass a range of (what may be broadly termed) working and middle class jobs in the case of the fathers. The occupations of the mothers are, as might be expected for the period, predominantly housewives. In fact 19 out of the 30 were housewives although some had worked prior to starting a family, and since the respondent was aged 11. The highest level of mother's work was "in accountancy" although the grade is not clear. There were additionally four mothers who were school teachers and the remainder all worked in retailing of various types. Within the limitations of any class scale relying primarily on the occupations of men, the data is described to illustrate the class breakdown of the respondents according to Goldthorpe's Seven Class Schema incorporating the "service class" as classes I and II (see Goldthorpe, 1982; Drudy, 1991) (note a).

First it is notable that none of the respondents came obviously from Class I, the higher level of the service class, but Class II provided the background for 13 of the respondents (43% of the sample). As the engineers in their current work fall into Class II, this is unsurprising. What I did find surprising was that these class II occupations only include 4 professional engineers (13% of the sample), and two of these had qualified as scientists. The four engineer fathers were not in electronics or electrical engineering, however, the specialisms represented being mechanical engineer (for respondent 3); physicist, eventually technical manager and then general manager (for respondent 6); chemist, became chemical engineer (respondent 13) and civil engineer (respondent 26).

I expected, from the study of other professions such as medicine, that the influence to "follow in the father's footsteps" would be strong in some cases for a child with similar abilities and opportunities. The data shows that in practice, this was not rated as at all important by any of the sons. The son of one, respondent 26 now a Product Group Manager aged 33, said of his father, a civil engineer who had come through from a mechanical engineering apprenticeship:

> "Looking back I'm not sure I had any clear idea of what he did... I had no idea of what most professional people did." (respondent 33)

Another son, respondent 3, considered that any influence from his father, who had risen from graduating as a mechanical engineer to board level in a midlands foundry company, was definitely secondary to his own interest in electronics and amateur radio. A third, respondent 6 who is the son of a technical manager from a physics degree background, limited his father's influence to his choice of where to study at university rather than what to study ...nearest to where the family boat was moored. At that time the son wanted to study ship science and only had vague thoughts about his career, which turned out to be on the software side. Lastly, respondent 13, the son of a chemical engineer with Metal Box, said he was quite fixed in his ideas of wanting to become an engineer by the time he sat A-levels, which he put down totally to his father buying him an electronics set as a present while he was a child. It is important to note that of course these respondents were to some extent following their father's example on two levels: being a professional or service class worker and also having a bias towards the "designing and making" of engineering. But that is the limit of "like father like son" influence in initial career choice. Other father's occupations in the "service class" Class II include two accountants and a bank manager. A further two respondents had a father who was involved in engineering at manual or technician level but the same lack of career direction applied.

The intermediate classes (III to V) make up 27% of the sample. Class III holds four respondents' families, the fathers being in clerical occupations (respondents 10, 14, 19 and 20). Class IV accounts for four respondents, with none in class V.

In the working class categories VI and VII there were a variety of occupations held by fathers in the appropriate period. These comprise six in Class VI, and two who socially had climbed furthest, from Class VII. The fathers of those in Class VII had been semi or unskilled workers in industry, one an assembly worker (for respondent 17) and the other an unskilled labourer (for respondent 15). Respondent 16, whose father had been a coal miner, described his background as classical Scottish working class, but he had always been championed to go to university from as early as he could remember. Meanwhile many of those from Classes II and III were from a social stratum and educational system in which some form of higher education was expected. Members of both groups ended up as Technical Managers. I have already discounted direct parental influence as an important factor in why most young people choose engineering. What emerged from the data as more important than parental example was parental expectations. I see these operating in two ways. First, and underlying all, are implicit expectations of achievement in a recognised "good job" of some sort which was perceived by the parents as within reach socially and educationally. I expand on the parameters of what might have been perceived as the best accessible job available in the next section; indeed it seems that in some cases parents (as well as schools) had a lack of expectation of their children.

Then there are more explicit expectations about where their child would find a place in society, leading to particular action like encouraging certain "boys" activities which may act as constraints on the possible future career of each individual. This idea fits with examples from the data. For example, just over one third of the sample had a parent in a professional occupation which gave the possible advantage of a wider range of opportunities, especially a choice of education for the child through relatively high family incomes. This very fact is part of implicit expectation by the parents about what their child will achieve in life, though no causal link can be established here very easily. But to put this into practice, the parents' explicit expectations can be observed in how they reacted to those opportunities. For example, it is more likely that through influence and direct action on the child's education, such as sending them to a private school or an all-boys school of whatever type, the parents narrowed the potential career options for the child considerably.

The operation of these constraints in secondary and higher education is explored in section 6.2, but first I want to expand upon the significance of social background and develop a typology to describe it, using two categories. In summary the sample divides as follows:

Service class: 43% of sample (13 respondents)
Intermediate class: 27% of sample (8 respondents)
Working class: 30% of sample (9 respondents)

I propose to divide these according to their different exploration stage experiences, categorising the service and intermediate classes as "middle class" experiences, separate from "working class" experiences.

First I consider here the technical managers whose parents' employment placed them in the "working class" (classes VI and VII. Nine respondents, or nearly one third of the sample, came from these classes, most of these being from manual unskilled or semi-skilled parental backgrounds. It was difficult for each respondent to state what their parents' expectations or influences may have been here. None were actively discouraged from study or aspirations to become an engineer, but none of the respondents remembered being actively encouraged either.

However, relative to the parents own occupations, the sons can be said to have matched any implicit expectations the parents held for them by climbing socially into the service class; even though as respondent 28 commented:

> "My parents didn't have any idea of what type of career I was capable of doing." (respondent 28)

This group are the "bright working class boys", seeing engineering as a good career, reported from various studies by Glover and Kelly (1987 p113). It appears from the data I have collected that they were not necessarily even able to see professional engineering as a career option. They had distinct disadvantages compared with children from professional backgrounds. Not just the obvious financial constraints were mentioned. Lack of knowledge about potential of a university degree or how to apply were quoted. Some children in these circumstances are assisted or pushed by their parents to educate themselves out of the working class, such as respondent 16 mentioned above. But most of the working class sector of my sample were not. Respondent 31, from Class VI background but now a Senior Project Engineer, was almost bitter about the gender-defined constraints of his education and the problems of being perceived as working class. He said he missed the opportunities to move outside working class expectations:

> "You tend to be channelled if you're brought up in an area that's working class, if you want to think in terms of a class society. The options you think you've got open to you in terms of future are based on your surroundings at the time. I mean I wouldn't have been able to contemplate becoming a doctor, because it was outside my reference. It wasn't even that it wasn't possible, it just didn't occur." (respondent 31)

He felt he did not have

> "...the opportunity to *think* outside of that. It's not so much your expectations as your field of experience and the people within which you move; your parents, your parents' friends or whatever... I had a lower set of expectations perhaps, than my abilities. I think that is realistic though it sounds a bit conceited. I could have done better than I started out to do. For instance, I took an apprenticeship as a toolmaker..." (respondent 31 - his emphasis)

Other respondents had an earlier realisation, for example on performing outstandingly well at O-levels, that there were wider possibilities than their parents' working class occupations had implicitly suggested. There was Respondent 28 again, who states his parents' attitude to his abilities and developing aspirations:

> "Shock really! They were shocked that I'd got some academic capability, because neither of them...; well they certainly weren't educated. Whether their level of intelligence is high or not I don't know. Well, it isn't a very nice thing to say, but it's certainly not in my mum's case. She'd be the first to admit. But my dad's capable of getting a grasp of most things although he doesn't have the same capabilities I do." (respondent 28)

This whole aspect is not adequately covered by Glover and Kelly (1987 p113) when they say that there are individual and social processes at work. Certainly there are individual aptitudes, qualifications and so on. And on the social side there are basic values of society as well as the structural constraints of the demand for labour and the nature of the labour market. But the individual's knowledge of that labour market is crucial, and this knowledge is directly related to position in society and the basic values of society. The knowledge is not something which stems entirely from the individual alone. Acquiring that knowledge for the engineers with working class backgrounds, was a difficult process, yet one which most of the respondents were pleased to relate.

This group of working class potential engineers emerges as a distinct category from the data. Although I am reluctant to use what may be seen by some a derisory term, I have called the group the "bright working class boys" or BWC boys. Their orientation is clear at this stage - to achieve the best career open to them, and the respondents typically recalled a reluctance to go into semi-skilled or skilled manual jobs when asked if they had considered finding work at age sixteen. So their future orientation is not really questionable. The common characteristic of this group was hard work at school on academic subjects in a fairly narrow scientific area, and the pursuit of any after-school activities in that same area, eg. the school electronics or amateur radio clubs which I mention in more detail later in this section.

These BWC boys can be seen as deviating from the set of normal expectations of what they might achieve in a career.

However, it must be stressed that this deviance was not some conscious decision on the part of any of the respondents, at least in the way they related it. There was no fantasy notion of earning a fortune or bettering the family's society position. This was at the same time not deviance from the expectations of the schools in most cases, who sought to encourage achievers, albeit in pre-defined channels. In fact the difficulty of gaining knowledge from the social group on what possible opportunities were open, career-wise, is seen as heightening the reliance of each individual on the career knowledge given by the school. This took the form of implicit or explicit guidance, either in a positive way or a negative way through a new set of structured constraints on what it was thought a working class pupil could achieve. These pre-defined channels and the careers advice coming from schools are examined in the next section 6.2.

In many ways there is less to say about the other category in my typology at this stage. The group I identify as coming from the "middle class" (II to V) comprises 17 out of the 30 respondents. I term them "practical middle class boys" or PMCs. This does not imply that the PMC boys were not bright, and the "practical" prefix will be explained in the next sections. Nor does this imply that the BWC boys were impractical, far from it. The PMCs are simply characterised by their practical capabilities rather than aptitude for subjects which were often preferred by the types of schools they attended, such as arts, humanities or pure sciences. Some were quite general in their aptitudes until A-level, when they specialised in subjects which they knew could lead on to a practical career in applied science or engineering. For example, respondent 1 said he first considered a career in engineering:

> "When I went on to do science subjects for A-levels. Because in O-levels my highest gradings were in English. I got 1s in English and 2 in science. ...I didn't want to teach, that was the first thing. I wanted to go into engineering, at that time we were both in the Air Training Corps, a very successful squadron, I was group flight sergeant. At that time it was quite probable that I would have gone into the RAF, either flying or flight engineering. ...there was not much available in the sticks in Norfolk in the way of apprenticeships or anything like that. So I think there was a lot of traditional grammar school route in our background and education." (respondent 1 - "we" refers to his twin brother)

The evidence I have suggests that all the PMC respondents were similar in their experiences, particularly in their movement through the grammar or private education routes. They tended to know more about what they wanted to do, although as the quote from respondent 26 earlier in this section implies, they did not necessarily know what professional work would actually entail. These boys were just as channelled as the BWC boys, but crucially the opportunities from which they could select definite career options were wider, and the sector of society in which they were brought up tended to allow them greater information on what those options would entail.

But for both categories, I note an important finding is that the individuals were already making choices. For some these were difficult choices due to lack of information, and due to peer pressure to conform to societal norms. The BWCs had to struggle to achieve their desired career, or at least the opportunity to be educated and trained for it, from an early stage. In this they differ from the PMCs with parental roots and expectations in a professional career. Yet I also perceive the PMC boys struggling, often in a school system which under-rated practical aptitude compared with straight academic ability. There is this similarity despite the differing circumstances, but I explore the actors surrounding it in greater depth in section 6.2 on education. Some, but by no means all, of the PMC and the BWC boys had few choices to make as they followed a natural progression into the stratum of the labour market which was expected of them, even if it wasn't always the most highly rated subject. A deviant choice strategy was not required in all those cases.

Far more important than any influences directly from parents to their children on the subject of schooling or career was the way in which practical talents were encouraged. I examine these later in the context of the years spent in education, but first here more generally looking at pastime inputs to career choice.

Not all the respondents spent all their teenage spare time tinkering with televisions but, as might be expected, I found that almost all had a strong practical ability. Those who did not are the software trained engineers, one of whom is mentioned later. This practical ability characterises both PMC and BWC groups, but in the case of the former the respondents consider that their practical abilities marked them out at school and in leisure time, whereas with the BWC boys it was their academic ability which marked them out.

The range of practical interests shown by the respondents stretches far wider than just electronics. For instance, two respondents (6 and 29) liked messing about with boats, including building one and making novel steering and sail-trimming systems. They went on to do study ship science or mechanical engineering at degree level. Now both Technical Directors, of different companies, both in work of a high electronics content, both in organisations designing electronic systems partly or mainly for marine use. Therefore although messing about with boats is not tinkering with televisions, it is clearly a practical ability which has a link to their particular engineering career.

One BWC background respondent (31) has seen both mechanical and electronic sides of engineering in his career, through HNC and subsequent work experience respectively. Both these grew from his childhood experimentation with practical objects, and he was able to sum up the common experience:

"In the early days, when I was a child, when I wanted a pushbike I made one, you don't buy one. You scrounge a wheel from here, a frame from there and a saddle from somewhere else. When you're 10 or 12 and we weren't so well off as people seem to be now, that's how it is. Again it is self-satisfaction, and it progresses on to getting a motorbike or a car, and you take it apart and put it together again." (respondent 31)

His electronics aptitude came similarly:

"I'd always been messing about with electronics, from 14 or so, playing with things, taking radios apart. It came from when you find a pair of cutters - wire cutters - and you start chopping a radio about to see how many bits you can take out before it stops working!" (respondent 31)

A whole schoolboy fascination could be built around this, as an electronics Chief Engineer explained:

"I think what... influenced me in my choice of career was my interest in electronics and amateur radio... That stemmed from reading a few books in my early teens I think, and building up an enthusiasm from there, reading magazines and books and getting hold of hardware and playing around with it. Televisions, radio, amateur radio licence, that sort of thing." (respondent 3)

Respondent 1 found his interest gained a profit incentive in the early 1950s, along with his twin brother:

"[We were] always interested in mechanical things and when we were about 15 or 16, we got friendly with a local radio repairer, and he gave us a lot of old magazines, and they were ... "How to build yourself a crystal set"; they were a sort of 1920s radio magazine. We got interested in this and we built a lot stuff. We built a lot of our radios from those magazines and we ended up undercutting most people in the area for radio repairs before we went to university! (laughs)" (respondent 1)

These technical abilities led not only to a knowledge of how things could be assembled, but how they were designed, how they worked. Crucially, these young people were not dismantling radios or whatever to repair them, or even on every occasion to make something new with the components. They wanted to see how the items worked. At times, as one respondent recalled, putting the family radio back together after satisfying this curiosity was more difficult and not as exciting as he had thought.

Some of these practical abilities had quite formalised channels in school societies for electronics or amateur radio. This does not necessarily imply that schools which encouraged such practicality also encouraged the pursuit of this basic technical orientation into higher education or the working career. One manager, on looking back, recalled this as the major disappointment of his school days.

The engineers who comprised the sample for this study all succeeded in following up their pastime by turning it into their occupation. There was absolutely no evidence that this lessened their enjoyment of electronics or whatever their appropriate practical background was. In fact their comments suggest the reverse is true. The pastime interest engenders an ongoing technical orientation which is not easily changed, and I pick this theme up again in chapter eight.

This orientation to practical or technical pastimes in the career growth stage can be termed "practical creativity" which may be seen to link two of Schein's (1977) career orientations: technical competence and creativity. The creative element needs careful definition here for its later use in the following chapter as a basis for *design* and technical leadership. It has already been established that engineers' creativity involves more than just assembly, it involves finding out how existing things work and making new things work. This means finding solutions to problems where none already exist; and often defining the problem first. One Software Manager, respondent 5, sums this up very well through relating the process of self-appraisal he went through when the company he had worked within folded, and his exceptionally narrow technical skills meant similar employment was unlikely. He said:

> "...you've seen these big glossy adverts from the like of Sun and Dec in the papers but in the UK you're just a support person at the end of a telephone. You're not doing any new work, and that's the thing I want to do; design things, do things, create things I suppose. I'm creative, I think. I think that's my main aspiration all along, to be creative, but in the technical sense of the word not an artistic sense of the word" (respondent 5)

The lack of artistic creativity in favour of technical, or perhaps more generally practical creativity is underlined by respondent 31, who contrasts his own design ability with the designs of his daughter, now studying art:

> "Yes, I'm creative in terms of putting things together. I could sit and do you a drawing. I could sketch a box, for instance, yet if you'd asked me to sketch a vase with some flowers in it I wouldn't have a hope in hell. I just can't do it. I can't visualise the bits that make the art, art, and don't make it a box, if you see what I mean, with all the shading and all the fiddly bits. I find it amazing that my daughter can sit down and draw, I can't do that." (respondent 31)

This practical creativity element is important in understanding the design work of engineers as central to their technical specialism in the career exploration stage. From the comments I gathered, I suggest it is more than assembly but not quite art; it has more to do with precision than imagination. Engineers' creativity is constrained by the available components, in whatever form these take in their specialism, which are known quantities, measurable and tangible, and solving problems with them.

Section 6.1 has been a long and involved analysis of a complicated process with many actors, taking us through the career growth stage. I have considered all the influences on engineers up to this point and the inter-relationship between social background, career orientations and the career opportunities which are open to the individual. There is a great deal of detail without which the analysis would be incomplete. In the next section I go on to look at how the PMC and BWC boys used their practical creativity and their academic abilities to become engineering students in secondary and further or higher education.

6.2 Educational routes through school

Starting at secondary school level in the career growth stage, the respondents education can be divided into the following categories:

Grammar schools: 20 respondents, of these schools 10 were all male and 10 co-educational.

Secondary modern schools: 3 respondents, all these schools were co-educational.

Private schools : 2 respondents, both these schools were all male and boarding, but one respondent attended as a day pupil.

High schools (Scotland): 2 respondents, both these schools were co-educational.

Technical schools: 2 respondents, of these schools one was all male and the other co-educational.

Additionally, one respondent (14) does not fit, having been born to Indian parents in Malaysia and brought up there, being educated latterly at a technical institute in Kuala Lumpur before higher education and subsequent employment in the UK. Although his parents seem to fit Class III well, his education (some two years behind UK) and this type of school are not compatible with the UK system as it was, this respondent is excluded from the following analysis.

Working with the remaining 29 respondents summarised above, there is remarkable consistency in school attendance, only one respondent (20) having changed schools in the secondary period. But the system the sample was educated in is rather different to today, their secondary school years mainly concentrated in the late 1950s, the 1960s and the early 1970s. At first sight it seems that experiences of education initially fall into two distinct categories: those who at age 11 passed the "11-plus" examination and those who failed. This is complicated, however, by the two BWC respondents in the Scottish system at high schools, which all pupils attended and which segregated abilities within rather than between schools. There are also the two respondents who attended private schools as boarding or day pupils. So basically out of the 29 the "pass-fail" distinction falls into 20 respondents who passed, 5 who failed and 4 who did not sit it.

The combination of class and school education data leads to the following categories:

PMC boys:

Classes II:	Grammar schools:	9 respondents
	Secondary modern schools:	1 respondent
	Private schools:	2 respondents
	Technical schools:	1 respondent
Classes III - V:	Grammar schools:	6 respondents
	Secondary modern schools:	1 respondent

BWC boys:

Classes VI - VII:	Grammar schools:	5 respondents
	Secondary modern schools:	1 respondent
	High schools:	2 respondents
	Technical schools:	1 respondent

Typically the respondents studied at school for A-levels and/or Scottish highers, three or four subjects being usual. The most important aspect of subject studied seem to be the availability or non-availability of certain subjects in some schools, particularly the lack of some sciences in technical and secondary modern schools or schools only for boys, and the lack of practical subjects in grammar schools. The set of A-levels which most engineers in the sample seemed to regard as typical - maths, physics and chemistry - was rather remarkably not available as a subject combination in at least two respondents' schools, and biology was commonly not available in boys schools. These details of school type and subject availability contribute to an understanding of how some respondents feel they were structurally constrained in the career growth and exploration stages.

The experience of school education and the constraints it could place on career aspirations and opportunities are linked to the expectations a school had of its pupils. Some respondents (PMCs and BWCs) seem to have conformed to the expectations or advice of their schools, but many did not.

There were clear cut "normal" school expectations in practice - eg. most leavers getting an apprenticeship - as well as the more idealistic expectations of other schools - eg. the maximum number of leavers gaining Oxbridge entry. The process works in a similar way to parental expectations described in section 6.1. This is not really the place to comment on the motivation of schools. It was noted, however, that many school careers advisors, if the post existed, had little idea of what engineers actually do (note b). However the individual boys perceived engineering as a career, those who had made a positive choice to pursue it found the careers advice they received at best a formality and at worst, misleading. The experience of respondent 27 in a boys grammar school is fairly typical:

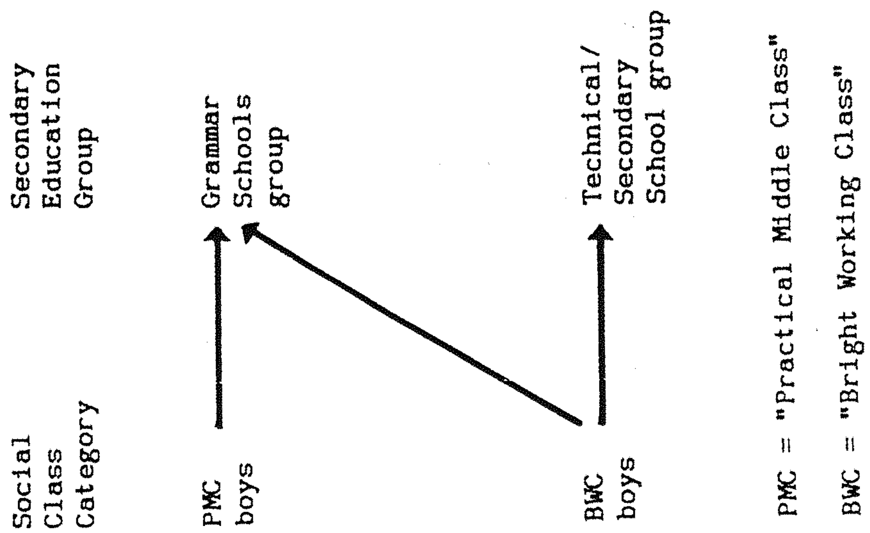
> "We had a careers office but it was just a matter of turning up and telling the career master what you wanted to do and he would advise you what subjects you should have taken. I didn't really have a problem because I was fixed in what I wanted to do, so I didn't actually experience the need for advice, if you like. He only pointed me to what A-levels I should have taken, but he didn't give that advice until I'd actually done them! ...but I was quite set in what I wanted to do."
> (respondent 27)

Such advice as was given was seen as in the best interests of the pupil concerned, but crucially this was inside the parameters of the expectations of that school (note c).

While the experiences of aspiring engineers in schools all seem fairly similar on the surface, I suggest it is useful to make the most obvious divide between the experiences in different types of schools. This complements the typology of social background influences. Therefore I make a distinction for this thesis between state technical schools for boys, plus the few who went to secondary modern schools on one hand; and the state grammar schools, plus the two respondents who spent at least some time in a private school in the 14-18 age group on the other. I make this distinction on the basis of the type of education received and the careers which the respondents were encouraged to look for when about to leave each type of school.

Five BWC boys attended grammar schools, and more BWCs than PMCs certainly went to high, technical and secondary modern schools. Grammar schools dominate the PMC category to a greater extent, and certainly the potential education of PMC boys in secondary or technical schools does not seem so likely to have led to a career in engineering. I present figure eight as a preliminary to subsequent figures. Figure eight shows the most common relationship between these class groups and the types of schools attended.

Figure 8 - Educational route and social class group



In the secondary modern or technical line of education there were a limited number of options for pupils, which did not encourage aspirations to go on to higher education. For example, two respondents at secondary modern schools found that the single language, French, which they were able to take, was insufficient to gain entry to some universities at that time. The lack of an alternative language, and timetable clashes, meant that certain doors were closed for the future without the pupils in question even being aware of it. One respondent (8) was unable to gain sponsorship from the Royal School of Naval Architects without a language, as he had given up French before O-level. He therefore had to attempt French alongside four A-levels, in which he succeeded. In secondary modern schools the opportunities were there to study enough A-level subjects to enter engineering, but subject combinations were conventional and limited.

Technical schools had even more limited subject combinations which often prevented any aspirations above taking up an apprenticeship at 16 or after taking, say, one or two A-levels at 18. The engineers who have risen to technical management positions from this background tend to be dissatisfied with their schooling and felt it led to them aiming too low. Respondent 9 was the only one to attend a technical school from a PMC background after failing the 11-plus exam. He had gone on to complete a Bachelor of Science degree and a doctorate some years after leaving school partly, it seems, to prove that he could despite his schooling. BWC respondent 31 said of his technical school experiences:

> "... you were channelled. You'd got your woodwork and your metalwork to deal with, you'd got drawing, you'd got your physics side but we didn't have chemistry and we didn't have biology, they were only for the girls side of the school, but then they also had the needlework and the arty things. So they set off in a whole different set of directions. You don't get a balanced view." (respondent 31)

The apparently technical subjects typically studied were skills or techniques for manufacturing industry, but they were not concerned with designing or practical creativity. Woodwork, metalwork and drawing were concerned with what might be called "constructivity", not the background that professional engineers were interested in although if they learned the skills at school they could be useful at times in later life in understanding the work of others drawing offices or workshops. None of this schoolwork was concerned with learning about technology.

In the state grammar/private line of education, the same set of constrained expectations did not apply, although the teaching of technology was similarly non-existent. Academic achievement seemed less explicitly defined by social class or ability at age 11. But a different set of constraints biassed against practical subjects and manufacturing industry were substituted.

Most respondents from the state grammar/private line of education found that their schools gave more advice concerning university entry than advice on the career a degree might lead to. These schools attitude was orientated to the pure subjects in sciences and consider that any pupil who had the capability to study sciences and/or at Oxford or Cambridge should do so and was wasting their ability if they did not. Three respondents were entered for Oxbridge examinations for arts or pure science subjects, but were not successful, and had the remainder of that academic year to think much more deeply about their future.

One PMC respondent (3) - now a Chief Engineer aged 40 - looked back on his boys grammar school influences with amusement.

> "I had a fair idea that I was going to do engineering, I think, all the way through my school career that I can recall." (respondent 3)

His interest in amateur electronics suggested an electronics degree, but the experience of passing through three boys grammar schools disturbed this ambition. Despite the enthusiasm in staying on for an extra sixth form year, his determination to enter engineering via university, and a definite idea of where he wanted to go, the suggestions from school were for Oxbridge entry, which he failed. Then a chemical engineering degree at Birmingham presented itself as the most appropriate extension of one of his A-levels. Six weeks before the course was due to start, he phoned the university and changed back to what he had originally wanted to do - electronic engineering...

"...the influence to do chemical engineering was that it was very fashionable and thought to be a well paid thing in those days, and I'd been doing chemistry as one of my subjects at A-level. ...I suspect that although chemical engineering, if you're in the right business, is a very well paid profession, it's had its ups and downs over the years. Electronics has been a more stable business to be in, although that could be quite questionable at the moment! (laughs)" (respondent 3)

The choice of engineering in such a definite way is less common than the experience of this Research Manager (respondent 4) for example. He was very keen on electronics as a hobby in his early teens, and only discovered the potential opportunity to go to university after excelling at physics at O-level. Despite this, he made the choice of which options he did not want to take up:

"I did five years to O-level and then two years in the sixth. I was destined to do a third year because the physics master wanted me to go on to Cambridge to read physics; engineering was very much a sort of secondary subject in that school, they were very much purists in science. And also I was assistant head of the school, deputy head boy, and I knew full well if I stayed for a third year I would be head boy and I wasn't too happy about doing that particularly. Bit of a rebel, you see! What I did as a sort of honourable way out was to do voluntary service overseas..." (respondent 4)

Like several other respondents experiences, these actions show a *searching* career strategy which involved deviance by rejecting conventional wisdom dispensed by the school. These experiences have strengthened the individual's view of the success of their early career. All who embarked on an engineering degree despite the disapproval or some aspect of the advice of their school considered in hindsight that their route into engineering was a good one.

It must be noted, however, that two PMC respondents entered engineering from the state grammar/private school background having gone on to study physics at university. One, now a Software Engineering Manager aged 37, contrasts the view of engineering at his school as "a very dirty thing" with his passion for computers. Having gained a physics degree - but worked in electronic engineering for British Rail during the vacations - he then made an abortive attempt to gain a PhD in high energy nuclear physics, and became very disillusioned with the academic system. Finally he turned to software engineering as the natural outworking of his interests and a chance to earn sufficient money. The career choice in this case had been postponed until a very late stage compared with the students of engineering, yet effectively the education route taken offered not discernibly greater range of career options than an engineering degree.

In conclusion of this section and section 6.1, I suggest that a relationship between class and education/capability background emerges; it is clear from the data that in the case of the PMC group, a practical aptitude was of greater importance than academic ability in enabling an individual to choose engineering as a career, although academic skills had to be present. Similarly the corollary is true; the dominant reason why BWC boys succeeded in their struggle to overcome constraints which may have prevented an engineering career was because they had the academic ability to achieve in subjects that mattered. They were also practical, which led them also to aspire to become engineers in the first place.

6.3 Further and higher education experiences

Turning now to the post-school period at the end of the career growth stage and into the exploration stage, the most outstanding feature is the high level of academic attainment in the sample. The following data indicates performance in further and higher education for all 30 respondents before the age of 25, with notes also on courses some commenced after 25.

The route through part-time study either by day release from an apprenticeship or by evening classes is universally known as the "hard way" to qualify as an engineer. It is this "hard way" on which I focus first in this section. Berthoud and Smith (1980) termed it the "practical" route, but this is a less useful term in the context of technical managers, who more often than not seem to fall into Berthoud and Smith's rather ambiguous category of having later gained a degree as well. The engineers in the sample who came through this way were typically the "bright working class boys", and I have found that their horizons remained limited in this exploration stage of their careers. Professional qualifications for institution membership were also studied for part time in a similar way. By implication the degree route into engineering was perceived as an easier route.

There are 5 respondents who achieved their engineering qualifications via Higher National Diplomas (full time) or

Certificates (part time). Respondent 9, after achieving an HNC and ONC at Borough Polytechnic, later went on to achieve graduate and postgraduate status, as related in detail below. Similarly respondents 29 and 30 went on to study later for an MSc and BSc respectively, almost straight after qualifying as HND/C and these are included in the degree figures later in this section. By contrast respondent 27 failed the second year of his course at Queens University, Belfast and settled for working on an HND at Ulster Polytechnic instead.

Respondent 31 is the sole example who remains as a straight HNC qualified (mechanical) engineer who obtained his qualification while on a toolmaking apprenticeship with Metal Box. After suddenly handing in his notice and getting some short lived work in a small electronics firm, his leisure time passion for electronics had become his full time job. Then on equally sudden redundancy, he was fortunate to gain work at organisation L where he continues as a technical manager. But due to a decline in the very specific skill shortage which enabled him to turn his hobby into a job, I suggest he is unlikely to move further up the hierarchy with only HNC qualifications. In general engineers have to improve their qualification to degree level if they are to be pulled or pushed across the "option plan" in figure 2 towards technical management; but respondents 27 and 31 seems to have taken on some managerial responsibilities without a degree in their educational background by remaining within the same organisation, which I suggest may recognise particular on-going abilities without necessarily looking for academic achievements to back them up.

Although this way in was hard, the immediate career choices it presented these BWCs were not. Most of the BWC non-grammar school leavers, either with or without A-levels, had a limited choice of places they might gain an apprenticeship, and a limited range of branches of engineering open to them. The places with firms which offered the opportunities to gain significant high qualifications were not necessarily those which offered a competitive starting wage which might seem most attractive to a school leaver. Structurally, much depended on the industry of the local area, too, and if the prevalent local industry was, say, printing, then far more pupils would go on to become printers than engineers. Geographical mobility does not seem to have been encouraged.

An Engineering Manager, respondent 9, the unusual example of educational route who came from a PMC background and into a technical school, reflected on the limited exploration stage choices open to him thirty years before and the one way in which he could show individuality:

> "...it was far less common for people to go to university. A common thing from our particular school was that people went off to do apprenticeships and do part-time studying, and I suppose one fell into the trap of doing the same thing as many other people, though I went off to a company that no-one else went to! (laughs) So I didn't follow everyone else in that sense. ...there were a lot of people going on to

do engineering things, for example to a company making lifts, a chap who went on to become a civil engineer who's still a good friend of mine. So a lot of them went into engineering of one type or another." (respondent 9)

It was not so much a trap for the unwary, as a net which caught up all his technical school colleagues because they knew no alternative. Yet the BWCs certainly had the ability, but not the other resources, to reach an alternative. Respondent 31, when asked what prevented him from going on to take up a career in electronics, which fascinated him, when he first left school, highlighted this lack of information:

"I don't know. I really don't know. It was one of those things that wasn't expected. It wasn't inside your sphere of activity really. ...It just didn't really occur. I just enjoyed it; it didn't really register that you could make a career in it." (respondent 31)

His choice was the pursuit of an HNC qualification (part-time). The HNC or HND route was a tough training ground; typically:

"...it depended what part of the course I was doing, parts of HNC I ended up doing one day per week and doing two nights a week as well. It's not easy doing two nights a week and finishing at 9 o'clock at night, and then you've got a lot of lab work and homework on top. It is much tougher than doing it full time." (respondent 9)

This type of commitment seems to have built a dedication to the design aspects of technical work which some graduate engineers admire over and above their own training. One Technical Director, respondent 8, himself with a masters degree, told me he considered only recruiting engineers with diploma backgrounds because they worked harder, knew more useful technical detail, had more experience and more loyalty compared with graduates, with whom staff turnover was rather high and rising. Certainly two of the attributes he, effectively representing the employer as a whole, ascribed to the HNC/D engineer were observed in the career histories of the respondents. He suggested that the HNC/Ds had a depth of technical knowledge in specific areas unparalleled by the graduates. This was built up through longer experience in the same technical area, on the same technical design level of work, because it is more difficult to gain promotions into leadership and managerial positions in the majority of organisations without a degree qualification. There was some anecdotal evidence from respondent 10 and others to suggest that the HNC/Ds showed greater loyalty to a firm, but no direct data was collected on this. The HNC/D engineers who by whatever means did progress up the career ladder to become technical managers had left this orientation to narrow technical specialism behind.

Respondent 9 again, who started with an electronics HNC and went on to study for a degree and higher degree in later life, felt dissatisfied with his experience of the "hard way":

> "I regret the fact that I didn't go to university in the first instance, or to stop on and do A-levels. I think that was a mistake, other people would say that it builds a different character and that is true. I probably wouldn't be the same person today; I may be a better person,

> but I wouldn't be the same. But it was a mistake because it took me a long time and a lot of hard work. I went back (to full time education) when I was about 26 or 27. It's quite difficult at that age, once you've been earning good money in industry and you've had quite a reasonable job. People were astounded and nearly sent me off to a psychiatrist asking was I still sane?" (respondent 9)

Another respondent, 29, had a related experience in which he felt misled into the HND route by poor advice, a factor alluded to many times already in narrowing career options perceived by an individual:

> "I did a student apprenticeship. When I did my O-levels I was predominantly interested in sciences and maths, particularly maths. I didn't really know what I wanted to do when I left school, probably like most kids of that age. So I went on to do A-levels - pure maths, applied maths and physics - and I was very keen on sport. I actually got a place to go to Loughborough College to do teacher training. But I kept my options open right to the end, and I also got a place at Bristol University to do a degree in statistics, and I also applied for a student apprenticeship at a local company - Hamworthy Engineering - and on the advice of the training officer from Hamworthy Engineering I opted for the student apprenticeship with the HND. On the basis of the information he gave me, which was an HND is the equivalent to a degree. So when I left school I was misled into thinking I could stay at home, I could get some training in engineering which I was interested in as a sort of science based job. I mean when I was at school it was basically science and maths, engineering wasn't really a recognised career path... the pure sciences were a rather more traditional, respectable course... So I went for the four year student apprenticeship with Hamworthy with three 6 month periods to do the HND. I finished the HND and I got good marks. I got mostly distinctions but at the end of the apprenticeship I was left feeling that an HND wasn't really anything like a degree. I regretted not going on to do a degree. It wasn't taxing at all; so much so that when I finished I wanted a degree and made enquiries about a further degree." (respondent 29)

By a complex process this respondent did gain his degree - a masters at Birmingham sponsored by Hamworthy Engineering. These few technical managers like 29 had consciously cast their sights wider than the initial sanction and structural constraints imposed by their social background, education and engineering qualification. The experiences which went with their choice provide a useful insight into their structural career constraints, such as mobility, and at a more individual level, time pressures which surrounded them.

In contrast to the "hard way", the other category of further or higher education is Berthoud and Smith's (1980) "academic" route. Technical Managers in the sample who had gained degrees at colleges, polytechnics or universities were usually those for whom a degree had been a natural progression in their education. But even if individuals were expected to go on to a degree, they often had to make a positive choice to study an engineering subject rather than a pure science.

Of the 26 degrees held by the respondents, all were Bachelor of Science degrees but obtained at a variety of institutions throughout the UK, usually for three but occasionally for four years (for example respondent 1). 22 degrees were granted by universities, 3 by polytechnics and 1 from a college of higher education. All of the latter two institution types are local to the fieldwork area - Brighton and Portsmouth Polytechnics and Bournemouth College who were offering suitable courses for high technology industries growing in the region at the time. The degree subjects break down as follows:

5	BSc Electrical & Electronic Engineering	(respondents 3, 4, 13, 14, 15)
5	BSc Physics	(respondents 1, 5, 22, 24, 26)
3	BSc Electronic Engineering	(respondents 10, 19, 20)
3	BSc Aeronautical Engineering	(respondents 25, 28, 32)
2	BSc Electrical Engineering	(respondents 17, 30)
1	BSc Physics with Electronics	(respondent 23)
1	BSc Mechanical Engineering	(respondent 8)
1	BSc Computer Science	(respondent 16)
1	BSc Mathematical Sciences inc Computing	(respondent 12)
1	BSc Mathematics	(respondent 11)
1	BSc Cybernetics	(respondent 2)
1	BSc Ship Science	(respondent 6)
1	BSc Applied Chemistry	(respondent 21)

At university the degrees tended to be less practical than those at polytechnics or colleges of higher education; although no structured set of questions were asked on this. The project was an important part of many degrees in/with engineering or computing. Engineers who completed a project in their final year tended to remember it in great detail even if it bore no relationship to the work they took up as their first job. One respondent (17) said that his experience of college indicated that a higher quality of individual tuition was available there than in the university who granted it's external degree. But the content of the course was not up to date, and on leaving the college:

> "I didn't know what TTL was. We'd done RTL - resistor transistor logic - and DTL - diode transistor logic - which came before TTL - transistor transistor logic - but of course in 1970-1 everybody was using TTL and we'd not mentioned it. Similarly the op-amp work that we'd done had not really prepared us for transistor IC op-amps. Most of the op-amp stuff we'd done had been valve op-amps. So actual practical relevance to modern techniques was very poor, but what you did learn was basic theory which of course is the important thing. With the basic theory you can apply the first principles to more modern techniques or components and find the same principles are at work. But you do need the ability to

work from first principles, which I think anybody on a degree should be able to do." (respondent 17)

All the degree holders were generally satisfied with this period of their education. It equipped them with many technical design type skills which they could market to many companies in their field instead of the industrial experience of the HNC/D student which was limited to one organisation.

Most of the university students in the sample had been actively offered a place and funding to study for a higher degree, one respondent (4) in particular having great difficulty in *not* staying on. Higher degrees in the form of masters or doctorates were achieved by 8 respondents before the age of 25 and additionally respondent 9 achieved a masters and a PhD in his career establishment stage after initially entering industry with an HNC and ONC. Also later on in their careers, two respondents have gained Master of Business Administration degrees. The breakdown of the total 12 higher degrees in detail is as follows.

Masters degrees took individuals into a particular specialism in some depth, for example respondent 8 went on to complete an MSc in Ocean Engineering at University College, London, after his degree in Mechanical Engineering there. A similar pattern was followed by respondent 15 who stayed on at Queen's University, Belfast to complete an MSc project in

Simulation of a simple digital computer after his degree in electrical and electronic engineering. Respondent 24 specialised in electronics with his MSc at Southampton University after a first degree in Physics at the University of East Anglia.

By contrast respondent 29 qualified for an MSc in Mechanical Engineering basically after completing two years of a BSc course following his HND qualification in the same subject; an unorthodox route. And respondent 9 waited until he had been working for several years before returning to higher education to take first an MSc in digital electronics at UMIST and then a PhD at Manchester.

Respondent 2 went straight on from his first degree to achieve a PhD in Control Engineering at Reading University. Respondent 14 completed a PhD studying Microcomputers and peripherals at Portsmouth Polytechnic in a similar way. Respondent 21 specialised in electronic engineering through his PhD subject after a first degree in Applied Chemistry at Brighton Polytechnic, by filling the need at that time for materials work in the electronics industry. Using expertise from chemistry he successfully developed a thick film humidity transducer, which launched him into the electronics industry proper. Finally, I note that a number of the respondents were considered suitable for PhD work and were offered places, and one (25) attempted an Aero-Astro PhD at Southampton but did not complete it due to financial and family commitments. What the PhD potentially offered was a fine environment for being creative, but "only" research which some of the engineers said they weren't really as interested in as the process of actually making something commercially "useful". However, it was noted that later on, in the technical management role, a few engineers harked back to their days in their first job immediately after graduation, or to the notion of doing engineering research, as their opportunity to be a "real" engineer.

Software/computing trained engineers did not always exhibit the practical aptitude from pastimes in their teens. This did not necessarily prevent them from completing a fairly conventional engineering degree but their technical competence orientation was subtly different from most of their peers, leading to a career change later on. An example is the respondent (25) who is now Product Group Manager mainly responsible for software aspects in organisation K. Having considered studying for a mechanical engineering degree, he rejected the idea because he did not have the practical enthusiasm for designing mechanical things. What he did have was an embryonic interest in logical problems which may have led to the much later interest in computers, so he chose aero-astronautical engineering which appeared much less based on practical aptitude and much more on design. He pursued this in industry for a while before a move to the computing side became obviously more technically interesting.

A couple of members of the sample had subsidiary qualifications, such as respondent 19 who holds a postgraduate certificate in education for an abortive attempt at school teaching very early on in his working career.

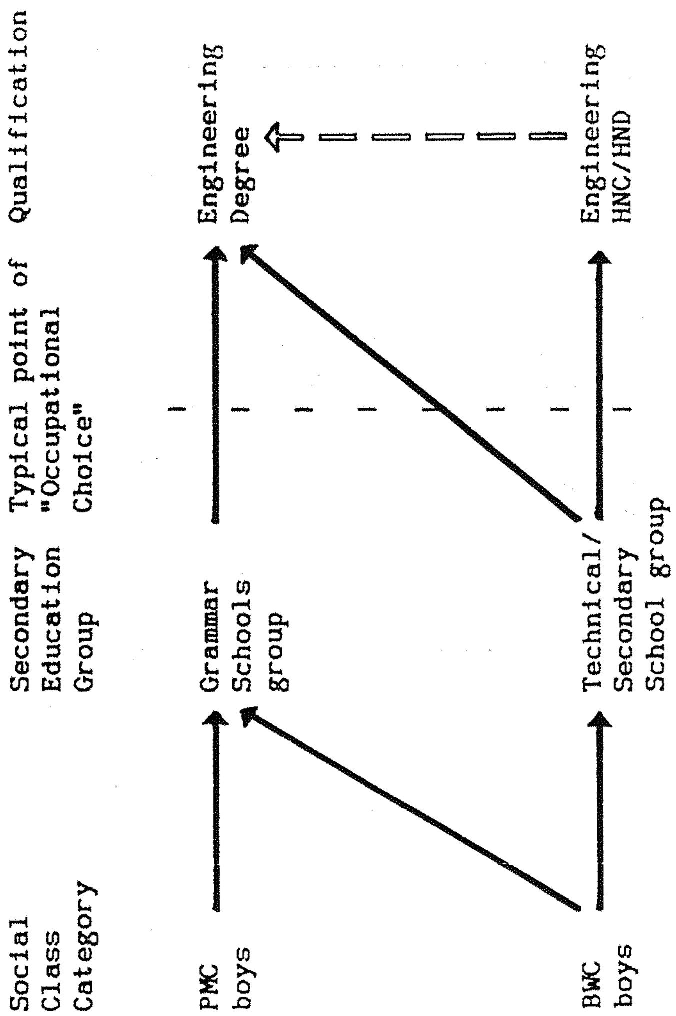
The MBAs achieved recently by two respondents stand apart from the other postgraduate qualifications in that they were taken specifically for the purpose of advancing the career, crucially in a different direction to its existing orientation. Respondents 12 and 14 have gained MBA qualifications through part-time study at Warwick and the Open Universities respectively.

These higher degrees in general are important indicators of the very high level of education achieved by a high proportion of engineers, whether or not they move into technical managerial posts. They also act as indicators of specific technical and managerial orientations, both in the career exploration stage and also particularly significant when undertaken in later career stages.

So, in summary, a pattern of two levels in higher education has emerged. Links between this and the two levels of school education and social background are notable. By building the engineering qualification options onto the previous figure, figure nine results. The diagonal lines represent a filtering of BWC boys from technical or secondary school education onto degree courses at a university or polytechnic. This leaves few respondents on the bottom line of figure nine to study for an engineering HND or HNC qualification. Two of these (already quoted in some length) later went on to a degree course at some stage; this accounts for the vertical line to the right of figure nine.

Therefore the pattern which emerges among the technical managers in the sample is one of two distinct routes from childhood, with typically different experiences for the BWC and PMC boys. But over time there is gradual conformity to the academic route by various means as the BWC respondents filter upwards, mostly at the stage of the opportunity of a grammar school place, taking that option and making a suitable career out of it. Some also filtered up at the higher education stage, and a couple even later after their HND/C courses.

Figure 9 - Route to engineering qualifications



PMC = "Practical Middle Class"

BWC = "Bright Working Class"

Marked on figure nine is the point at which typically the respondents in the sample made their "occupational choice" as the work presented by Musgrave (1974) would narrowly term it. That is, their decision, implicit or explicit, that engineering was the career they wanted to follow. As already noted, a few respondents made that choice even as late as post higher degree, if they had pursued a science subject. And of course, I have shown that at an earlier age the respondents were already making choices. However, the typical point of decision in the minds of the individuals was on the point of deciding what degree to take or which firm in which to take up an apprenticeship, as some quotes such as that from respondent 29 above have already indicated. I feel it is rarely accurate to pinpoint any "occupational choice" decision like this, but have marked the typical situation on figure nine because it indicates how relatively early many of the respondents had made up their minds, which has implications for the options in an employing organisation which can be expected later.

6.4 Nature of initial employment

Still in the career *exploration* stage, it is relevant to look at how the newly qualified engineer applies his or her orientation to creativity and technical competence, in the form of design, to the first job, and to analyse other facets of career orientation which emerged from the data.

The experience of engineers entering employment for the first time is one of facing up to the reality of how far their day-to-day work is going to be based on their orientation to creativity. These experiences divide the engineers three ways.

First, the HNC/D route students, as summarised above, had fewer career options open to them than the degree qualified engineers. The fact that there are only two members of the sample of technical managers with HNC/D as their highest qualification is a finding in itself, although what causal relationship exists between ambition or opportunity within organisations, and the apparent inability of HNC/D engineers to reach technical managerial positions is not clear. It must be said that I am dealing with only a handful of data here from five respondents, three of these moving on later to aspire to gaining a degree, but it is not surprising to see why the HNC/D engineers did not display much ambition at this stage. It is detectable from the responses recorded that these individuals felt, at least for a time, that they had reached the goal they had chosen. This is an unsurprising result bearing in mind that the choice of career made by these individuals as BWC boys was already higher than what was expected of them. The practical orientation to experiment technically, always looking for new technical problems to solve and so on, remained constant but there is not evidence of wider ambitions for career development. Certainly it seems that HNC/D engineers were less able to move outside their immediate geographical area than their degree qualified counterparts, unless the former were employed in a large organisation which could offer a transfer to another plant. If there is little initial evidence of ambition among the sample interviewed, who had eventually gone on to become technical managers, then I think it is reasonable to conclude that the same is true among those who don't go on.

The other group, the graduates, actually subdivides into two categories; on one hand those who were sponsored for their higher education such as respondents 8 and 10 (7% of total), and on the other hand the majority (76% of total) who were not.

The sponsored students had guaranteed vacation employment and at least one year of industrial training, plus usually an obligation to continue to work for the sponsor for a period after graduation. This period was for one or two years.

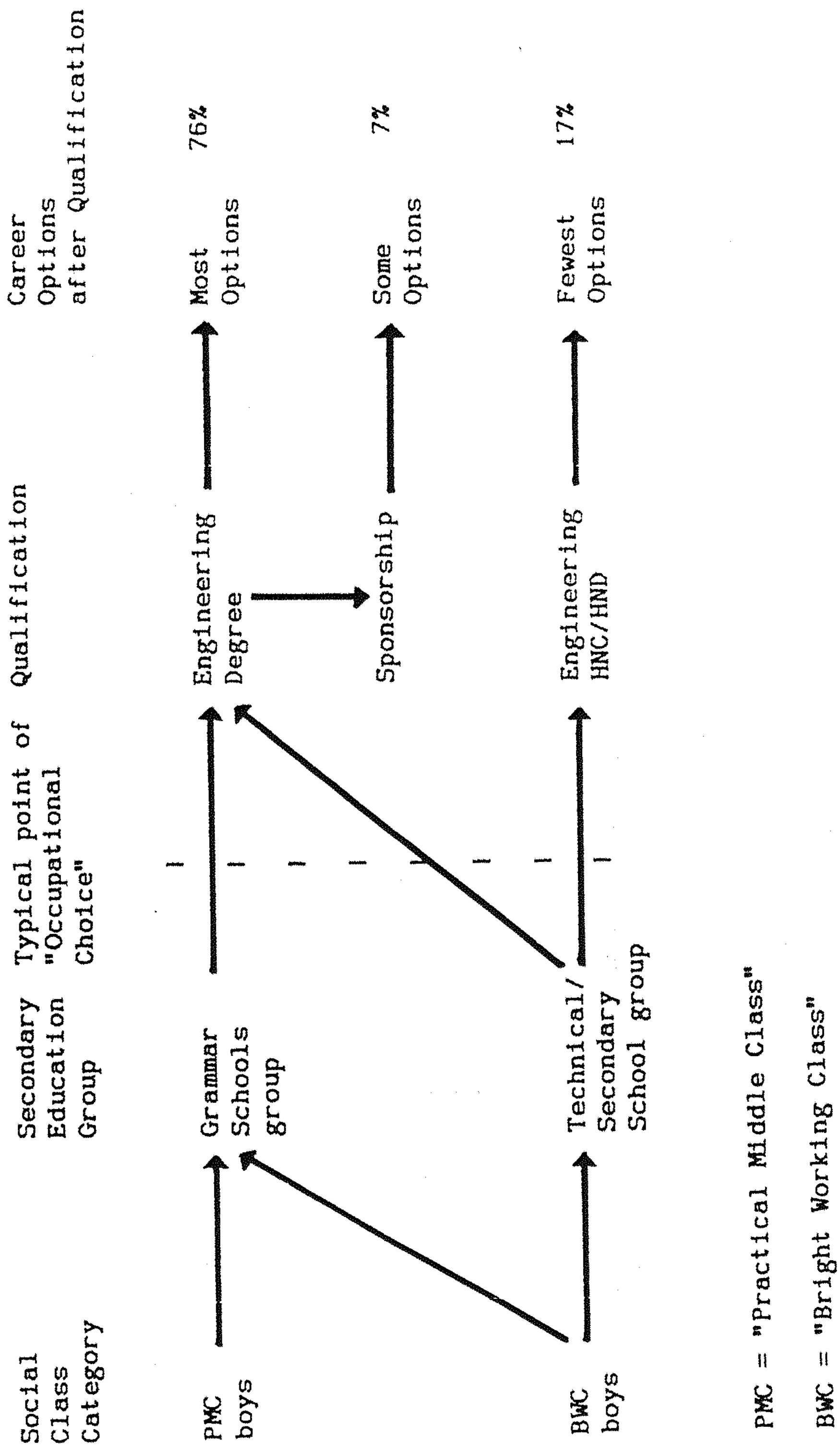
The sponsorship situation served to narrow the individual's career choices in the first job. This was perceived by the relevant respondents as useful when they started their degree in that the promise of employment at the end of it provided a legitimate reason for going into engineering at all. This was implicitly seen by respondent 10, for example to make engineering a suitable subject to study as a PMC boy, and he was encouraged to take an engineering degree on this basis by his school. And for BWC boys such as respondent 8, sponsorship was perceived as almost essential in studying for a degree due to financial constraints; in his case a fairly far-reaching commitment was made to the Royal Corps of Naval Constructors and the package made him effectively a civil servant from the time he left school.

Experiences of sponsorship were mixed but generally slightly negative. As the degree progressed, a student could see the sponsoring organisation's structure providing only narrow career options and was likely to become more critical of them as an employer. The constraint on vacation time could be a source of useful income but prevent long holidays. These views are not surprising in themselves. They can be seen as a growing perception of the need to match the individual orientation to certain technical design work and certain types of organisation, and whether a mismatch was likely to occur. The sponsored engineers are unusual compared with most professional groups in that their future employer was chosen before they had started any relevant formal training.

The majority of graduates in the sample were not sponsored students and faced a wider choice of immediate career options in engineering on completing their degree, but the nature of this choice depended on the degree subject. The respondents who had studied physics had varied experiences which rarely used their actual physics skills, but instead applied them to software work.

So how do these findings extend the figure showing career exploration characteristics developed in the previous section? Having identified the most important career choice point in figure nine, the engineers split into three streams. This is expressed as figure ten which continues the typology set up in figures eight and nine. The aim of this figure is to show the relative number of options available when it came to choosing a first job, in terms of type of work and type of employer, which is open to individuals on each stream at about the age of 21 when engineering qualifications are typically at or nearing completion. For clarity, this is not strictly the first job of an HNC qualifying engineer, who has been working part-time for several years, and this point was elaborated when discussing working career length for figure eight in section 6.2. Here, the important point is the range of options before an individual *after* qualifications have been obtained.

Figure 10 - Relative options in first job



As may be expected, the HNC/D students, mainly BWC boys, have fewest options because they are already tied to an employer, effectively from the same point in time that they chose engineering. The HNC/D route, particularly the part-time HNC can be seen as the ultimate sponsorship which provides job security on one hand, but very restricted job choice on the other. The length of time spent with first employer by those HNC/D qualified was on average just over 11 years and 2 months, compared with a mean for the whole sample of just over 9 years 4 months for first employer and just under 6 years 9 months for all employers. Unfortunately the sample is not large enough to draw any significant conclusions from this. The inertia of many HNC/D route engineers to move around stems not only from this tie to their first employer, it must be remembered, but from the social and educational constraints which led them to the route they took in the first place. Still, the links between this and the levels of school education and social background are remarkably straightforward.

The graduate engineers often showed a pattern of thinking more widely in the career exploration stage. I consider this a willingness to "experiment" with their careers, as described by Watts (1981); see section 2.2. This willingness may be related to the way in which degree courses in, say, electronics, also allow the student to see at first hand the work of mechanical, electrical and other engineers through common first year courses. Perhaps less likely is the influence of the full-time higher education environment itself which, although it sounds cliched, "broadened the horizons" of the individual showing opportunities in totally different potential careers as well as options in engineering.

Later on, some graduates were prepared to take up opportunities to explore other sub-disciplines of engineering, or to take on technical responsibilities which were different from the technical design work they had been taught, as described in chapter seven.

This experimentation ranged from some minor career shifts within the same organisation to radical career movement, even taking the individual out of engineering to another occupation which was perceived to offer similar outworking for technical creativity. A good example of the latter which failed is respondent 19, now a Chief Engineer, who enjoyed his first job as a microwave engineer in a research establishment for two years after graduating with an electronics degree. Then he decided to follow up an idea of moving into school teaching, so studied at a college of education for one year. His actual experience as a Physics teacher at a grammar school was disastrous. Having lasted four months in the job at the end of 1973 he returned to his former employer with a new enthusiasm. Through the combination of inertia to experiment further, and the continuing opportunities presented by that employer, he has remained with them to the present time. Another factor was increasing social responsibilities around that time, which mark the end of the career exploration stage for that individual.

For those who stayed in engineering all the time, experimentation involved responding to some demanding challenges, such as the assignment of one embryo project to a single engineer, to explore and bring on the idea, and to prove its worth, with no guarantee of positive results. Respondent 12's experience is a interesting example:

> "I spent 3 to 4 months on a graduate training programme because in those days although you come out of university with a lot of computing experience you really didn't know a lot about computers that were in use in the real world. So I was one of six graduates hired by the company and we were set off to build a system..." (respondent 12)

His experience of this first team showed talents he did not know he had in terms of leadership capability from very early on, whereas before he just knew he could write code very fast. The opportunity to take a part in leading this project was becoming a career option in his mind, and this turned out to be an option he was prepared to experiment with.

For graduates, entry to their first job could entail taking part in a graduate training scheme (commonly known as the "Cook's Tour"). A fairly typical such training scheme is described by respondent 6, first employed by Vosper Thorneycroft:

> "Vospers actually offered to run me through their graduate training scheme, which seemed like it was recognised by my institute and would qualify me for chartered status. It wasn't the highest paid offer that I had but I decided it was probably the best for my future, to actually go through an approved graduate training scheme... Well I spent three months with school leaving apprentices at their apprentice shop at Woolston, which was bending bits of metal and fitting them and welding, this sort of exciting stuff which was actually a waste of time, I mean I could have spent a week there rather than three months and learned just as much probably. They had to spent a year in this training school not just three months. But after that I went around various parts of the shipyards and their various divisions. Everything from working with fitters to welders, to painters, so really starting to do a bit of everything; two months here, two months there. Then I moved into an office type environment which I did at controls division. I actually started playing around with computers a bit, which I hated at university and got to quite like, and eventually my tutor, who was actually based at controls division, offered me a position, so I accepted that. I spent some time in a drawing office as well, and they offered me a job in design, but it all seemed very antiquated stuff drawing with pencils and rulers and this sort of thing... I did want to be in touch with new developments." (respondent 6)

Some graduates did not have the opportunity to "do the rounds" on a graduate training scheme, such as this respondent:

> "It was a case of being assigned what projects happened to be available at the time, and of course there was some on-the-job training. There was no formal training scheme such as we operate now and I would think, looking back, that is something that I missed, experience wise. Certainly the opportunity to go round different departments and learn a bit about what the other departments do. ...obviously one gets a superficial view of what goes on in other departments but its useful to have a real hands-on feel for what they're really doing."

One typical PMC graduate, respondent 32, now a 40 year old Chief Engineer, chose to avoid seeking first employment in an organisation providing a Cook's Tour and had several years experimentation working on short term project management in Europe and the Middle East, all for the same organisation - Chicago Bridge and Iron. His technical experience gained from this was very useful but it gave limited other experience, and had serious implications for life outside the workplace. He therefore chose to abandon this approach to his career and has spent five years in the a new organisation, where he intends to remain settled.

This approach of being involved in whatever project happens to come along will satisfy some engineers for their entire careers. Importantly, though, a distinction must be drawn out of this data about what makes the technical managers who form the respondents in this study somehow dissatisfied with that approach. They were not prepared to have their technical design work wholly controlled by the organisation and just work on what they were assigned. They were prepared to have more technical autonomy and prepared to be involved in taking an overview of technical projects.

So what is the sum total of these orientations and influences on the growth and exploration stages of the career? It has been my intention to try to separate themes and streams of engineering education and training in this chapter according to various factors. Engineers are not a homogeneous group but in one respect they were all united. Any engineer is anchored in a very specific technical competence, design. This is a combination of Schein's (1978) two categories of creativity and technical competence.

What most of the engineers wanted to emphasise in creativity was design. An ability to design rather than just plan things out on the one hand, or just building things on the other, was key to each of the engineers self-assessments. The ability to design was fundamental to the meaning of describing a colleague as "a good engineer". This is in line with the findings of Glover and Kelly (1987 p219). This core attribute of engineering is what holds engineers in common together. A "good engineer" was first and foremost one who was a good designer. Ability to design is the technical work which first sets the engineer apart in the workplace, wherever that might be.

From the data in the interviews, there also seems to be a common link in the route taken to become an electronics engineer or to be working as a mechanical engineer or whatever beside them. This commonality is not in the mechanics of the route taken, for the data shows that despite the dominant (and increasing) recruitment of graduates there is great diversity in this, especially amongst those old enough to be in technical management. The commonality is in what is loosely termed here "the usual route" in a broader sense. It is the academic approach to practical things, the rational thinking and the education, however it was acquired, which builds an engineer out of these attributes. None of the respondents found this very easy to express but a couple succeeded better than the others. Here is an example from respondent 5, underlining the basis of the technical skills he felt he had now partly left behind:

> "Very few people I've met can hold down... well, not this sort of job, but this sort of job plus the sort of job that people who report to me have, without some sort of... (thoughtful pause) They don't necessarily have to have gone to university, but to have that sort of academic bent, because you've got to be able to analyse things, without getting emotionally involved in things." (respondent 5)

Whether each individual actually believes this approach is best served by the degree route or "the hard way" is a product partly of their own background but also their belief of what universities actually teach. One respondent (30) - now an Engineering Manager aged 46 - criticised the lack of design ability found in university graduates compared with those coming up through HND or HNC. Others who voiced an opinion thought that the design capabilities of graduates were far superior, or would even aim to recruit holders of postgraduate degrees whenever possible.

In relation to the analysis of divisions in technical work in chapter seven, I noted that the phrase "he's a good engineer" was often suffixed with "but...". The clause which followed usually concerns that colleague's ability to organise their own technical design work. Alternatively the clause could criticise his or her ability to lead or control the technical design work of others, or some other aspect of the role of a "technical strategist". A clear distinction will be made between these types of technical work in the next chapter.

6.5 Summary

This has been a detailed chapter, building up a typology of early career development through the growth and exploration stages alongside accounts of the experiences of those developments. The chapter presents data on career orientations to which I will return in chapter eight.

The range of opportunities available to the "bright working class" boys was narrower than the "practical middle class" boys. Quite a few BWC category boys obtained a grammar school place and therefore can be seen with two sets of constraints on their actual career options: those stemming from the expectations of their parents according to their class, and those of the grammar type schools which did not always favour their pupils going into engineering. Without a grammar school education a degree was unlikely and an apprenticeship was the highest ambition they could have within the confines of their stratum of society; effectively barring those individuals from eventual managerial posts even if they wanted them (this being in part why few are represented in my sample).

The PMC category school leavers mainly from the grammar and independent schools had to adopt a different approach when faced with a wider range of opportunities and actual career options. A more conscious choice was made in most cases to deviate from the preferred options of the school and follow up a pastime interest and turn it into a career. The PMC entrants to engineering were gradually joined by BWC entrants at three key points in the career exploration stage: going to school, going on to higher education, and gaining subsequent qualifications. But I suggest a similarity exists between the groups, that they both had to struggle to some extent to keep engineering open as a career option. What the chapter shows in this area is how much more influence the values of society and education system have on translating a range of potential opportunities into real career options through structural and sanction constraints than previous research covering the careers of engineers has credited.

The second and most significant finding of this chapter has been in the on-going area of career orientation. It concerns the anchoring of the engineers, in this study, in creativity; particularly interesting as creativity seems to have had a practical outworking through pastimes and education as well as in work. The practical bias continues in the background through ongoing pastimes to the present stage of their careers. Further, an intrinsic interest in the technical design side of engineering persists in clouding the division between work and leisure, thereby increasing the enjoyment of the engineers' work. What makes this remarkable is that all the engineers in question, who related to me that they enjoy the creative technical side, had moved on from the "bench" some considerable time ago, through supervisory role and on to technical management. In fact, on looking at their current managerial work in isolation, from some objective viewpoint, it would not be totally obvious that all of them have been engineers.

I suggest that this practical creativity and a continued desire to tackle technical problems and "talk engineering" unites the engineers regardless of "BWC" or "PMC" background. Although it is analysed more fully in later chapters, it is important to state at this point that the data showed little evidence for a likely orientation change away from creativity later in the career, nor evidence that enthusiasm will diminish as the career progresses, even if technical competence or position in an organisation do not permit an individual to get involved directly.

So, at least in engineers who stick with it, the orientations stick; even through changing technical work and through a possible change of career direction to move into controlling and overseeing technical design work. In this respect the apparently naive assumption of the engineering institutions, that engineers always remain engineers whatever their current employment, is strangely correct.

I argue that this finding has major implications for the following chapters, which look at how technical responsibilities change for the engineer who climbs the career ladder. As a transition into technical leadership takes place, the practical and strictly technical aspects of the engineer's work slowly become squeezed aside. Then on entering technical management proper, the basic engineering orientations and identity are potentially challenged by a future working life predominantly as a manager, albeit in an engineering setting. The following chapters first examine how this process occurs, and secondly how later career choice is adversely affected.

Chapter 7 - Movement into Technical Leadership

This chapter examines the career establishment stage in an attempt to answer the question "how do engineers become managers?". Following the career exploration stage up to the age of about 24, the data reveals the establishment stage as one which, in line with Super and Jordaan's (1973) model, is characterised by a desire to establish a stable career. In this establishment stage I intend to examine how the engineer's work changes, and I have noted distinct effects on subsequent career choices.

I present data in support of my argument that far from being a fallow period, as it may appear to the casual observer, this is a transitional stage in which the work of the ambitious engineer changes noticeably but undramatically over time. As such the changes are difficult to present in an illustrated form, and so in this chapter I will rely on text, using the words of the individuals interviewed. The opportunities which engineers face at this stage create career choices of a different type to those of previous years, leading the career in different potential directions. The establishment stage is typically one of a series of implicit choices and constraints rather than explicit decisions to be made.

The major finding of this chapter is a distinct type of technical work apart from technical expertise in engineering design: technical leadership, which I define, explore and explain from the data. I also propose in this chapter that the transition which links the two types of technical work is an important process in itself. The model of transition cycle by Nicholson & West (1988, p9 et seq) does not seem to be of suitable scale to be applied to these ongoing tiny changes, sometimes reversed, but which will transform what an engineer does in a working day. I also outline here the differences in the skills required and suggest reasons stemming back to early influences and orientations described in the preceding chapter which explain why certain options are chosen and others are rejected.

7.1 Defining technical leadership

In chapter 5 I presented data on the current technical and managerial responsibilities of the technical managers in the sample. In this chapter I propose that there are in fact two distinct types of technical responsibility, and I propose to examine one - "technical leadership" - in detail. I define this term in this section, and in effect I argue that this makes previous descriptions of technical work as homogeneous inadequate. These types have not emerged as distinct in previous studies such as Whalley (1986). Whalley (pp58-60) describes the method by which engineers function as trusted workers, and analyses the way entry to the profession is regulated. He establishes the fact that engineers' technical knowledge background is in theory held by longest serving manager and new recruit alike, and that trusted worker status is built on that by gradually increased responsibility. What he does not look at is how. I suggest that the failure of two types of technical work to emerge from such research is not because they are indistinguishable one from another, but because the boundary between them is marked by a transition not a divide.

In a similar way it is insufficient to describe the technical and managerial work as fused together (Causer and Jones, 1990 p11 et seq) at this level. The "supervisory" work of engineers and the administrative work they take on quite early in the working career are essentially based upon and measured by technical competence, not a skill base in managerial competence or even an enthusiasm for managing projects as such.

Causer and Jones do mention that "project leadership functions are undertaken primarily by staff who are graded as Senior or Principal Engineers, rather than as part of the department's formal complement of managers" (p13). This is because the work is largely technical; it is partly composed of elements which appear to be the management of human resources, but I found that the way the work was organised and judged by superiors was on technical merits. The people who took on the responsibility were not called managers. The technical leadership or supervision role calls for the fine-tuning of the individuals technical skills, but not at this stage the adoption of managerial skills. Personnel and most administrative functions continue to be handled by their immediate manager as an engineer takes on technical leadership of a project.

So what exactly is technical leadership? There is some difficulty in defining the phenomena I have observed in terms of existing literature on technical and managerial work. Technical leadership is perhaps best described as heading up a group of technical specialists, because an individual has the necessary technical expertise for a particular project and can work with the other best specialists for that job. It is more quasi-technical than quasi-managerial. It is not purely technical work because it typically involves considerable *interaction* with people as leader of a team, but it is not technical managerial because there is virtually no *responsibility* for the work or well-being of human resources, nor *responsibility* for the allocation of these resources. I see technical leadership as the supervision or leadership of individuals involved in technical work, without having areas of responsibility for them that are managerial in the way that term was defined in chapter 2. Technical leadership can include any of the following managerial traits: interpersonal roles of figurehead, leader and liaser; and/or the informational roles of monitor, disseminator and spokesperson as defined by Mintzberg (1973). But these are only traits, applied in technical work and I do not find evidence for any of the decisional roles. And importantly these roles which technical leadership does encompass are within a purely technical framework; this is responsibility given and measured on the grounds of technical not managerial competence (note a)

It has become obvious from the data that the engineer who has left college or university, say a year ago, has a certain type of technical expertise and responsibility. This is a technical design function, the type of work for which he or she has been aspiring and studying for several years. It is the type of work inspired by the certain creative element in every engineer, and the type of work which is a logical extension of that engineer's childhood interests: the fascination with electronics (or whatever is appropriate), the technical problem solving, making things work.

By contrast the engineer a few years later can be doing a different technical job. The engineer who has shown an aptitude for project leadership, planning the technical aspects of new projects, getting jobs done to time and cost, and covering a broader range of technical design specialisms within his or her understanding to at least a limited depth, is in a different technical role in the organisation. Their career has perceptibly changed direction even though in every case studied it was impossible for the individual to look back and see any corner which had been turned at a specific time.

The movement between the two distinct points had been a gradual, uneven curve of job change, diverting the engineer from his or her original starting point in the one technical design specialism. The movement is a transition, not a jump, which I intend to trace and explain later in this chapter.

Who becomes a technical leader? Not every engineer becomes a technical leader, only some engineers. Other engineers, indeed most engineers, can be expected to remain wholly in the technical design function, or as shown on figure 2 in section 3.5, to move out into the technical margins of engineering or work outside. But the phenomena studied here is those who do move on. The responsibility for technical leadership is separate from technical management, in that leadership work entails supervision of engineers' technical work but not the attendant personnel functions or financial responsibilities for an entire project, but again in terms of the "option plan" in figure 2, it is a step on the path to technical management.

It must be noted that some of those engineers who move through the transition to leadership responsibilities will then move on to become technical managers of some kind. Technical management is an opportunity among several for those who want to take it, although the structural constraints of a narrowing organisation hierarchy mean this is only an option for some not all. Here I will focus on the data collected on the technical leadership role, to understand how it operates and is developed, and I will offer a few reasons why some engineers achieve promotion into leadership and others are more likely to remain in design.

7.2 Transition into technical leadership

In this section I examine the process of entry into technical leadership roles from a starting point in engineering design. As shown in chapter 6, there is a technical design specialism in every engineer, or in some cases he or she may have developed more than one such specialism. In every case studied, a design background had to be well founded before a set of technical leadership responsibilities could be built onto it. And usually these responsibilities were built up in the context of one employer, usually the individual's first employer, or started very soon after joining a second employer.

Typically a period of two to five years had to elapse for an individual engineer to assert their technical design competences in the workplace before they appeared to have a chance to take on leadership responsibilities. From the data, this typically takes the engineer to Senior Engineer level, but these titles do not reflect strict responsibilities or types of work and are not universal. The period could be measured following on from leaving college or university, or similarly measured from the point at which a respondent had made a change in their technical design specialism, for whatever reason whether related to technological changes or their own new or changing technical interests.

Technical design work carried out as an individual was the least likely starting point for the transition process to leadership. Several of the respondents had a period truly working alone, often on a totally new project. Less extreme, some had a period when they were loosely attached to a team but spent most of their time on a project by themselves. Engineers call this "being shut in a room" and love it or hate according to the technical work they were expected to work on in that isolation. The experience of respondent 6 in his initial technical leadership responsibility is relevant here:

"I would say that certainly the initial work I was doing was very much self contained. A quite specific part of projects and so it wasn't a project in its own right. It was to simulate a new control system. I was given various bits of information by manufacturers and I just went away and did it basically. I must confess I was never really conscious of working in a team at that time.

Q. At that time; so when were you first involved in teams?

Well I would say when I actually ran the simulation department and tried to get things more... well I tended more to higher level team meetings on the projects. I obviously had to brief the rest of the team on what they had to do.

Q. So that was in the 18 months or so that you were Senior Design Engineer; so you've put here (on questionnaire sheet) four graduates...?

Four graduates in total; it was quite a small group.

Q. So you were supervising those three others then, were you?

Yes." (respondent 6)

This respondent reveals the limits of his supervisory responsibility for those other three engineers: simulation was one tiny part employing all four of these engineers and respondent 6 had to brief the others with orders from their project manager or technical manager. He said this technical supervision:

> "...opened my eyes a little bit about the importance of making sure everyone knew what they had to do and actually then monitoring their progress against the targets. It involved a bit of admin, because we had no monitoring system at all beforehand, so I set up a very crude one, just agreeing how many hours it was going to take to do a little module, we'd look at that module and when it was finished we'd cross it off and see how many hours it actually took and plot it out on a graph. We just ran a simple graph for each project on cost versus accomplishment and timescale." (respondent 6)

Another respondent (27) described how he allocates and uses an engineer in a leadership function now, giving them great responsibility for technical details, but also his support if they have problems:

> "At the moment there are about 4 projects running in the group, and what I will do is assign a lead engineer on each project, so he effectively runs the team of engineers. I then talk to him if there are any problems, or he comes to me if he's got problems and we sort them out together. And that works quite well; really if you give them as much responsibility as possible, so they only come to me with major decisions or major problems, and then they just report on a monthly basis to me, and I feed that into the system, in a formal way. ...The people who are lead engineers at the moment are quite well motivated, and I can let them get on with it. They don't just bring problems, they bring problems plus solutions! (laughs)" (respondent 27)

If loosely attached to a team then at least there were a few individuals for a leader to turn to for advice as well as their manager. If an individual moved into a position of working alone on a project after a period of team work, then the transition process of acquiring strategic skills and responsibilities halted, an experience related by respondent 13 when he moved to organisation E to work basically alone for a year or so.

However, an individual often does not work alone for very long, especially in small firms. The data shows that if work proceeds well against targets a project assigned to an individual can expand in scope and the number of engineers, often not just from a single technical design background, employed on it. This again is what happened to respondent 13 and has major implications for career choice and the type of technical work done. The first engineer usually progresses as project leader, their strategic responsibilities being built around and beneath them over time.

Having established the basis of technical leadership, over the next few sections I intend to build up a picture of the parameters of this work and some of its characteristics and specific factors which influence its development.

So what were the sort of responsibilities which were necessary to build up a technical leader and what came first? I will present a fairly typical sketch from the data. This Software Engineering Manager (respondent 5) described the way in which his technical responsibilities expanded over the first two or three years in his first job. When he started he was basically doing ordinary programming jobs:

"...but even then I was given quite a lot of freedom. The guy I was working for ran things quite loosely. Probably like I do here. He trusted people if they could prove themselves. Basically you go through a few months proving exercise, so you get given some simple jobs that don't matter too much, and when you've proved you can do that you get bigger and bigger jobs. I tend to find it the best way to treat people, the way I was treated. You don't limit the scope of people except by their abilities, you give everyone the opportunity to do what they can do." (respondent 5)

This engineer did have a short time working as an individual, but as the project he was involved in was expanding, his job changed. He had other engineers brought in beneath him to form a new team, and naturally he supervised their integration into the project. He provided the technical leadership for the team as project leader.

Three other technical managers interviewed had similar quite spectacular periods of success as project leaders. This was success not only technically, in developing a project as an individual so that it became important enough to warrant a team, but also in terms of their own career. Their career was powered by the technology they were using, and their ability to do technical design work had propelled them into a particular technical leadership niche. Most notable is the experience of respondent 21 in the embryonic Organisation K in the early 1980s. Each of the four respondents who had been through this experience of promotion by growth underneath had been working in small departments.

The organisations concerned seemed to benefit most from this situation by promoting the leader only so far as was necessary to accommodate sufficient team members on lower grades. Further promotion to technical management was unlikely at this time as the leader was too useful where he or she was, not *necessarily* through a lack of competence in other areas. The Software Engineering Manager (respondent 5) quoted above became absorbed in the technical leadership work and looking back, felt this had delayed his career progression to managerial levels by up to ten years. He felt he had been considering the company over his own career. Crucially, he had been given a lot of freedom, but he had not been encouraged to use it. Instead he had been encouraged to take on different technical responsibilities which were more useful to the organisation.

There are various ways in which an engineer can get offered the "bigger and bigger jobs". Three stages of the choice process were observed as crucial to the gaining of technical leadership responsibilities. Individuals could be searching for such opportunities, or as in the case of the experiences related at the end of the last section, the opportunity just came along as something interesting and an intrinsic part of being involved in a new piece of work or a particular planned hierarchy in an organisation.

First is presentation of the opportunity. The organisation, through management decision on the use of human resources, offers the choice of increasing and changing technical responsibilities. More often than not in the cases studied, this was by informal means or by default. In other words, no formal procedure was used to recruit; it was simply a case of a need rather than a definite vacancy. A new project, an expanding project taking on a technician or another engineer, or an existing project leader leaving or being promoted led to such needs.

It was not always the case that an engineer offered the opportunity had the most experience or was best qualified. In one department studied (Organisation C), the allocation of team leadership and membership was on a fairly strict rotation basis among the engineering grades above graduate engineer. The projects were typically of less than six month duration so everybody had a turn at taking technical responsibility for one. It was not even dependent on senior engineer or principal engineer status, or salary. Thus the leadership role could reverse: a team leader one month could be led as a member the next, and a few months later be leading a slightly different team. All this was negotiated between the technical manager and the engineers. There was evidence from comments made by several respondents that most of their colleagues were given the opportunity to take on technical leadership for a minor project at some time, as a test of the adaptability of their technical knowledge or their general commitment to project based work (specific examples came from Organisations B and K).

Secondly the engineer has to recognise that the opportunity is present and a choice is there to be made. There were expectations in some of the departments that engineers would always want to explore technical work beyond the basic design level, especially when they had been promoted in the accepted way above engineer or senior engineer grade. This was partly an expectation that an engineer who had been in a certain field for three or four years must be a greater authority on technical design matters even if they weren't a great leader or planner of the technical work.

Third is the time when the engineer actually makes the choice, or has it made for him/her by default. A rejection of the chance to take on greater technical responsibility *per se* was not found, but two respondents talked about their experience of turning down the chance to lead projects alongside their own. In general the engineers accepted the offer of such responsibility as a tribute to their technical competence even if that was more illusory than real. This example of being "thrown in at the deep end" is typical of several examples recorded:

"I had an honours physics degree, and I was [working in] an engineering firm which was not going to use my physics at all." (respondent 1)

This respondent was employed in the avionics division, moving around several projects and reporting to senior and principal engineers for a couple of years:

"I certainly wanted to get on in engineering and get more experience, but I didn't really have a mapped career plan. It was very much living from day to day, and one was quite busy. I was sent for by the research director who said, 'You've got a physics degree, spectroscopy is physics, have you heard of Electron Spin Resonance?' and I thought back to final year physics and thought yes, it was half a chapter in 'Magnetism' - Bates' book, our prof - I said 'Yes I've heard of it.' 'Well here's an opportunity, we want somebody to start this off, you've got the ability to do this sort of thing, you can go and chase people around and be a fireman, it's a chance for you, Peter, do you want to take it?' I said 'I'll think about it.' Just to look good, I'd already said yes! Thought about it for another half a day. ...that was the first job I really ran." (respondent 1; "fireman" see note b)

For this respondent and for others who found a similar position, the choice to take up this sort of opportunity marked the distinct end of their career exploration stage. This is because they then remained in the technical leader role developing their new project for a period of several years and expanding their responsibilities with it, in respondent 1s case until he became a technical manager and then suddenly had all his technical responsibilities taken away from him for a time.

A further respondent (12), now Engineering Group Manager in a large department designing and developing office equipment, had slowly changed his technical specialism in some respects, because he saw opportunities for the leadership of hardware design work. He had worked his way up through the software side but started to explore and spend much more time with the hardware engineers on his projects. When asked exactly why, he explained:

> "That's a good question, maybe because I enjoy it more. I think perhaps because it's more complex, and I don't mean that in the technical sense, but in the logistic sense. To build a piece of software you can take six extremely good software people, and pretty much lock them in a room. As long as you've got the spec right and the tools right, you've got a good chance of success. The trouble with the hardware department is that if you take six design engineers and do the equivalent, you actually discover you've got to have about another thirty people in the company to make it successful; to turn out prototypes, to run tests, to qualify new components that we need to build, to actually introduce the product into manufacturing, and to reflect on the need of the field service organisation. So there's a massive complexity which makes it much more difficult ...a lot more can go wrong with it." (respondent 12)

His choice of this opportunity was not forced upon him. As he said at the beginning, he saw potential enjoyment in the challenges it brings more than if he was responsible for leadership in his original background in software design.

This is not to say that the potential technical leader is likely to accept all such challenging projects. In fact it is an important part of the technical leader's definition that he or she perceives things from a purely technical point of view, having not (yet) taken on the divided loyalties of being a technical manager. Some respondents commented that a technical leader is likely to turn down work on a project because it is not seen as technically feasible or worthwhile, even if direction from management indicates that the project should continue against all odds. Several examples of this were noted. Eg:

> "I refused to run the project that got canned, because I could see no future in it. And no future for me either! I wasn't going to inherit another load of... someone else's problems! I've seen that happen too many times." (respondent 5)

Unfortunately on that occasion it happened again, when an engineer from a different background did take on the project leadership. The losses it eventually incurred were large enough to bring staff cuts and a very cautious outlook to the department. Another respondent turned down the opportunity for technical leadership after he had been working as a technical specialist for about five years. About refusing this position he said:

> "I certainly resisted a change earlier on in my career, which I felt was putting me on the management ladder far too early. This was about 1981 or 1982 when I was told that I was going to be doing a certain activity and I said 'I'm sorry, I don't want to do that. I think it is a waste of what I've just learned. I would like to apply what I've just learned to the next job and make more of a success of it'. And I was quite stubborn in refusing that position. I was told by the person that was offering it to me that I was making a big mistake and that it would have a retrograde effect on my career... And I think events actually proved me right. So I turned it down, that position. (respondent 10)

This respondent turned down the first chance he was given to take on a technical leadership position, as he saw it then the first rung on a ladder to management, because he felt he still had a lot to offer as a technical specialist. However, it could be argued that the onset of obsolescence in an individual's technical specialism could lead to a desire to take up a technical leadership role. The attraction could be seen as the narrow specific field with which the engineer would have to keep up to date. However, from the data it emerged that if anything the technical leader's role was a more technically demanding one than design work, because it required understanding of the applications and techniques used in other fields of engineering which were to input to the project. So I do not see the transition in technical work as a haven for the engineer overtaken by obsolescence in the same way that technical management roles have been perceived as such.

However, one Electronics Design Manager (respondent 14) provided evidence that some engineers may take a long term view of the likely course of obsolescence. He intended to move into technical management partly as an insurance against being unable to keep up with the detail of technological changes later in his career. This had involved moving through a short period of technical leadership.

Changes in the personal circumstances may be seen as a contributory factor to the transition into and through technical leadership. Marriage and/or children mark the crucial stage when experimentation with the career becomes less feasible. Respondent 31 made this comment concerning the time in his career when he took on more project responsibilities and simultaneously got married:

"Your personal life comes in fits and starts and that certainly has a big effect on what drives you". (Respondent 31)

It was at this time that a couple of engineers were able to recognise that they could not be geographically mobile in quite the same way, therefore they had to satisfy ambitions to move into different technical roles or managerial work within the context of their existing organisation. Hence the conscious or subconscious acceptance of new technical work as a project leader.

Simultaneously the likely increase in financial commitments as the individuals moved out of the career exploration stage led to an increased interest in technical leadership positions because they offered better reward packages (note c).

7.3 Development of technical leadership

In this section I focus on the transitional change which brings about an expansion of technical leadership responsibilities, and the perceptible growth of what could truly be defined as managerial work. Whether or not the leadership opportunity came as a result of the individual's project expansion, or was more commonly offered because of a team vacancy, the role required a gradual change in the technical components of the working day. Typically this new work included costing out the technical work, a lot of technical report writing, and also some technical sales support.

Respondent 5 achieved his technical leadership position through championing a project when another leader left, and found he had to help recruit the necessary engineers himself even when still quite junior:

> "There was a software guy who'd been around for a while, and I was working with a hardware guy; it was a team of three of us and we recruited another person, a hardware guy, so there were two hardware and two software designing a new computer. We were working locked away in a room on our own, basically. Then the reason I moved up was the team grew and the guy who was leading it (the other software engineer, who had been on the project from the outset) left, so I took over and I recruited more people into it, because the project worked and we got bigger and bigger. ...I was it for a bit; I was the software side on my own, then we had to recruit some people so I recruited them! ...they worked for me, quite frankly, it was that basic! (laughs) I got it through growth not through planning. I had no one to lean on for advice to start with, I had to find out the hard way, that's the problem. ...I've never been trained at all." (respondent 5)

Only after this had been operating for some months was this respondent promoted from programmer to project leader. Despite his comment, his "recruiting" of extra staff was limited to identifying a need for more software engineers rather than being involved in selection of candidates. Then a financial aspect came into play when he had to technically justify a bid for more funding from the Department of Trade and Industry. Since then respondent 5 has remained with Organisation D and become a technical manager of the same type of work, despite much upheaval within the organisation.

Another respondent (6), now a Technical Manager in a small organisation and small department, started his technical leadership of a team in a very large one. This came after a period of self-contained work as a Design Engineer which was loosely linked to teams. He first spent 18 months as a Senior Design Engineer and became responsible for the supervision of four other graduates; a small group in that context but one which was quite rigidly fixed and not reorganised on a short term basis. This was offered to him because:

> "...the chap who was running the department left to join another company and the Technical Manager of Controls said 'How would you like to do it?' and I said 'All right'."(respondent 6)

As already related for this respondent, the basic administration of the technical work was the only distraction from bench work itself, all other decisions being made by his technical manager. Then came a move to a different set of technical responsibilities in a different division - Hydraulic Power - as a Principal Engineer handling more general R&D activities as an individual. At this point the large organisation did not offer any opportunities for further work of this type and he moved to the much smaller organisation with a yet different set of responsibilities co-ordinating a wider array of technical activities. He perceived this as a conscious backwards step, career wise, but it led to his current Technical Manager position in which he acquired his first personnel and major budgetary responsibilities.

Respondent 28 related the transitional process clearly when he described the way he was moved from his first technical leadership position after only six months:

> "This big contract that was expected, came. I was moved on to team lead that, and the job I was working on we sub-contracted out; it was a smaller job. And I had the advantage of having done what felt like only six months preparation work for this other job, which was similar, but we had pushed off to one side and I was ready to move onto the other one. I was lucky that it was in an early stage of its development... [managerial responsibilities] came gradually. I don't think that there was a sudden change of direction, because I'd always got detailed technical involvement. I can't remember when management began to dominate. It's something that grows. You get one team member, and you're working together and there's virtually no man-management involved. And then you start to build up more and more people, then you get your first problem person, and that will start to develop. Then you get your first hassles with a project, and everything starts to slip, and you start to develop the skills of knowing where you are and what everyone's got to do... The training did come, but it came marginally too late! (laughs)" (respondent 28)

The process can be seen in the first cases to be narrowing the technical field of the engineer's work to what is directly relevant to a project, but increasing responsibility and breadth of his or her inputs to that project. This widening of inputs to the project may, however, increase the range of engineering design specialisms the engineer has to co-ordinate and is responsible for. So for example engineers were brought on to a project with digital experience whereas the technical leader of the project had no digital experience. Similarly mechanical engineers were brought in to design the casing, etc. This may lead to one of two reactions; either the individual leaves those specialisms in the hands of the team members, and just gains an overview of how they input to the project, or he/she can attempt to gain more detailed grasp of those specialisms by attending training courses or picking up as much technical knowledge.

There are possible new aspects of technical work which may present problems to a new team leader who has hitherto been just a team member. In one research establishment, (Organisation C), it is an essential part of the job at technical leadership level to look for new work. This was not for marketing opportunities for existing products; the organisation didn't really have any products emerging from that site, only contract research for other parts of the holding organisation and other firms. It was for identifying technical gaps and the potential to undertake contract research for parts of the organisation or other firms who did not have the facilities to do it themselves. This therefore required a network of customers with whom the leader could negotiate new work contracts at a very detailed technical level. But this cannot be taken as a typical technical leadership level responsibility and is indicative of the possibility for variation between organisations in how this type of technical work is structured.

A few respondents, those who identified themselves still as (good) engineers, saw on-going technical knowledge as their basis of authority, as Respondent 17 explained:

> "I have my own style of leadership which is very much a technical leadership. My way of working is always to be able to do the work that I'm asking anybody else to do, and to be able to demonstrate that I can do it. That is the way I got respect from the people who work here. Other people would get their respect from other skills, perhaps; a rousing speech like Churchill perhaps? I don't find that easy to do. But what I do is build up respect over time by demonstrating technical ability." (respondent 17)

This strategy had been successful in the technical leadership role, caused this respondent anxiety in his present post having been promoted out of technical leadership into technical management; I follow this up in the next chapter.

7.4 Summary

The most significant finding of this chapter has been the establishment from the data of this distinct type of technical work, the technical leadership role, and an examination of what it entails. This leads to the description in the chapter of the process involved. The new technical work which the transition leads through displays the following major characteristics:

i) technical autonomy, to define the technical solutions to product development problems as defined and allotted by technical managers;

ii) technical responsibility for the completion of one project including administration of technical matters such as limited costing of components or time.

iii) technical leadership of the project, with scope for including engineers from different technical backgrounds to the leader's own.

The transition described in this chapter is characterised by opportunities presented to engineers on many occasions. The willingness to see opportunities as career options leads directly to the choice made to accept or reject them. The transition is made up of a series of opportunities, leading to a response of implicit or explicit choices, which may lead to a pattern of job changes and further opportunities. Unlike most inter-organisation job changes, though, the state of search may prevent an individual from seeing or from being offered any opportunities.

The transition process is directly driven by the ongoing state of change in project types and team membership in an organisation over time. The transition is more concerned with job changes offered to individuals rather than changes sought by them. The way in which the engineers described this stage of their career is data in itself because it revealed the irregularity, informality and chance involved, hence their inability to plan the transition in advance or to pinpoint landmarks in hindsight.

What is revealed at this point in the thesis is the engineer increasingly constrained by organisation structure. Career choices so far have been relatively straightforward for an individual to make from several options. Where they have been conscious, they have been typically perceived as technically based, intrinsically rewarding, within the technical competence of the individual and still based on practical creativity even if a few costings and other administrative details must be dealt with. Indeed the technical leadership role is ideal for the engineer who wants to get on in the career establishment stage. Technical leadership is noticeably different to the engineer's first job, and it is starting to take him or her away from a range of technical projects and more deeply into one specialism or project. It also carries more responsibility, but often counteracted by a higher extrinsic reward.

In short, the technical leadership role is quantitatively different in terms of time allocated to certain technical tasks but not qualitatively different. Crucially it is still within the realm of what they have qualified for and what they normatively perceive as "what engineers do".

The external social and obsolescence factors continue to operate through time and the next stage for the technical leader is to face is more of a challenge; the technical managerial position. This involves a sharper reappraisal of what work is involved and whether it too can be classed as part of "what engineers do". The data collected on attitudes to choices in this final stage are analysed in the next chapter.

Chapter 8 - Movement into Technical Management

This chapter serves two purposes. It presents further data in answer to the question "how do engineers become managers?"; and it also looks at "why?". In answer to these questions I argue the following: Having reached the point of technical leadership, and increasing responsibility for personnel and administrative functions by the process of transitional change described in the previous chapter, the individual engineer is faced with a new set of career options, constraints, and decisions to make. These concern how far the individual intends to progress up a career ladder which is predominantly managerial in nature during the career maintenance stage.

I start this chapter by looking at exactly where the individuals have reached at the end of their technical leadership role. I describe firstly the functions of a technical manager and the division of their combined role. Then the process of entry is examined and I assess how planned this was. I present again "push" and "pull" factors in connection with figure two in section 3.5.

In the context of why the movement to technical management has taken place, this chapter also examines the respondents' present self-identity. Through appropriate indicators, career orientations are assessed to compare with the earlier orientations discussed in chapter six.

8.1 Technical management functions

In section 3.5 I defined a technical manager as having four lines of responsibility:

i) strategic technical planning of projects,

ii) controlling budgets for projects,

iii) administration of a project team or department,

iv) personnel management of a project team or department.

In this section I enlarge upon this definition with the individual career experiences gathered at interview, which reveal the skills and expertise a technical manager acquires during the transition from technical leadership. There is variety in these experiences not just because of different aptitudes or organisational circumstances, but because technical management may cover two levels in a hierarchy (hence the two levels from which several respondents have been sampled). Therefore, in the years an individual may adapt to certain problems in their new responsibilities, only to be faced later by new ones. I examine the individual experiences approximately in the order of the headings above.

Looking first at technical knowledge needed for planning, the technical manager's technical knowledge needs to be different from that of the project leader. On one level he/she needs his/her technical knowledge for quantitatively less of the work in a typical day. I presented basic data on the division of technical and managerial responsibilities figure six (section 5.3). Although figure six shows great variability in line with different organisation structure and hierarchical position, it primarily shows the decline in the technical work of sample members. If the respondents could recall the most important feature of a new post as a technical manager, then the loss of direct technical involvement is what they highlighted. This 39 year old Engineering Group Manager (respondent 12) was fairly typical:

> "I would say that 5% of my work is 'technical' ie. intrinsically technical activity and therefore requires technical knowledge. There's probably about another 40% that is not 'technical' activity but where an absence of technical knowledge would be a distinct handicap". (respondent 12)

Respondent 22 commented simply:

> "I've more confidence in the technical side than the managerial side because I've been doing it for longer." (respondent 22)

But in fact, on another level I found that the quality of technical knowledge was also different. It did not need to be so project specific; instead it needed to be organisation specific, or at the least specific to the (part of) the department for which the technical manager is responsible. The same respondent as above provided the following observation:

> "Now ... to be a manager of technical activity you must always be sufficiently smart that they can't pull the wool over your eyes, you must always have sufficient understanding of the complexity of tasks and where you need particular skills that are rare; ...so you typically need some kind of technical background to do that. ... I think my

> technical background helps me manage the process because I understand the people and where they're coming from. Credibility is incredibly important in technical roles." (respondent 12)

A qualitatively different part of the technical manager's leadership role compared with the technical project leader's role is in formal responsibility for strategic planning on a departmental and project/product idea scale. Most respondents did not spent much time working up project/product ideas into technical feasibility studies anymore, this work being passed down in broken down form to the technical leaders and specialists who had sufficient detailed knowledge. The technical managers are typically responsible for bringing together the ideas again to assess for cost and personnel requirements, and invariably classed this as a managerial task rather than technical:

> "On the managerial side you have to start right at the top with things like budgets. So for next year we have to predict what budget we're going to need, what we're going to spend the money on, how much we need to be allocated. We then have to try to match that against staff numbers and also capabilities." (respondent 9)

Seeing this work as managerial was often a rather reluctant admission on their part, for typically respondents were often involved in delegating to their teams the technical feasibility study on an exciting new development which they would have liked to have found time to do themselves. One Engineering Group Manager (respondent 27), who was fairly satisfied to maintain at least some tenuous technical links with new ideas, assessed how this responsibility fitted in:

> "There's probably three areas actually. There's the nauseating administrative work that goes on, things like overtime, monitoring people's sickness, counselling, that sort of thing. That takes up 15 to 20% of my time at the moment - quite a lot! 30% of my time is spent working on technical problems. The remaining 50% is spent on managerial tasks and generating ideas. Again that draws on technical experience I've had, but it's a managerial type activity. It can be quite satisfying sometimes, because when you're an engineer and you're coming through you see things you think ought to be done better and now someone's giving you the chance!" (respondent 27)

Moreover, the technical manager typically finds him or herself with a responsibility to oversee the entire technical work of a whole department and see that a whole range of details are available to be reported upwards when required. The post invariably means seeing that the organisation philosophy, in larger firms particularly, is adhered to and a strategic plan for project/product development devised and followed. An Engineering Manager (respondent 30) said his input to technical work was, in a word, strategic, which he described in the following way:

> "We cannot allow each individual to go off and do his own thing. We have to have a core "philosophy", if you like, on the way we design things, the way we produce them, the way we do the job. That's really what I mean by strategic. It's mainly setting the framework around which the individuals work and put their own stamp." (respondent 30)

Almost all the technical managers were unwilling to see this side of their work increase any further, even if offered a post with significantly higher extrinsic rewards, because the intrinsic rewards were already diminishing. This led to a thoughtful reappraisal of where their career was going, and whether they had already risen far enough.

Budgets have already been mentioned above, and as a technical manager each respondent had altered their responsibility for budgets compared with their time leading technical projects. The level of control was much higher, with budgets for all aspects of a series of projects, and the necessity to take on or shed labour according to project funds available. Technical Managers often had to trade off budgets of competing projects, a rather different task from the component parts allocated to each project leader.

One respondent (14) - an Electronics Design Manager - had started handling budgets at the broader level four years ago. Neither he or the technical leader of a new project he was very keen to see funded had any training in budget preparation, and he freely admitted that their initial costings were very inaccurate:

> "We just estimated and we didn't have the skill to break down the projects. Now if we have to budget for a project I can break it down into very fine elements, that's a very valuable way. I do that all myself." (respondent 14)

The majority of respondents rely on the judgement of their technical leaders or project team members to supply enough detail for costing proposals or tenders.

Administering the staffing and equipment for projects raised many responses, particularly from individuals' first months or years as a technical manager. Respondent 30 made a comment about the design engineers in his charge and how he had to judge and use their technical skills:

> "If he knows what he's doing, then you can ask him to do it and forget it. Then there's him who's free, he thinks he knows, so give him something to do but for heaven's sake don't leave him on his own for too long!" (respondent 30)

This respondent, coupled with the last quotation from respondent 12 above, identified the two principal technical inputs made by the technical manager to ensure a task is completed to time and cost:

i) knowing the technical complexity and potential problems in a particular piece of work.

ii) knowing what skills are needed and how readily obtainable these are.

As a technical manager takes on these responsibilities for a variety of projects, the variety of technical specialisms they cover is also likely to increase. It can become increasingly difficult to maintain credibility and prevent other engineers, even those in technical leadership positions, from "pulling the wool". There were a couple of different ways in which the respondents coped with that, in a similar fashion to their reaction in the technical leadership stage.

There are of course instances where a technical manager has the best specialised technical input for a particular project under his or her control, and this may disrupt the typical technical/managerial balance for a week or so. I found that the technical input is more confined to certain techniques, such as a knowledge of a programming language, which could be useful in troubleshooting when a project ran into problems because a suitably trained engineer was unavailable. Troubleshooting on projects is typically the last vestige of "bench" technical work that a technical manager is involved with. Respondent 15 related an interesting experience from late 1985. It concerns the period immediately after he had made an inter-organisational career movement which marked a shift from the technical side to the managerial, when he became Senior Engineering Manager. He said:

> "I can remember an afternoon, when... I'd been at [Organisation J] for a couple of months. There was a product which was being developed and it was in some difficulty. I went to the lab with some engineers with [a variety of specific testing and monitoring equipment] and sat there for a couple of days, thinking 'Maybe it's this, maybe it's that, maybe we should try the other'. All sorts of things like that. And then I just said to myself 'This isn't my job, I shouldn't be doing this anymore'. I remember that very well indeed. Other things were piling up because I was at the lab having fun." (respondent 15)

This is the stage at which the "fusion of technical and managerial work" (Causer and Jones, 1990 p11 et seq) can be observed, in the career of an individual as well as in the structure of a department or organisation. So it becomes increasingly difficult to separate out some parts of the individual's work.

Each respondent was asked about their involvement in performance appraisals and job review tasks, as an indicator of their involvement in people-management tasks. Also each was asked about their role in recruitment procedures. These parts of the technical manager's job took up a large amount of time. This is because effectively the technical manager has to keep this burden off the technical leaders of the projects, for example by invariably preparing the majority of annual appraisals. In turn the personnel department in a large organisation should take away some of the staffing burden from the technical manager, but as this Engineering Research Manager related, this job is often quite involved for himself and his fellow manager on the same grade:

> "We have to raise requisition forms for new staff, we have to ensure that the personnel department will push those through and advertise or whatever else they want to do. They get suitable CVs in, we have to make sure that I or one of my staff go through certain CVs, it depends on the seniority level. If they're for junior level then it's up to them, then interviews have to be held, and then you have to make offers to people. The formal offer goes out from the personnel department but obviously the offer in terms of salary level, where they fit in the department, everything else, comes from us. I have guide lines for people's age, and what we're looking for in terms of qualifications, etc." (respondent 9)

As with budget handling, the respondents frequently talked about their experiences of personnel functions in contrast to their enjoyment of technical work. For example respondent 13 commented:

> "I have to be at the stage where I'm happy that whoever is working for me can take on the technical side of the work, the tasks I've been doing up to date. I think there will be more of a shift, but I still have an interest [in technical work] and wouldn't like to lose that entirely. How that sits with [Organisation H] I'm not sure. As far as I'm concerned if I could fulfil all my managerial responsibilities and provide an input to something that is of interest to me as well I would like to do that; its what I enjoy and I wouldn't like to give it up. ...All my managerial skills have come as and when required; some might not really be skills as such. I'll tell you what I'm not so good at and that is the man-management stuff - appraisals, reviews and so on." (respondent 13)

This respondent felt he had not done well on the personnel side and needed to spend more time on it; he had not been on any training for this at all, only courses in software technology and leading projects. For many of the respondents, the personnel side was the most unknown, potentially the most threatening, and also some said they knew it was "supposed to be" potentially the most rewarding too. I detect from the responses of respondents such as 22 that most had little idea how much "juggling" of human resources would be necessary. An Engineering Group Manager (respondent 27) commented:

> "Especially people management is not easy. When you're technically trained, everything conforms to formulae and you know exactly where you're going. And suddenly you're up against people and they don't function in the same way; you can't program them the same!" (respondent 27)

The quotations above give a representative indication from a wealth of data on the experiences of technical managers. This section has been largely descriptive; it has established differences in technical involvement, and the issues which caused most problems such as personnel matters and getting used to budget handling. In the next section I begin to examine how and why the movement to technical management took place.

8.2 Entry into technical management

The process of transition through technical leadership is made up of a series options and choices to be made, which are not always apparent to the individual who goes through them, and which are largely defined by the organisation. Therefore a full appraisal of the direction the career is taking is often not possible in the midst of the transition. Respondent 12 is typical of this:

> "I'm not sure that looking back I can tell you that I thought about [changing from an engineer to a manager]. ...there were new challenges. I don't think it ever occurred to me at that stage that I was transitioning; I was just doing different things, and they were paying me; paying me extremely well and I felt pretty good about it!" (respondent 12)

It is only when the individual was faced with the managerial responsibilities in a new post - which one respondent noted only on seeing "Manager" on his door - that missed opportunities can typically be recalled. But there were a couple of respondents who although they started out well motivated by technical work and technical leadership, saw technical management as a distinct new set of challenges which they must train for and work towards, such as respondent 14.

Typically most respondents did reveal a few regrets about the transition process to technical leadership. One respondent

(11) thought over how he had been carried along into leadership and eventually management:

"I was not consciously building my career, but one was quite happy that one moved in nice circles within a small company. I mean the chairman used to come in regularly and you could get to know the people that mattered. ...One was on first name basis with people who are now chief executives of this company; if one had been career orientated one might have made more of these contacts... I didn't really use them but I was motivated by the fact that they existed. You can't help but be bulled up when you work with people like that." (respondent 11)

The missed opportunities perceived by a few respondents included the chance to take up a technical track in a dual track career structure. None of the respondents had taken up a technical path consciously at any time. But in the back of the mind of those who knew the opportunity existed for them was the knowledge that ultimately they would not achieve the extrinsic rewards that a path into management offered. This is despite the fact that the intrinsic rewards a technical track offered were more attractive. The technical management stage has also been the point of a career change in terms of moving to a different scale organisation for two of the respondents. This Electronics Design Manager (respondent 13) is one, who when a Principal Engineer had become disillusioned with large firm career paths for technical leaders, and began looking "half-heartedly" (his own term) for the best situation he could find as a technical manager:

"I had the opportunity to go and work [as a technical leader] with [his multi-national employer] in New York... I think I was looking for some work of that nature; I was certainly prepared to go. That was blocked,

> it wasn't to be. I think it was my wife who saw the advert for this place (small firm) and really forced me to go along. I was very anti and thought it must be a tin-pot little firm. I just wasn't enthusiastic and to be quite honest I didn't have a great deal of information or knowledge of what (the small firm) manufactured. I wasn't happy with the name of the company, "(name deleted)" just didn't sound right but she forced me to go along. ...The initial interview opened my eyes a bit. I think at the time I was prepared to give anything a try; I couldn't lose. They were offering a good salary and so on. I think perhaps when I did join the company it took me a long time to throw off this sort of cloak that (the multi-national) had drawn around me... something of a big firm mentality." (respondent 13)

So this respondent developed a new career direction, still within the definite constraints of where his technical leadership experience had led him, but in an environment which he found more satisfactory. The typical picture is of engineers "happy to oblige" and fit into a bureaucratic structure, even if the tasks they are asked to do are not the ones they perform or like best. This "happy to oblige" mentality was also noted by Whalley (1986) (see section 3.5)

The "happy to oblige" outlook which seems to characterise engineers' attitude to promotion into management I suggest acts to push them into a type of work which if freer to choose, they would think more carefully about. Indeed as I mentioned in chapter three, factors may be observed "pushing" and "pulling". By "push" factors I mean some aspects of technical work are becoming less attractive, causing an individual to look around at the options schemed on figure two (in section 3.5). "Push" factors may also be the constraints of an organisation hierarchy offering no viable alternative.

By "pull" factors I mean that there are attractions in moving towards a managerial role, however general it may become, rather than moving to the margins of engineering or out of the industry altogether. So for the rest of this section I will examine these factors in turn.

The clearest "push" factor in the career maintenance stage is the erosion of technical knowledge by the process of obsolescence. This is a constraint on career development caused in part, at least, by the failure of organisations to update their engineers. Alternatively it could be seen as an inability of the individual to take updating initiatives. An onset of obsolescence in an individual's technical specialism and/or leadership responsibilities could lead to a particular desire to take up a technical management post. The attraction of technical management could be seen as a narrow specific field with which the engineer would have to keep up to date.

However I argue that obsolescence is a factor in why engineers become managers and it works exclusively as a "push" factor. For as I showed in section 8.1, the technical manager has to take a step back from the technical work and yet have an even broader base of general technical knowledge with which to manage complex project schedules and skill requirements. Then there is the strategic function, planning technical work at quite an abstract level in terms of general direction and goals. None of these things come easily to the typical design engineer. So in the same way as I do not see technical leadership as a haven for the design engineer overtaken by obsolescence, I do not find technical management as a haven for the leader who has lost or is losing his or her technical "edge" on the new projects they have to supervise. Engineers who have lost that "edge" move out into the margins of the industry, not into the front line as technical managers.

Instead I argue that the obsolescence process works in a different way. Data from the sample suggests that obsolescence works in the way discovered by this Technical Director (respondent 8), who finds himself a manager because he has *moved* away from his original detailed specialism; ie. he has, crudely, lost it by moving with the technology as he moved up, rather than somehow *forgetting*. When asked how he considered himself now, he replied he is probably a manager rather than an engineer. In response to the vignette interview question, he thought he could probably market himself as an engineering manager although his work is currently (by his own estimation) 98% managerial with absolutely minimal design type technical work. Respondent 8's original background had been in traditional, now largely obsolete, naval architecture, but later developed into mechanical and electronic engineering while in a leadership function. Earlier in an interview he had stressed the great importance of his more recent technical background in the leadership function which remained, but said:

"I don't believe I could now go out and market myself effectively as an engineer, to undertake purely a design or engineering function. I could probably do that still if I went right back to basic naval architecture. But my detailed skills are not high enough to do that, I don't think, in mechanical engineering. Certainly not in electronics." (respondent 8)

An Engineering Group Manager (respondent 12) suggested how it might be possible to cope without an engineering background if such a post as a consultant was possible:

"I would say more than half my job does not require any technical knowledge or background at all. I could have come into this from a totally different discipline. There's certainly the 5% that is an absolutely technical role and so if I wasn't able to do that I could get somebody else to help me. It would perhaps reduce the quality of my job somewhat, but I would get a consultant in to do that very heavy technical part." (respondent 12)

These quotes exemplify the obsolescence factor, which also prevents most engineers from becoming successful on a technical career track moving up to the technical consultancy role which the last respondent mentioned. There were a few examples heard about but not interviewed who had operated as software consultants, at least for a time, but in general the industry does not make room for many technical consultants because the technology does not allow engineers to keep sufficient pace with its developments to become consultants.

The obsolescence "push" factor is not alleviated by the technical manager's combination of broadening, shallowing technical responsibilities coupled with a decreasing amount of work time to be involved with technical tasks, even in the specialism in which the individual has most interest or experience. Some respondents commented that they did not now have so much time to spend alongside or around the other engineers who were involved in "hands-on" tasks, even socially. I found that the journals and conferences or colloquia with which the engineer or technical leader had previously kept technically up to date had changed in type. Time acts as the major constraint on updating, as this Technical Director (respondent 8) observed:

> "I necessarily rely on the guys working for me to maintain themselves adequately up to date. Yes, and I think that is probably about it. ...I occasionally skim journals. But I mean the journals I do spend more time on are the ones of a marketing interest; the mags that are actually telling you what is going on in the industry rather than the technical journals." (respondent 8)

Having identified the "push" factors of organisation structure and obsolescence directing an individual away from technical work, I now look at the "pull" factors.

The most obvious attraction to potential entrants to technical management is the typically higher level of extrinsic reward. The motivation behind this may be fuelled by the family commitments which all but two of the respondents had taken on board. For example respondent 30 came back from the USA to work as an Engineering Manager because of his family, specifically their education, which he thought would be too poor quality and unaffordable in the USA.

Hierarchically this move back across the Atlantic was not a promotion, the only career benefit as he saw it was that the post was in a larger organisation (G). There may also be social considerations in taking up a "management" post rather than a technical one which is likely to be misunderstood by an individual's social contacts, particularly when the low status of engineering as a whole is remembered; but although the low status of being an engineer was mentioned by the majority of respondents, this link was not specifically made.

Despite the problems encountered by engineers new to managerial tasks, there were some attractions to the nature of managerial work itself which appealed to a few respondents. It is not difficult to establish a causal link on work content alone, and the data indicates to me that the attraction of managerial work was occasionally a substitute for technical competence under stress from the obsolescence process.

Whatever the underlying motivation, managerial work was not seen as a soft option in any way. Some respondents had poor experiences on first taking up a technical management post, as have already been related above. These stemmed from two sources. Some performed unsatisfactorily when handling personnel issues, such as respondent 12's experience related in section 8.1, or two respondents who had to handle difficult project team members and contemplate sacking them. Others found the administrative burden too great, such as respondents

10 and 27, or difficult such as respondent 13. The easier source to explore at interview was the first of these, in which the first responsibility had included a difficult task thrust on the respondent by the organisation; for example the respondent (1) who took charge of a research plant and then very shortly afterwards had to set about moving it to a new location.

An attraction emerged in the opportunity to work less erratically as a technical manager. For in moving out of technical leadership the cyclical nature of intensive work, late in the workplace or at home, related to project deadlines, may be broken and smoothed out. However, managerial responsibility has its own costs in this way which respondent 20 summed up:

> "I'd be quite happy to take a different role eventually because I can't see me doing this job forever. It is the *worst* job in many ways. It is. It is the worst job because you 'get it' from both sides really." (respondent 20 - his emphasis)

In respondent 20's motivation to move into management was the "happy to oblige" idea, and that he was taking his turn as a manager before going on to do something else, as yet unknown.

Other attractions of managerial work as perceived by the respondents mainly centred around higher level decision making and being able to do things in a way they had wanted to try when they worked in design; this was mentioned in section 8.1. A similar attraction was being able to build up the reputation of a research, design or development group or department, in terms of technical quality and performance to time/cost. Respondent 15, a Hardware Development Manager, had an interesting and successful experience of trying to restore the reputation of his new group just after a disaster in which a project supposedly one month from completion was suddenly found to have slipped two years. As well as the challenge of coping with that particular problem, respondent 15 had to turn around the low morale and reputation:

> "On a monthly basis I turn out a very comprehensive report of everything we're doing at Reading and I give that to a whole bunch of people including the vice presidents. There's still this feeling that 'Reading is bad, Reading screwed up, we won't trust Reading', but they know now that 'if [he] gets into trouble, at least we'll hear about it'." (respondent 15)

Respondent 15 was very pleased with this achievement which he had tackled in a systematic way and was the sort of task which would appeal to most of the engineers who didn't mind report writing. I propose that the "pull", or appeal, of this sort of work to an engineer is in the crusading attitude with which it can be effectively tackled. It is not just the repetitive administrative and staffing work which engineers dislike so much. Managerial work which can be tackled with the intensity of a technical project, like the software engineers being shut in a room to get on with it, can act as a "pull" factor. For example respondents 14 and 15 both identified the attractions of seeing a project through as a technical manager rather than just as a technical specialist, as part of a team. There are elements in a few (certainly less than 20%) of the sample members which reflected a willingness or acceptance to face new challenges, whether they were technical, or leadership, or administrative, or managerial, or whatever.

To conclude discussion of the push and pull factors, it is clear that in individual cases a certain motivation can be detected, and I have given details of a few cases. I suggest that what underpins the transition to technical management is the "happy to oblige" notion. As Whalley (1986) has proposed, engineers are part of the service class, enjoying their status as "trusted" workers. I perceive this as particularly relevant at the technical managerial level because the individual is expected to develop not only a willingness to work unsupervised, but also an initiative to train him or herself for whatever new challenges are met. Engineers expect autonomy and independence to a certain extent, and seem to know that they are trusted to get on with the job in hand; they appreciate the workplace freedom and variety this brings. Consequently, when a new post is offered informally as is often the case, then the individual seems to perceive taking it as part of his or her trusted status. This "happy to oblige" mentality is not quite the same as "what engineers do". This is because while many engineers will go along with the push and pull factors and move into management, this does not necessarily mean they perceive that path as an integral part of the engineering profession, or one which gives them much job satisfaction. There is an ambivalent attitude in the words of respondent 12, who said:

> "I think later I got to the stage where I said, 'Oh, I've become a manager, did I want this?' but it never really bothered me." (respondent 12)

This "happy to oblige" mechanism worked well during the transition process to technical leadership, when job changes were small and gradual, even imperceptible. But I observe the "happy to oblige" mentality breaking down with the onset of managerial tasks as the respondents more fully realised where their career trajectory lay. This is particularly because jumps in responsibility could be more marked and sudden. And typically the respondents did not anticipate these changes or consciously develop their own careers in this way very readily by asking for, or expecting, any formal management training for their new responsibilities. In the next section I examine the individual identities each respondent has in their role as a technical manager.

8.3 Self identity as a technical manager

In this section the technical managers gave their view of their own identity. All the respondents gave some answer to an identically phrased question: "We have looked at your career as an engineer, but now, would you think of yourself as an engineer, or a manager?". To this:

13 respondents (43% of sample) said they are still engineers
9 respondents (30% of the sample) said they are now managers
8 respondents (27% of the sample) said they are a combination, an engineering manager. Those who identified with engineering typically recognised that this did not actually fit well with their current division of responsibilities. For example, respondent 4, who estimated he has only 10% technical involvement, summed this up clearly:

> "I don't know. I think both. I think I would have said very much an engineer, but I am trying to be objective about this. I think I've got man-management, personnel and leadership skills ... and I think that it's not unreasonable that I should be a manager. Having said that I still feel I am an engineer. So, a terrible hybrid. I wouldn't like to say what I was. Quite frankly, lets say that the organisation I work in was destroyed overnight, I would find it rather difficult to choose whether I went into an engineering job or a management job. In so many senses I'd probably be happier in the engineering job." (respondent 4)

Two respondents (28 and 32) said they thought of themselves as engineers, even though they are clearly managers by function. This, they said, is because management is inevitably a part of engineering careers, and they therefore were prepared to hold on to the career or professional identity they started out on. Others, such as this respondent, thought that although in technical management at the present, a choice was imminent between going on into management or somehow reverting to a technical track:

> "Well there lies the decision I've got to make, doesn't it? I still regard myself primarily as an engineer, no doubt. But the decision is whether I want to change that over. ...I'd have to decide I wanted to be a manager before I went and joined some [management institution] ...I've picked up one or two things: one was called "The Manager's Handbook". What was the other one? About being an entrepreneur, I think. ...You can't really run people their way ...not people of this level anyway; they'll tell you where to stick it! (laughs) I need to decide which way to go. If I stay on the technical side I'd need to go to the USA with this company, or change companies. I just couldn't develop it here. We're too far away from the centre for that. On the managerial side, certainly in the next five years I'd like to go and join another group, an entirely different one. In another company or in [Organisation J], it doesn't matter much. But it could be in the UK, or Europe. If I chose management I would have to find managerial challenges." (respondent 22)

Other respondents recognised the balance between the sides of their role as a technical manager of which respondent 6 is typical:

> "I think a manager. Interesting question though. I would probably cop out and say half and half, actually. I think it would be hard to say that I am more of a manager than an engineer. I still do have quite an involvement in the engineering side which I enjoy. I think by the nature of the company, as quite a small company, it has had a very active development programme and is very much a technically led company. You've got to be; you've got to maintain close involvement in the electronics side. You just can't put that all to one side." (respondent 6)

Then again, there were a couple of engineers in Organisation C – respondents 19 and 20 – who had managed to delegate so much of their administrative load and a bit of human resources management down a stage to various team leaders, or upwards or sideways, that they had the majority of every day to devote to working back as a technical leader again. These two both regard themselves as technical engineers, and appeared more like engineers than any other respondent. They had achieved this division of their time by their own efforts. Respondent 20 said:

> "I'm still a technical engineer really. I think that though my management skills are fine for [Organisation C], I don't kid myself that I've got any great management or even man-management skills necessarily. I think I handle these types of guys very well, but they're a particular type of person, you know." (respondent 20)

Of the technical managers who now identified themselves primarily as managers, the data revealed something of an identity crisis through a combination of not exploring managerial training or professional institution membership, and still applying engineering solutions to human resources problems, as alluded to in the anecdote at the end of the last section. Respondent 15 emphasised that to succeed at all as a technical manager the allegiance to engineering had to still be there to be able to understand the issues and problems. He expanded on this:

> "I think that to be a successful engineering manager one has got to have a feel, and empathy with what it takes. You know, those emotions that we talked about in the Tracy Kidder book, what it feels like to say "Oh shit, this doesn't work right", the getting on with a machine, the drive and energy to achieve something. I think that unless one has experienced that and unless one understands the psychology of that, one is not going to be a successful engineering manager. A guy with an MBA who knows all the right questions to ask and how to optimally organise projects,

> won't be successful unless he has empathy with the engineers. That quality or attribute or whatever you want to call it is something that you can't learn. So, I don't want to lose that. I don't want to be an 'MBA'." (respondent 15)

This brings on an obvious problem, which is that as a professional engineer, respondent 15 is saying that it is best to be managed by professional engineers who have moved into management; but it seems that few of them want to.

In general in this section it is difficult to draw any correlation between identity and current responsibility, or between identity and past or future career paths. It was a very personal thing, clearly linked with individuals' perception of "what engineers do". A better indicator of how they respondents felt about their career changes could be found in career orientation data, in the next section.

8.4 Career orientations as a technical manager

I suggest the most important key to understanding the data presented in this chapter is the professional group to which the individual feels they belong, and whether as a result they are:

i) maintaining their initial career orientation.

ii) maintaining social and working contact with their technical colleagues;

The underlying career orientation of most of the respondents remained in some way technical. Most aspired to continue the technical creativity aspect of their work for as long as possible, or to pursue it outside the workplace. Respondent 28, now an Engineering Group Manager, said:

> "I like anything of a mechanical nature - motorbikes, go-carts, I used to help my dad on the cars; any electrical stuff - lights, horns, anything I could get my hands on. I'm still interested, very, but it's the lack of time now. Now that I've got the money to buy a few things I've no time to play with them! Now, with my son, we mess about with things; I'm not sure who gets most out of it, but I do like that." (respondent 28)

The pastime interest engenders an ongoing orientation which is not easily changed, serving to break down the barriers between work and leisure. Several engineers commented that their working environment gave them continuous chance to experiment with the latest components and equipment, to acquire equipment at very reasonable cost and even the opportunity to design new commercially viable products in their spare time. One respondent went so far as to wonder how anyone could be so lucky as to be well paid for playing with exciting toys like these all day, every day!

Experimentation work only loosely connected with the employer or squeezed out by pressure of managerial tasks, usually took place at home rather than by staying late in the workplace. One Software Engineering Manager, while having only limited musical talent, has produced several prototype electronic instruments in his home workshop such that he had the nucleus of his own business if he wanted to exploit it. Those respondents whose role as a technical manager has taken them largely out of contact with "on-the-bench" technical developments, or whose original expertise has been made obsolete by the passage of time, keep their practical interest satisfied too. The entrepreneurial respondent I mentioned above qualified as a Massey Fergusson combine harvester mechanic and continues to use that expertise in the restoration of a vintage sports car. Particularly the latter I see as another outworking of practical creativity.

It is in professional identity that the real allegiance of the technical managers is revealed. To recall the work of Child et al (1983), he indicates that technical managers are moving from one professional group to another. This is something the respondents recognised in their career path, or their future aspirations. A set of questions used in the interviews yielded data on professional institution membership, as well as implicit allegiance to the engineering or managerial side of their work in their own perception. Respondents were keen to talk about a range of topics on the subject of their allegiance to engineering and their professional identity. I noticed that the respondents often wanted to talk about the status of engineers in society which I have alluded to as a "push" factor in section 8.2. This discussion typically centred on public image of "dirty work", perceived skill shortages, and how these might be directly overcome to ensure the future of "Engineering UK Ltd." (as it was described on several occasions). There was little suggestion of any collective action to raise the "standard" of the professional engineer, only action by the organisational framework in which they work. And indeed the organisational framework was mentioned in terms of a bureaucratic system constraining career development to certain paths.

Public image was recognised as complicated by the fact that "engineer" is not a reserved professional title, but the issue was always discussed in terms of misunderstanding by the public rather than anything which engineers could solve by any stronger collective identity. It soon became clear my questions probing engineers' identity therefore had to avoid terms such as "professional" as far as possible. To gather relevant data they had to centre upon perceptions of why the initial occupational choice of engineering had been made; current identity; and by unpacking the role of the institutions and how far the respondents identified with values and practices which the IEE, for example, appeared to represent on their behalf.

Professional institution membership in the sample covered ten different institutions. There were three basic reasons why people joined:

i) because the institution was related to their original higher education subject, and they had felt obliged to join in the hope it might be useful;

ii) to receive the technical journals published by those institutions, and/or to attend their meetings, to keep technically up to date;

iii) to meet socially with other engineers with similar background and interests; and informal network which gave access to some job opportunities.

The fellowship and membership of these institutions breaks down as follows (five respondents were in two institutions):

Institute of Electronic Engineers: 7 full members, 2 associates
Institute of Mechanical Engineering: 3 full members
British Computer Society: 3 full members
Institute of Electrical and Electronic Engineers (USA): 2 full members
Royal Institute of Naval Architects: 2 full members
Royal Aeronautical Society: 1 full member, 1 associate
Royal Television Society: 1 full member
Royal Institute of Chemistry: 1 full member
Chemical Society: 1 fellow
Electronics Defence Association: 1 full member

Ten respondents do not belong to any institution. The majority of respondents have a low opinion of the relevance of the activities of the IEE, whether they belong to it or not; two respondents have joined the IEEE in the USA as a more up-to-date alternative. Nine respondents hold chartered status, one (21), however, being a chartered chemist rather than engineer, a position which reflects his particular route into electronic engineering through materials work. Respondent 17, as well as being chartered, has gained the new European EURING status.

Although the engineering institutions were not particularly attractive in their activities to all but the two respondents who had participated to any great extent in office holding or attending meetings, they represent an allegiance to engineering as a whole. The respondents who commented at any length found the journals interesting but not particularly useful, and would generally not go to meetings even though they seemed to think it was quite important to be a member. Part of this allegiance is connected to chartered status, which demonstrates loyalty to the professional practices of engineering in terms of quality of work.

The engineering institutions in general were not held in very high esteem, but typically any management institutions mentioned were regarded more unfavourably. Those who mentioned institutions such as the British Institute of Managers said that they would have nothing in common with most of the other members. The breadth of the membership would be so great that a smaller proportion of BIM activities would be of interest than was already the case with, say, the Institute of Electrical Engineers or the British Computer Society. Either that or the level at which the BIM deals was seen as totally unsuitable for a technical manager; for example:

> "I've read some of their stuff and put it in the waste paper bin! The level they are aimed at is so trivial, it's the wrong sort of level. I've been on courses at the Business School at Cranfield and things like that. The level we have gone to has been far ahead of what they talk about. I'd find myself wasting time. ...You might think I am disinterested when I say that. I don't mean I am disinterested. The level at which they deal is not the level at which I would wish to deal. It's too trivialised. It's like me picking up a book on a stall on amateur radio of that sort of thing. I mean I only flick through "Electronics Weekly" to pick up on odd bits; all the rest of it goes in the bin." (Respondent 9)

Importantly none of the respondents have joined institutions for managers, even when they considered that they are now a manager than an engineer, and despite the fact that few had received managerial training of much relevance to their new daily responsibilities. There are two possible reasons for this. Either the individuals regard engineering management as a part of the remit of these engineering organisations, but none of them said this. Or alternatively they regard management skills and responsibilities as somehow separate from technical ones, and that management is a professional sphere they are not part of. I conclude that the latter explanation is more likely, but this is open to other interpretation. I find it rather surprising that from a sample comprising so many enthusiastic members of one distinct professional group, two thirds of whom belong to at least one professional institution and one third who have gained professional recognition through chartering; that none have made attempts to join a new professional institution which better reflects their current division of work rather than a past one. While it cannot be expected that each technical manager should automatically join the British Institute of Management, they would at least be expected to talk about this as an issue. I believe overall this data reflects a deep orientation to technical aspects of engineering and achieving professional excellence in those, however many managerial responsibilities have been taken on.

But two respondents had gone on in recent years to work for an MBA qualification. One of these was respondent 14 who was in my estimation the keenest on getting on in management and as such stands apart from the remainder of the sample. Respondent 12 felt more ambivalent about the time commitment the MBA entailed and where it might lead him in his career. He certainly had not relished his first step into what he called "business management" which he first took on when he became an

Engineering Group Manager, because straightaway he had to make fifty employees redundant. He said:

> "I never looked forward; I just regarded life as a set of challenges and you just keep facing new ones as they come along... I can remember climbing, and that at each stage the only reason I would want to consider doing that was because I could do a better job than the person above, not because I wanted it. There was no sense of chasing it because it was status or I was going somewhere else afterwards. It was simply that I could do a better job than that person: 'so move out of the way while I show you how!'. Very precocious no doubt, but that was the way I was! I think much later on I got to the stage of saying 'I think I've become a manager, did I want this?'." (respondent 12)

Therefore I perceive his MBA studies as more of a qualification for coping with that sort of situation, or simply a challenge rather than a look to the future.

8.5 Summary

In this chapter I have presented data on the experience of a technical manager and how an individual rises to such a post through technical leadership roles. Primarily I have focussed on the orientation of the technical manager, most successfully by the professional group to which the individual feels they belong, and their ability to:

i) maintain their initial technical creative career orientation.

ii) maintain social and working contact with their technical colleagues;

Clearly on the first point alone, by moving into technical management an individual can be seen to be moving away from, almost denying the technically based career perceived and aspired to in the career growth and exploration stages. Few respondents thought that management is an integral part of professional engineering. Few technical managers could strictly call themselves engineers any longer, even though they are of course doing what many engineers are pulled or pushed into.

Not all the technical managers did think of themselves as engineers any longer, and a few of these liked the fact that they were now managers. Of the latter, some were prepared to stay in a technical management role as long as the managerial and administrative functions in each day did not expand. Fewer of them were contented to see their career develop wherever the organisation might need them, even if that meant exclusively managerial tasks. The latter group were characterised by their greater awareness of where their career might be leading during the transition process of the technical leadership stage. They were more contented to maintain their career in a managerial position because they were prepared for what was coming and their career choices had been made more consciously. This is not to say that the one way to make a better manager out of an engineer is to tell him or her that managerial work is where ambition will inevitably take them. What it may point to, however, is that a greater acceptance might be observed in those managers who had the managerial competence to do the job if they knew it was coming.

Chapter 9 - Conclusion

In this chapter I briefly retrace the method used in the thesis, and comment upon the findings presented in the analytical chapters. I also identify areas in which further research may complement or advance the questions identified here.

9.1 Method and findings

I have carried out a qualitative study examining the careers of thirty technical managers in high technology industries. While the results may not necessarily be generalisable to other sectors of the industry, or to other professional careers, there have been three stages with important findings in each.

First I found boys making a choice in the growth stage of their career, relatively early, about the sort of thing they wanted to do. Making a choice which was generally quite informed, and overcoming a lack of information from school or home. I found boys making an enthusiastic choice based on their practical creativity and pastime interests. Typically making a committed choice which orientated them to a career in design engineering. Whether "bright working class" or "practical middle class" I propose that the boys were making a choice which was often not the one expected of them for various reasons. Then at the start of the exploration stage I found two typologies of students taking qualifications for an engineering career, by academic and applied routes which respectively allowed them more or less choice of their first employer and technical specialism. I found some engineers experimenting with their careers and finding a suitable size organisation in which a future career could be enjoyed.

Secondly, I found some of those design engineers going through a stage of career establishment, in which their technical work was undergoing a gradual change. Through a transition process I found engineers with leadership responsibilities, but who were still operating within a technically orientated framework. Technical leadership was identified as a distinct type of technical work. I found engineers who often did not realise at the time how much their work was changing, or where the process might lead them, as their social commitments increased and their relevant technical knowledge was steadily eroded.

Thirdly, I found a group of engineers who have shown the ability to take on technical leadership and advance their careers in that direction, but who find themselves squeezed three ways. These ways are between the social and organisational expectations to move up into management, the personal orientation to technical design work which tempts them to stay where they are, and the process of obsolescence which does not enable them to stay where they are for very long. They were attempting to maintain their careers, finding work as technical managers, but increasingly constrained by technical obsolescence and the structure of the organisation in which they work. A few of the technical managers enjoyed the managerial side of their work, but I found more of these individuals frustrated at their inability to escape the constraints and expectations which surround them. I found people with many rewards but very few choices, contemplating leaving engineering altogether, by becoming a general manager with their existing employer or another. I found some who wanted to return to the design level of work or who still kept in touch with it in some way. And I found a greater number who regretted that the work they were now doing was not closely related to the engineering they knew at the start of their careers.

On balancing the factors identified in the preceding analytical chapters I conclude that engineers become technical managers more because they are "pushed" into it rather than "pulled". I found virtually no evidence that the engineer's orientation had changed over the course of the exploration and maintenance stages towards a managerial competence. Nor had the enthusiasm for technical matters gone, even if obsolescence was a source of concern. What had developed in some engineers, however, was a perceptible increase in desire for security (a "pull" factor). This was typically in extrinsic reward terms, and employment in mainstream engineering rather than the margins, to the end of their career maintenance stage. Two respondents justified this new existence with new qualifications, and others regarded becoming a manager with almost fatalistic indifference. But for the majority of the sample, technical management was not as much "fun" as more technical involvement in engineering work, even though it was where they found some challenges. And for the majority, the logical next step up to become a director to a post with less technical involvement still, was not where they wanted to be.

9.2 Need for further research

There have been limitations in the method of this research which makes it very reliant on recollections of career events, often many years in the past. Clearly there are advantages in a longitudinal study of a larger sample of professional employees in organisations, not just engineers, to discover whether the operation of career choices and constraints are similar to those found here.

More specifically to this research, there are three areas which stand out for further investigation. The first concerns technical leadership, which demands an deeper exploration both in other sectors of engineering and among individuals who are actually in technical leadership posts. Secondly, the nature of career orientations needs a more thorough and systematic investigation than I have been able to attempt here, perhaps by using large scale questionnaire responses.

Last, and perhaps most important, the process of job change in high technology organisations seems to be such that an engineer seems unable to remain in a technical leadership role for very long due to the encroachment of technical obsolescence. Therefore there is little opportunity of maintaining the career at that level for the rest of the individual's working life, even though this is the stage of the career Super and Jordaan (1973) modelled as characterised by at least a desire to maintain the existing level of responsibilities and rewards achieved. So the engineer is constrained by being unable to stand still. And yet the "way ahead" contains the serious constraint of essentially losing contact with technical work, and taking on a role at a desk all day. This requires further analysis to understand whether this part of the career stage model can be applied to professional careers in organisations.

Notes on the Text

Chapter 1:

1a: New Technology Research Group was established at the University of Southampton to combine the expertise of social scientists and engineers to investigate the introduction of new technologies in work organisations. The Group was founded in 1979 by Dr. R. W. King and Professor R. C. Smith of the Department of Electronics; and Dr. J. W. Clark and Professor J. H. Smith of the Department of Sociology and Social Administration. Initial funding was provided by the Joint SERC/SSRC Committee. Recent work has studied technical labour in new technology industries. Further details and objectives of the New Technology Research Group can be found in the Group's Annual Reports.

1b: The research has been funded for three years by a research studentship from Science and Engineering Research Council.

1c: Any discussion or analysis of the technical labour force covers a very limited social group in terms of race and gender; even more limited than in class. Gerstl and Hutton (1966) noted in their social study of different branches of engineering that as a whole it was almost exclusively dominated by white males. Not much has changed in the intervening 25 years. Fortunately it has proved possible to find engineers from more diverse ethnic backgrounds for my sample but racial issues are not emphasised here. A separate study would be required. Equally regrettably it has not proved possible to tackle gender based career issues, but these will be addressed by a current NTRG research project. I have used gender neutral language wherever possible, the notable exception being the typology of "BWC/PMC boys" in chapter six, because all the sample are male.

Chapter 3:

3a: Function is the most useful and rigorous definition to be used here because, as mentioned above, it can be assessed at a point in time. However, in the context of this thesis, I note that in fact a precise definition of who is an engineer and who isn't is not particularly important for the following reason. The focus is on a relatively high functional level, of technical managers, who are already in the career *establishment* and *maintenance* stages after they have had to climb through at least three distinct steps on an organisation hierarchy. While not all the holders of a technical management position will possess degrees, all are likely to possess at least an HNC or HND qualification even if their most recent was obtained later in life than is typical. The holders of a technical management position certainly cannot be confused with technicians.

3b: Allen & Katz' orientation terms represent an individual's wish to remain in or move into one of the three orientations. Importantly, project orientation refers to a wish to work on a series of challenging projects irrespective of whether this would involve a promotion upwards. Allen & Katz found that the different career preferences were significantly related to age and various job and individual characteristics.

3c: This stage is referred to later as the "technical leadership" function because although some supervision of other engineers or technicians may be involved, the criteria by which recognition and success at this level is achieved seem to be typically just technical criteria. The definition is supported and expanded by data in chapter seven.

Chapter 4:

4a: In many cases, product specific parts of an organisation are hived off under separate control when they reach an arbitrary figure of, say, 200 employees anyway. No problem was found with making this distinction except within a large research and development site which conducted almost all UK research for a large electronics hardware and software manufacturer, plus some outside contracts, where each division on the site constituted a large department within the frame listed above. In this case the respondents were all drawn from within the Electronic Warfare and Avionics division only, and this was treated as the "organisation".

4b: The total of thirty interviews was an original approximate target figure. Two further interviews (nos 7 and 18) were conducted but sampling criteria had not been met in terms of the respondents turning out to be too high or too low on their organisation hierarchy. These latter two interviews were therefore discounted and new respondents substituted from the same organisations. Additionally data was collected in questionnaire or CV form from other potential respondents who were unable to be interviewed.

4c: As a general point, in analysing the careers of individuals who had in most cases moved through a range of organisations already in their career experience, I consider it relatively unimportant to establish *exactly* what type of organisation they were in at the time of interview, as a selection criterion. Details such as the number of company employees on site, its profit-centre status or magnitude of the owning organisation were largely irrelevant as long as the appropriate sort of high-tech activity was to be found at departmental and individual level.

4d: No respondents seemed to have much difficulty in recalling the necessary details; I did not consider a cross-check with organisation records or other documentary research was necessary and in any case a request for such information may have prevented access in several instances.

4e: These terms used by the engineers, such as organisation nicknames, were often of local origin. They were supplemented by others selectively gathered from case study literature on British and American hardware and software organisations, (eg. Whalley, 1986; Kidder, 1981 respectively) which were found to be still current.

4f: The technique was used briefly, for example when, having looked at the respondent's career as an engineer, he was asked whether he now considered himself an engineer or a manager. It was situation specific in the way that Finch (1987) suggests, but not quite the hypothetical framework she constructs in that it asks the respondent what *he* would do in the given situation. The suggestion was made that if the respondent's organisation were to be somehow destroyed overnight, how would he present himself in the labour market; emphasising either technical or managerial skills. The responses gave a better indication of how relevant his technical background remained, and with which side he most clearly identified.

Chapter 5:

5a: Ages of the respondents used here relate to 1990 when the fieldwork was conducted.

5b: The phrase "bogs and bicycle sheds" was a derogatory one used independently by three respondents (1, 4 and 19) to mean the man-management side of their work dealing with apparently trivial matters concerning working hours and conditions; a job which they perceived someone had to do.

5c: Marginal career opportunities, such as sales functions, or as respondent 5 put it "being a support person at the end of a telephone... not doing any new work" become more important later on if an individual does not want to move into general management. This issue is explored in chapter 8.

Chapter 6:

6a: Goldthorpe's (1982) Sevenfold Class Scheme as presented by Drudy (1991) identifies the following classes:

Class I - Higher grade professionals, self employed or salaried, higher grade administrators in central and local government, in public and private enterprises, managers in large industrial establishments, large proprietors;

Class II - Lower grade professionals and higher grade technicians, lower grade administrators and officials; managers in small businesses and industrial establishments and in services; supervisors of non-manual employees;

Class III - Routine non-manual, largely clerical, employees in administration or commerce; sales personnel and other rank and file employees in service;

Class IV - Small proprietors, including farmers and small holders; self employed artisans, all other "own account" workers apart from professionals;

Class V - Lower grade of technicians whose work is to some extent of manual category; supervisors of manual workers;

Class VI - Skilled manual wage workers in all branches of industry;

Class VII - All manual wage workers in industry in semi and unskilled grades and agricultural workers.

The groupings adopted by Drudy (1991) allow breakdown of the sample as follows:

"Service" class I & II: 43% of sample (13 respondents)
"Intermediate" class III-V: 27% of sample (8 respondents)
"Working" class VI & VII: 30% of sample (9 respondents)

6b: The respondents' school leaving covers the period 1960 to 1980 in which time there have been widespread changes in the school system which would cloud any indication of an improvement in careers advice, even if the data in this study was comprehensive enough to show it.

6c: A couple of respondents, notably 29 who described the careers advice he received as "abysmal", have taken an active role in careers advice in schools to better inform current pupils, either on the basis of an annual talk or, in 29's case, joining the board of governors with this as a specific aim.

Chapter 7:

7a: Many of the technical managers interviewed identified with what the term "technical leadership" meant, and it can be used as a concept which fits well with leadership literature. The term "technical overview" was also used by some respondents but is not very specific as it does not have the connotation of planning the technical work. The use of the term technical leadership is not intended to only refer to certain post holders with titles such as "project leader" or "team leader" on project teams. As I have defined it, the term is intended to be one which engineers understand alongside other frequently heard phrases such as "at the bench" or "down to the nitty-gritty" which describe other elements of technical work.

7b: "Fireman" was a term encountered in three interview conversations, which meant an engineer who was moved rapidly between projects, bringing in certain technical expertise, or at least an extra pair of hands, when and where needed. It had certain positive connotations of being useful and ambitious.

7c: Although many technical leaders were offered substantially increased reward packages, this was not universal. The shifting nature of some project team structures, and the poor recognition by some firms of the extra effort they required of those leading projects, led to some engineers being relatively under-rewarded vis-a-vis their team members. On reaching Technical Manager level a more consistent reward package was typically offered including perks such as a car.

Appendix 1

New Technology Research Group

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Fax: (0703) 593939
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Ext. 3564

Technical Management Research Project - Mark Smith

1. Research Objectives

This research concerns the work of technical managers, the skills they use and the processes by which these are acquired. It is intended to focus on individual technical managers and their careers, examining:

i) current responsibilities for technical and non-technical work;
ii) educational background;
iii) experience of changes in responsibilities during the career;
iv) the use of technical and managerial skills;
v) how these skills are acquired and updated.

2. Methodology

The study will include approximately thirty respondents who are engaged in technical management roles. The companies from which these respondents will be drawn will be of varied size and structure, selected from electronics and electronics related firms in central southern England. Each respondent will be asked to send a copy of their CV, or alternatively to complete a brief questionnaire. An interview will then be arranged. This will last up to ninety minutes and comprise questions on the main issues outlined above.

3. Use of the research

The information collected will be used in the preparation of a thesis for a higher degree, a summary of the findings of which will be sent to all participants. Papers or reports for academic conferences and journals may also be prepared on specific issues raised.

4. Confidentiality

All the information gathered during the research will be treated in strict confidence. The anonymity of each individual and each company taking part will be preserved in any research reports.

If you require further information on the project please do not hesitate to get in touch with either Mr Mark Smith (ext 3564) or Mr Gordon Causer (ext 2571).

Appendix 2

New Technology Research Group

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Technical Management Research Project - Mark Smith

EDUCATION & CAREER HISTORY

Your name:................................Date of birth:.../.../19...

Organisation:............................Contact tel:...............

Your current job title:...

Section A. Education and Training:

1. *Please summarise your education on the table below. Please include schools attended since age 11 and any college or educational establishment after leaving school, either as a part-time or full time student, including any degree courses.*

	Dates attended	Name of Institution	Course studied	FT/ PT	Qualifications gained and any subject specialisation
1					
2					
3					
4					
5					
6					
7					

Section B. Career: 2

1. *In order to provide information on the way in which you have moved from one job to another in the course of your career, please complete the table below as fully as you can, stating dates including month wherever possible. Please include all positions held since completing full-time education, including any periods in the services, listing each change of position/title within the same organisation as a separate entry, but exclude any part-time or vacation jobs. The list should conclude with your present post.*

	Period of employment	Name of Employer	Location of Employer	Job title & brief summary of responsibilities
1				
2				
3				
4				
5				
6				
7				
8				
9				

Please continue on page three if necessary

	Period of employment	Name of Employer	Location of Employer	Job title & brief summary of responsibilities
10				
11				
12				
13				
14				
15				

2. Are you a member of any professional institutions? If so please state which and the length of time you have been a member:

....

....

Thank-you for taking time to complete this questionaire.

Please return it to me in the stamped addressed envelope provided.

Mark Smith
New Technology Research Group
University of Southampton
Highfield
Southampton SO9 5NH

Appendix 3

New Technology Research Group

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Technical Management Research Project

[QUESTION. T25]

INTERVIEW QUESTION OUTLINE

January 1990

A. Current Work - 4 questions

B. Career choice, education and entry into industry - 7 questions

C. Transition in work components - 7 questions

D. Supervisory and managerial skills - 2 questions

E. Technical skills - 2 questions

F. Training and updating - 4 questions

G. Managerial and technical identity - 6 questions

H. Future career progression - 3 questions

Respondent:

Position:

Organisation:

Interview date & time:

Future access:

A. <u>Current Work</u>

1. Could you briefly describe what your current work involves?
   - department organisation
   - title & formal responsibilities
   - what the job actually entails
   - who do you report to?
   - how many people below you?
   - how many report directly to you?
   - how long in the job?
   - relate current to previous job
   - factors which led to move

2. What is the nature of your involvement in the technical work here?
   - own definition of the "technical" part of work
   - over-view advisory role
   - general/specialist knowledge input to projects

3. How would you define the other components of your work?
   - own perceived grouping of work
   - suggested, or "administrative" / "managerial"

4. How many hours would you estimate you work in an "average" week?
   - how much work taken home?
   - type of work usually taken home
   - reasons for this
   - time divided between any identified work groups [week]
   - time divided between reporting up or down [week]
   - time directly spent on research and design work [week]
   - time spent on performance appraisal & job review tasks [year]

B. <u>Career choice, education and entry into industry</u>

1. What were your parents' occupations?
   - type of schools attended
   - age on leaving
   - clarify qualifications

2. When did you first consider a career in engineering?
   - factors led to choice of career in engineering
   - parents'/relatives occupations
   - perception of when choice was made

3. Why did you choose - to qualify as an engineer by the degree route?
   - to study for higher (HNC/D) qualifications?
   - alternative
   - "sandwich" period in industry
   - vacation placements
   - sponsorship
   - why alternative route(s) not chosen

4. How did the route you took affect your career progression?
   - advantages over alternative
   - disadvantages over alternative

5. Have you taken any further qualifications?
   - why / why not?
   - initiative
   - payment or sponsorship for course/qualification
   - benefit/dis-benefit in career

6. What did your first job involve after you graduated/qualified?
   - organisation
   - location
   - technical work
   - any effect on subsequent jobs applied for

7. What can you remember about how you hoped your career would progress and where you were hoping to end up?
   - compare/contrast with present
   - technical / managerial

C. <u>Transition in work components</u>

1. How have you been involved in working on specific technical projects?
   - as an individual
   - as a project team member

2. When did you first start to supervise the technical work of others / another?
   - who were these others?: engineers/technicians/other staff
   - job title
   - why supervisory work was taken on
   - training received before/after/never
   - on-job experience gained/used
   - any differences from expectations

3. When did you first have responsibility for co-ordinating the technical work of several other team members?
   - who?: engineers/technicians/other staff
   - job title
   - why co-ordinating role was taken on
   - training received before/after/never
   - on-job experience gained/used
   - any differences from expectations

4. When did you first have responsibility for administrative tasks for technical projects such as managing budgets?
   - what were you working on?
   - job title
   - why these administrative tasks were taken on
   - training received before/after/never & initiative
   - on-job experience gained/used
   - any differences from expectations
   - any means of delegating the work

5. When did you first take on formal man-management responsibilities?
   - what is entailed?
   - formal performance appraisal and pay determination
   - recruitmant selection procedures
   - who for?: engineers/technicians/other staff
   - job title
   - why formal man-management was taken on
   - training received before/after/never & initiative
   - on-job experience gained/used
   - any differences from expectations
   - any means of delegating this work, who to?

6. Was there any stage in your career which you can identify as marking a shift in the balance of your responsibilities from technical to the managerial side?

7. As you have moved through these stages of responsibility for the work of others, how has that affected technical work you have done yourself?

D. Supervisory and managerial skills

1. Which do you regard as the most important managerial skills you use in this job?
   - relative to importance of technical skills
   - importance of formal training versus experience
   - formal training received & initiative
   - those which stand out as useful/less
   - qualifications
   - intended/desired future skills/training

2. Are there other management skills which would have been beneficial to you in your current work?
   - reasons why not acquired

E. Technical knowledge and skills

1. What kind of technical knowledge do you need to do your work now?
   - compare with technical staff below

2. Can you think of any particular areas of your technical knowledge which you don't need to use any more?
   - knowledge has actually diminished over time
   - own knowledge surpassed by new developments over time
   - why and how this has taken place
   - any regrets of this process

F. <u>Training and updating</u>

1. How do you keep up to date with technical developments relevant to your current work?
   - how much is this necessary?

2. Do you attend conferences or training courses to keep abreast of technical changes?
   - frequency
   - what sort of conferences attended recently
   - level of technical detail appropriate for your position
   - personal benefits of attending
   - why non-attendance
   - send someone else
   - reasons for sending someone else

3. Do you attend management conferences or training courses?
   - frequency
   - what sort of conferences attended recently
   - personal benefits of attending
   - why non-attendance
   - any particular subjects would like to attend for

4. In general, how well do you feel your employer prepared you for the new skills - technical or managerial - which were needed for the changes you have made?
   - formal methods
   - informal methods
   - reliance on own initiative

G. <u>Managerial and technical identity</u>

1. Would you like to have been able to make greater use of your technical skills?
   - any stage where refusing promotion was contemplated
   - option of dual-track path
   - reasons for decision
   - hindsight on those reasons

2. Moving progressively into management has been significant in your career; would you say that you chose management or that management was chosen for you?
   - any point or change in career which made this apparent

3. Did you regret any changes in the course of your career?
   - reasons for change
   - particular outcomes of decision
   - any enforced moves

4. We have examined your background as an engineer, but do you consider yourself primarily an engineer, or a manager?

5. Were any of your job changes motivated by a desire to take on more managerial responsibilities?
   - alternatively to change managerial responsibilities
   - to reduce responsibilities

5. Professional engineering institutions membership - see CV/career sheet
   - any reason why not a member
   - considered membership or been a member in the past
   - why membership lapsed
   - benefits of membership
   - read journals
   - frequency of attending meetings
   - office holding
   - office held in the past
   - chartered status

6. Are you a member of any professional management institutions?

   - any reason why not a member
   - considered membership or been a member in the past
   - why membership lapsed
   - benefits of membership
   - read journals
   - frequency of attending meetings
   - office holding
   - office held in the past

H. Future career progression

1. How do you hope your career will progress over the next five years?
   - more technical
   - less technical
   - ties to this location/organisation/technical area.
2. Will you be able to fulfil this within this company?

3. What do you think you will in fact be doing in five years time?

Appendix 4

Organisation cohort - details of each fieldwork site:

Organisation A, Salisbury (medium department)
Two Respondents: 1 Technical Director
3 Chief Engineer

One small profit centre in a multinational, Organisation A at Salisbury is employed mainly on defence contracts, the majority being for overseas. It occupies a factory unit on the outskirts of Salisbury which is mainly given over to electronics design or testing workshops, for at Organisation A short runs of highly complex and specialised equipment are their stock-in-trade. The organisation employs some 21 engineers, of whom most are electronics engineers, making it a medium sized department. At the time of the fieldwork, a dual track career structure had been in place in the multinational parent for 18 months but was not in practice yet.

Organisation B, Eastleigh (large department)
Two respondents: 2 Head of Systems Engineering
32 Chief Engineer - Defence Systems

Organisation B was set up in 1987 through a merger of the engineering division of one parent company and the design and projects division of another. On the Eastleigh site it has about 500 employees in total, over half of whom are engineers, but half of these engineers are contract staff. The organisation was undergoing considerable management changes during the period of data collection, but these had a limited effect on the respondents interviewed, who headed up a large department of engineers with mechanical engineers in the majority but with approximately 25% in electronics and computer engineering. All the work was on one-off engineering projects with teams and groups constantly being formed and reformed for particular tasks.

Organisation C, Romsey (large department)

Three respondents: 4 Research Manager
19 Chief Engineer
20 Chief Engineer

At Organisation C, R&D/D&D work was not only carried out for the multinational parent company and its many subsidiaries, but also for any other organisation in a similar field. Sited at a converted country house, there are several divisions on site of which the Electronic Warfare and Avionics division has about 55 people in three main technology areas. Each technology area is headed up by a chief engineer. All work was in project teams which are highly flexible. Organisation C was going through a period of uncertainty about parent ownership at the time of the fieldwork.

Organisation D, Bournemouth (small department)

One respondent: 5 Software Engineering Manager

Organisation D had undergone much upheaval in the previous two years, with many engineers made redundant or transferred elsewhere in the parent company who acquired it as an independent five years ago. Organisation D makes CAD products and their own version of CIM - computer aided manufacturing. Basically this means a variety of printed circuit boards are seen through from conception to production. The premises are a trading estate unit comprising production facilities, open work areas and offices, housing 120 employees. Half of these are related to the engineering design side of the business, but not all are professional engineers.

Organisation E, Portsmouth (small department)

Three respondents: 6 Technical Manager
13 Electronics Design Manager
14 Electronics Design Manager

An example of an independent organisation, E concentrates on marine electronic equipment for navigational and other purposes. It is particularly innovative in new product lines and at the time of the interviews, was doubling the size of its factory and office/laboratory unit in line with its expansion.

Organisation F, Poole (medium department)

Three respondents: 8 Technical Director
17 Electronics & Software Design Manager
23 Systems Design Manager

Organisation F are defence engineers formed from the amalgamation of two companies in 1988, one making MoD specification electronic hardware, and the other specialising in cases for such hardware. The products include switchgear and radar equipment, virtually all for the British navy. There are 160 employees on the site at Poole of whom in total about 35 are professional engineers. One third of these are electronics engineers.

Organisation G, Basingstoke (large department)

Two respondents: 9 Engineering Research Manager
30 Engineering Manager - Fuel Systems

Organisation G is the second largest of four UK sites under the same parent organisation which also has plants in the USA. Its specialism is aerospace and defence systems, particularly radar altimeters and transducers, employing 900 people on the site mainly in production. Although hardware and software research work is carried out for these and other future products at Basingstoke, organisation G only just qualifies as a large department because the number of engineers at the site is 30, although a precise breakdown of their employment is not available. A contraction of the plant has taken place, after the fieldwork period, making a few engineers redundant.

Organisation H, Cowes Isle of Wight (large department)

Three respondents: 10 Design Engineering Manager
27 Engineering Group Manager
28 Engineering Group Manager

Having emerged relatively unscathed from a division of its multinational owner, Organisation H continued to operate as a manufacturing and research site although there was considerable uncertainty about the future. Employing 1300 on the Cowes site, these included 450 in engineering, 450 in manufacturing and the remainder in support functions. Organisation H primarily produces sophisticated radar systems for both defence and civil air traffic control use, as well as satelite systems and weather stations. The design engineering side formed one large department which was split into 6 specialist groups totalling about 140 engineers, then arranged in project teams as required. Perhaps through being relatively isolated, organisation H seemed to enjoy great employee loyalty and also emphasised HNC/D rather than degree based education.

Organisation I, Wokingham (large department)

Three respondents: 11 Research and Development Manager
16 Section Manager
24 Section Manager

Part of a multinational, Organisation I's department in Reading has its own identity and trading name, its own floor of a large modern secluded building, but is very much part of the American parent company's distinctive style. This style is reflected in the managerial structure and approach on the site and even the open plan layout of the offices with low walls and no doors. Offices are rather seperated from the engineers' workbenches and laboratories. The department has a payroll of about 170, with 80 being directly employed in research and development work on Organisation I's product range of information systems for commercial applications.

Organisation J, Reading (large department)

Three respondents: 12 Engineering Group Manager
15 Hardware Development Manager
22 Software Development Manager

Organisation J produces principally mass produced high technology office equipment and information systems, as part of a multinational operation, and is linked to a sister plant in Eire. The department in which the fieldwork was carried out occupies one end of a large modern building housing about 2000 employees. The department has about 160 employees most of whom are professional engineers, some being transferred from the organisation headquarters in the USA. The engineers' working area is a maze of laboratories, offices and meeting rooms all together.

Organisation K, Eastleigh (medium department)

Three respondents: 21 Engineering Director
25 Product Group Manager
26 Product Group Manager

A success story of the 1980s, Organisation K has grown rapidly in its field of optical fibre technology for telecommunications. It has moved from London to a trading estate building at Eastleigh, attracting new engineers to new projects. The internal organisation of the company had just been re-modelled at the time of the fieldwork to allow for future expansion.

Organisation L, Christchurch (medium department)

Two respondents: 29 Technical Director
31 Senior Project Engineer

Organisation L is one of four manufacturing subsidiaries of a larger company formed in 1957 totalling 1000 employees, of which the Christchurch site employs about 220. The structure is deliberately kept in small independent units; other parts of the overall company are located nearby, but organisation L is a discrete entity specialising in position sensor equipment. With 10 professional engineers engaged in R,D&D work, organisation L is borderline with the small department category.

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