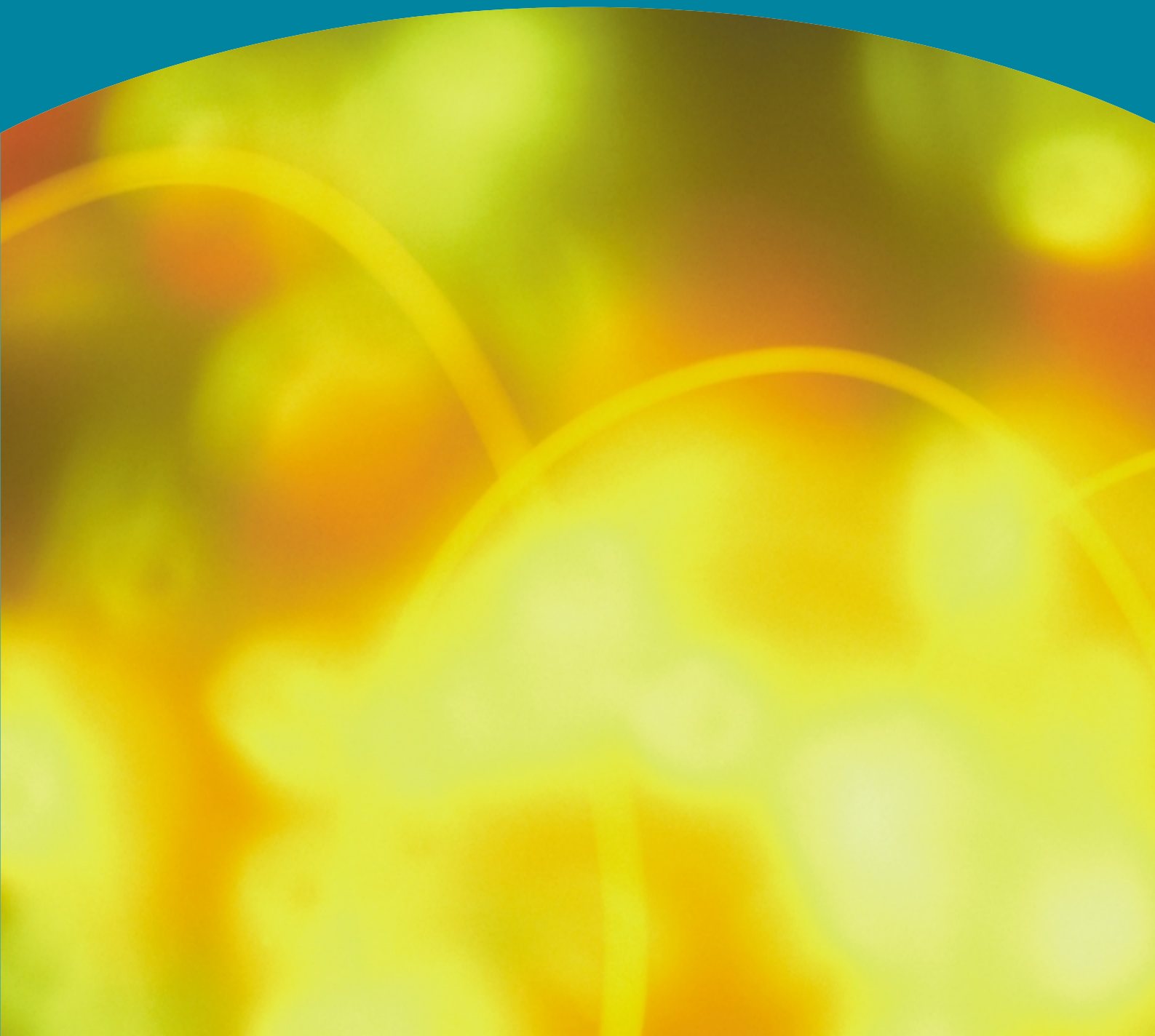
Employers Skill Survey:
Case Study
Engineering



EMPLOYERS SKILL SURVEY

Case Study - Engineering

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FOREWORD

The Secretary of State for Education and Employment established the Skills Task Force to assist him in developing a National Skills Agenda. An important part of this remit was to provide evidence on the nature, extent and pattern of skill needs and shortages and their likely future development. The research evidence assembled by the Task Force was summarised in *"Skills for all: Research Report from the National Skills Task Force"*, published in June 2000.

An important contribution to the evidence was made by a major programme of new research. This included two employer surveys, detailed case studies in seven different industries and a review of existing surveys. We are grateful to all those who participated in this research and so contributed to the work of the task force. This report provides more detailed information on one element of this research. Details of associated reports are listed in the rear of this publication.

It should be noted that the views expressed, and any recommendations made, within this report are those of the individual authors only. Publication does not necessarily mean that either the Skills Task Force or DfEE endorse the views expressed.

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EXECUTIVE SUMMARY

The engineering sector in the UK has been, and still is, going through major structural change. The changes not only carry implications for skill requirements, but also for geographical location of those skills, company support structures and the focus for change and developments in the future. The current position is one of turmoil as plants struggle to keep up with the speed of the changes forced upon them. These changes increasingly imply large-scale adjustments, either as a result of the impact on the UK establishment directly, or, indirectly through their position in an organisation that has to adapt to a changing global environment. Consequently, core strategic issues surround product and operational competitiveness and the changing mix of skills required at the establishment level in the UK.

This report has summarised our findings in a number of engineering and manufacturing case studies. While we have reported factually on our findings and interviews, we have also applied our wider experience of manufacturing and engineering processes and organisations to offer some evaluation of the policies and practices with which we were presented.

Our findings represent a very wide range of different practices and approaches - albeit with some themes common across a number of the individual case studies. As we have conducted this research we have considered and proposed a framework within which to assess policies, and to recognise that there seems to be no “best” practice - certainly not all represented within one case - but rather a series of practices that appear to be more or less appropriate to particular circumstances. We have characterised the circumstances of these case study establishments, and the skill implications, with reference to our model the “Puttick Grid” (described in chapter 3). This has allowed us to suggest that different establishments have circumstances and particularly product/market features which require different approaches, and that success comes not from applying a universal “best practice”, but from the application of practices and the deployment of types of skill set that are appropriate to the circumstances.

We have noted in this report increasing supply chain pressures for all companies, and increasing globalisation both in product distribution and in manufacturing and design processes.

It is evident that change needs to be continuous, and that the pace is increasing. In broad terms, it is those establishments and managers that appreciate and can rise to these circumstances that are clearly more likely to succeed; some of the skills deficiencies we have suggested relate to the ability of managers and management fully to appreciate their situation, develop suitable strategies, and successfully implement them. It was also evident that even if managers were able to develop satisfactory strategies likely to sustain the organisation in the long term, it was not always easy to capture and articulate the skills necessary for that policy to be put into effect.

We have identified varying degrees of involvement from the Human Resource specialists, and also varying degrees of understanding amongst them of the strategy being pursued.

There was clear emphasis on the role of the professional engineer, and how flexible but systematic thinking was essential, but not always available. At all levels, the skills of team and project working are seen as important, and in general the development of people with broader understanding of the business (but not at the expense of deep understanding of some of the technicalities or the role of the technician).

The key management level skill deficiencies identified in the case studies included:

- Professional engineers with design, development, project management and manufacturing system skills
- Technicians and technical skills
- People management and co-ordination skills
- Commercial awareness
- Real-time application software development capabilities
- IT systems development and internet application skills

The main shop floor skill gaps reflect the trend away from traditional "blue collar" work towards the inclusion of the additional "soft skills" needed in a knowledge management society including:

- Team leader and motivation skills
- Administrative, communication and manufacturing data handling skills
- Skills in setting and achieving productivity targets and improvements
- Forward thinking and planning skills

We identified two establishments that had been forced by market pressures into lower value added, low margin, mass production operations. In the context of a global environment, some competitiveness against low labour cost operations can be gained by increasing automation levels and focusing on the efficient use of capital employed. However, the greater scope for engineering establishments in this country, lies in the opportunity to aspire to higher value adding, innovation based strategies. The management and professional skills highlighted earlier would be even more important, of course, if these changes were to be implemented.

Only some specific IT skills were identified by our respondents as critical (generally these related to functional software rather than business applications), but it was notable that none of our respondents had identified internet skills as important, or at any rate not in short supply. This again suggests the possibility of further latent skill deficiencies, with even greater demands for IT skills emerging if firms move to exploit web-based opportunities more fully.

As far as Product Strategy itself is concerned, we noted a trend to pass more responsibility down the supply chain, so that the more successful suppliers were likely to be providing more complex sub-assemblies, with those near the top of supply chain concentrating on overall design, project management and integration. Much of this change was facilitated by successful partnerships between the various components of the supply chain.

Overall, our view was that while operational skills are clearly of considerable importance in the success of this sector, structural management competencies have a critical influence as do product life-cycle design skills and technical innovation capabilities.

1. CONTEXT TO THE CASE STUDIES

1.1 Aims of the Study

This report sets out the findings of the research that has been conducted as case studies with a sample of UK engineering establishments. These have been selected for their representation of different industrial segments within the engineering sector, for their different positions in a complex supply chain, and for the mix of issues that they face in differing degrees as an establishment in the UK.

The study has addressed the drivers of change that are impacting on companies and has sought to understand the establishment's response within the context of the larger organisation that they may be a part of and also within the larger market place in which they operate.

The study aims to build a deeper understanding of the changes taking place within the engineering sector, the factors that are dominant in those changes and the implications of those changes for skill requirements in the UK. The issues have been explored by looking at how the case study establishments devised their product market strategies, and the relationships between business strategy, human resources strategy and investment in human capital through training and employee development.

The study however goes beyond identifying the immediate reasons for change and probes for the underlying causes and linkages between apparently company specific issues and the common themes emerging from the wider issues of globalisation in the sector. The detailed implications of these changes have been questioned both in terms of how the company is addressing them and the requirement for different types of skill at different levels within the organisation. In particular, the research has questioned how the company is tackling skill shortages, skills that are now surplus to requirements and the related flexibility of the personnel, training or contracting issues involved.

1.2 The Case Study Establishments

The case studies were mainly selected on the basis of prior knowledge about their circumstances from links that the research team already possessed with engineering companies. A selection of establishments that varied with respect to their number of employees, position in the supply chain, location, and industrial sub-sector was required. Ideally, these should have been matched so that it was possible to compare the responses of two or more establishments that had more or less the same characteristics. In the time scale for undertaking fieldwork this was not possible, but evidence has been collected from 17 case studies that satisfy the initial set of selection criteria. As always in studies of this type a degree of opportunism enters the selection procedure: establishments that agree to participate fully within the time scale of the study have a high probability of being selected even if it is not possible to match them to a similar company.

At an early stage of the study the intent was to focus on critical functions within case study companies, such as marketing, customer relations, design, research and development, etc. The principal management respondent - usually senior human resource or senior engineering operations managers - was asked to identify critical functions but this proved difficult to sustain in practice. Instead, the case studies proceeded by discussing the overall position of the company, the establishment where

the case study was located (if a multi-site company), and then identifying functions that were experiencing change and to which the issues of recruitment problems and skill gaps were most germane.

All of the case studies are establishment based. Interviews were carried out with the following groups of staff:

- senior management;
- human resource specialists;
- engineering professionals;
- shop stewards;
- shop floor workers.

It has not been possible to obtain interviews with all these personnel in every case study but overall the study provides a full range of views.

1.3 Details of Individual Case Studies

The principal sub-sectors covered by the case studies are:

- automotive engineering (SIC 34);
- aerospace (SIC 353); and
- instrument engineering (SIC 333).

A few case studies cover other selected industries.

Table 1 provides some basic information regarding the case study establishments. It demonstrates that the case studies tend towards larger establishments that are part of larger organisations, although smaller single site establishments are included. Several establishments were original equipment manufacturers (OEMs) at the top of the supply chain, others were either suppliers to other establishments or companies within the organisation of which they were part, others supplied direct to the final consumer.

The case studies are not necessarily representative of the sector. Given the heterogeneous nature of the industry and the limited number of case studies undertaken, this proves to be an impossible demand. The Skills Task Force Employers' Survey reveals that the engineering industry[1] as a whole comprises: establishments that mostly employ a small number of people (64 per cent of engineering establishments employed between 5 and 24 employees in 1999); independently owned (67 per cent); and concentrated in the North-West (12 per cent), West Midlands (20 per cent), and South-East (16 per cent).

The purpose of the case studies was to understand the processes that link product market and skill strategies. Largely drawn as they are from the population of large, multi-national owned establishments the cases offer insights into what might be considered more elaborate or sophisticated approaches to linking skills to the demands of the product market.

1 The engineering sector has been defined as SIC(92) 28-35.

The senior managers and human resource managers surveyed at establishment level were able largely to identify the nature of their current skill gaps and the human resource and training issues affecting their establishments. They were less able however to articulate the longer term skill requirements of the establishment or the relationship between product strategy and future skill demands. Those engineering plants, which were also head office establishments were more aware of the skill-sets required over the longer term to allow the firm to successfully achieve their chosen corporate trajectories. Decisions over the long-term strategic direction of the establishment tended to be made at head office, which in some of the case studies was overseas. Management at establishments that were part of multi-national corporations rarely had significant leverage over the long-term product strategy that they were pursuing.

Table 1: Case Study Establishments

Code	Number employed in estab'ment	Annual sales or budget, £	Rate of growth/ decline	Single site, UK multi or multinat	Main product/ service	Scale of production/ deg. of product customisation	Type of main customer/end user
E1	1,300	90m	Steady growth	UK owned multi-site	Aerospace	Increasing customisation. Low scale production	Large global airlines
E2	900	39m	Static	UK multi-site	Defence and Nuclear Industry	Increasing customisation. Project size has decreased and risen in numbers.	Nuclear and defence companies
E3	800	20m	Growth after period of decline	Foreign owned multinat	Engine Manufacturing	Low volume production (although numbers produced rising). Increasing product customisation.	Main customer part of parent group. Others vary widely although majority final assemblers.
E4	~ 450	(1500m Division)	Static	UK owned multinat	Automotive Industry	Mass production, increasing customisation.	Servicing other companies in the Group.
E5	330		Decline	UK multinat	Component Manufacturer	Mass production, limited customisation.	Parent company/final consumer.
E6	8000		Steady growth	UK multi-site	Aerospace	Increasingly customised high value projects. Low volume production.	National governments - ministry of defence.
E7	142	8.5m	Static, declining sales	Foreign multinat	Component Manufacturer	Increasingly customisation and specialised product.	50% parent group. 50% original equipment manufacturers.
E8	700	60m	Steady growth	UK multi-site	Real time computing systems for engine control	Full customisation Low volume production	Aerospace Original Equipment Manufacturers
E9	290	21m	Growing strongly	Foreign multinat	Precision Engineering	Increasingly customised, specialised product. Medium scale production.	Large multinational market leaders who final assembly products.
E10	600	220m	Growing	Foreign mutlinat	Mainly Transport and Communications	Low volume. Increasingly customised.	Wide variety of companies.
E11	1500		Static	Foreign multinat	Consumer Electrical	Mass production of standard range of products.	Parent group companies.
E12	6000 company wide		Growing moderately	UK multi-site	Automotive	Low volume production - moving to higher volume production with new product launch.	Car dealers and the general public.
E13	400	150m	Static - beginning to contract	Foreign mutlinat	Consumer Electronics	Mass production of standard range of products.	Electrical retailers and Original Equipment Manufacturers.
E14	5	2.5m	Growing	Foreign multinat	Transformer Design	Production -low cost, mass production. Design and development -increasingly specialised and customised.	Audio industry.
E15	650		Growing	Foreign multinat	Consumer Electronics	Mass production of standard range of products.	Electrical retailers and distributors.
E16	660	108m	Growing strongly	Foreign multi-site	Automotive	High volume customised products.	UK based automotive manufacturers.
E17	900	650m	Decline	Foreign multinat	Automotive	Low volume, with plans to triple production.	General public.

2. PRODUCT MARKET STRATEGIES

2.1 Case Study Issues & Complexities

Most of the companies in the sector are under considerable pressure to fulfil increasing customer needs in the most effective and cost-efficient manner. The precise nature of the pressure does vary according to a number of factors - over many of which the establishments have little control.

The establishments in the study represent a range of differing products and activities, and at different stages in their life-cycle. At one end of the scale there are establishments producing relatively low-value, well-established goods where cost and function (with perhaps little to discriminate function between competitors) are the main features. At the other end, there are the complex products often operating in safety-critical environments and very often going into other products with very long life-cycles (e.g. aerospace, where product life-cycles might be well over 30 years). Elsewhere, there are products which are relatively young in life-cycle terms, and which display innovation or special features, which for the time being give the company or establishment, a leading edge in the market. Each different type of product creates different pressures and imperatives.

An additional feature which discriminates between establishments in the study is the relationship of the establishment to “product origination”. In some cases, the product was designed and originated at the establishment itself, where production and manufacture might have been secondary (but this relationship is not always true); in others the establishment was a production unit for a product designed and originated overseas - for instance in Taiwan, the US and Japan. From these comparisons, it was evident from our survey that those establishments, which contained at least some element of design or customisation, seemed in a stronger position to influence their own destiny, and potentially in a stronger position in relation to the market.

Certainly, of the companies contacted during the course of the development of the case studies, six were affected by structural and management decisions that reflected existing or new loss of control of engineering and product development in the UK. The result will be a deterioration of the potential for value addition from the remaining skill base required in the UK and a shift of professional and skilled engineering jobs overseas.

2.2 Drivers for Change in Product Strategies

The main drivers for change in products and processes depend to some extent on the market served by the product and the circumstances of the particular establishment. There are however, some common influences that tend to affect all companies to some degree and in general, companies tend to decide the market/product strategy and then look to working practices, technologies and skill needs.

A significant driver for product and process change is innovation. It is evident that products that display new features, significant new technologies, or additional functionality, have major (if only temporary) advantages in the market. It should be noted that there are some exceptions to this - especially in the area of critical safety systems, where tried and trusted technologies still have the edge. Even here, however, innovation will, in the long-term, fuel product and process change.

Those companies and establishments that have some input on design and innovation seem to be in a stronger position in relation to the market than those that are entirely dependent on designs and innovation from elsewhere (often overseas). In the latter case, an establishment may come to be regarded purely as a production facility that can be replaced in due course by another with more modern and appropriate facilities for new products. One of the case studies might be a case in point where production was focussed on a product that in due course may be obsolete, and there appeared to be no plans to set up new production facilities for a new generation of products.

It is evident that many suppliers are increasingly trying to work in partnership with their customers on custom product development, innovation, process changes, and many other matters. None of this reduces the immediate pressures on suppliers to perform, but it does tend to create the possibility of longer lasting working relationships and greater understanding between the parties. It also introduces concepts of life-cycle benefits from arrangements rather than a simple cost per product. An example of this is a contract with an aerospace customer not only for an initial order of a product, part or system, but also for lifetime support, servicing, training, and other services.

For all establishments in the study, innovation seems to be critical to survival at least in the long term. Not all companies have introduced major new products - although it is true to say that few are working with products totally unchanged over any period of time - but most have worked hard and successfully at production and other processes.

For many companies the process of developing relationships with customers has been changed and overhauled in recent years, and there is more project-type working incorporating technical, commercial and production people at an early stage.

For a number of establishments the process of problem solving has also received special attention. This is not perhaps a major customer-facing process like some others, but it has proved worthy of mention in a number of cases. With more multi-skilled working, greater flexibility, increasing exposure to the fluctuations of the market, and for some sub-sectors just-in-time deliveries, rapid and effective problem-solving is seen as essential. This often requires a wide view of the issues - usually including a technical one - and an ability to work systematically towards a solution.

2.3 Strategic Choice in Product Markets

Most of the companies and establishments visited were operating within the product markets that they knew well, and had been in for some time. For many of them any strategic choice of product market was made beyond the establishment, and in some cases outside the UK.

Some of the companies and establishments do from time to time make such strategic choices and tend to reflect the more innovative culture that some have towards developing new product ideas in current sectors or the transfer of capabilities into new sectors for them. The effects and decision processes however, tend to be on a longer time-scale than reflected in this case study material.

Nevertheless, it is possible to discern in some of the more successful companies, a trend over a period of time, towards products/services of somewhat higher value, with a corresponding shedding of activity towards the lower end of the value spectrum for that establishment. One multi-national case study had taken the decision to reduce its manufacturing capabilities in the UK, deciding not to invest in new manufacturing plants but rather to concentrate upon the service and research and development aspects of its business. This strategic decision to concentrate on the higher value-added aspects of the business in the UK was taken by the head office, which was located outside the UK.

Another case study was outsourcing increasing amounts of its in-house production and manufacturing engineering to external suppliers, whilst retaining and consolidating its control over the final assembly, design and functionality. This, in turn, allowed suppliers lower down the supply chain to increase their value added, facilitating partnerships over issues such as design and product development and the management of the supply relationship per se. Such changes in strategy require each organisation in the supply chain to continually develop its manufacturing capability and resources, in most cases moving closer to the customer as it does so.

It is arguable that without this process of upward value development, an organisation's activities are not sustainable in the long term. In one case study company for example, new product models offered additional functionality at a price premium, but in several other case studies additional functionality was 'given' to the end customer in order to maintain competitive position.

As products pass through their life cycle, they increasingly become commodities (see next chapter on the "Puttick Grid"). At this stage the major issue is cost, and customers are increasingly capable of global sourcing (often based on internet bidding and supply-chain management). Very few UK manufacturers are capable of competing globally on cost alone, except perhaps in situations of very high capital investment and complexity, where labour rates comprise only a small proportion of the total product cost. Thus, one strategy is continually to add value and quality to the product so that the product begins to move into higher complexity sectors.

This trend was evident from both directions in our case studies. In one case, a supplier to the automotive industry was working with its customer to develop greater product functionality, and more integration with other related products and parts. This would allow the automotive customer to reduce assembly times and cost and also to reduce the total number of parts. This arrangement adds values for both parties. In another case, the ultimate customer was outsourcing much of its component production that had been previously carried out in-house. This presented opportunities for local suppliers and allowed the customer to concentrate on the high-end design and integration. The actual time-scale implied by this is however variable and depends on the product and market involved. In some cases the 'value' cycle could be as little as one to two years, whilst in others it may be a decade or more. Issues surrounding product/market classification and their life cycles are discussed further in the following section.

3. SUSTAINABILITY & ALTERNATIVE PRODUCT STRATEGIES

3.1 Factory for the Future

This section introduces and utilises an extremely useful conceptual framework developed by Warwick Manufacturing Group in 1998 concerned with manufacturing strategies and competitive performance[2]. The framework is highly relevant in that it offers a means of understanding some of the complexities in the sector and the issues described in earlier sections of this report. In particular it provides a means by which skill requirements can be examined against best practice competitiveness in a particular company situation. The approach not only provides insights into the complexities in the sector, it also provides a means of assessing and positioning alternative strategies and their potential sustainability.

The framework offers a model that individual companies may be able to apply in their own individual circumstances. However, if the model can be developed and appropriately scaled across the whole community, it also holds the potential possibility of application on a wider front to the engineering sector as a whole in the UK. Though that work is not within the scope of this study, the basis of the framework is summarised in the sections below as an introduction to the possibilities.

3.2 Puttick Grid

Figure 3.1: Product Classification

2 The work carried out with the companies in these case studies is consistent with a body of research in the UK, France and Germany that was conducted and developed between 1995 and 1998 by the Warwick Manufacturing Group. That work was led by John Puttick of WMG and developed a number of aspects of manufacturing styles and systems of direct relevance to the competitiveness of such engineering organisations.

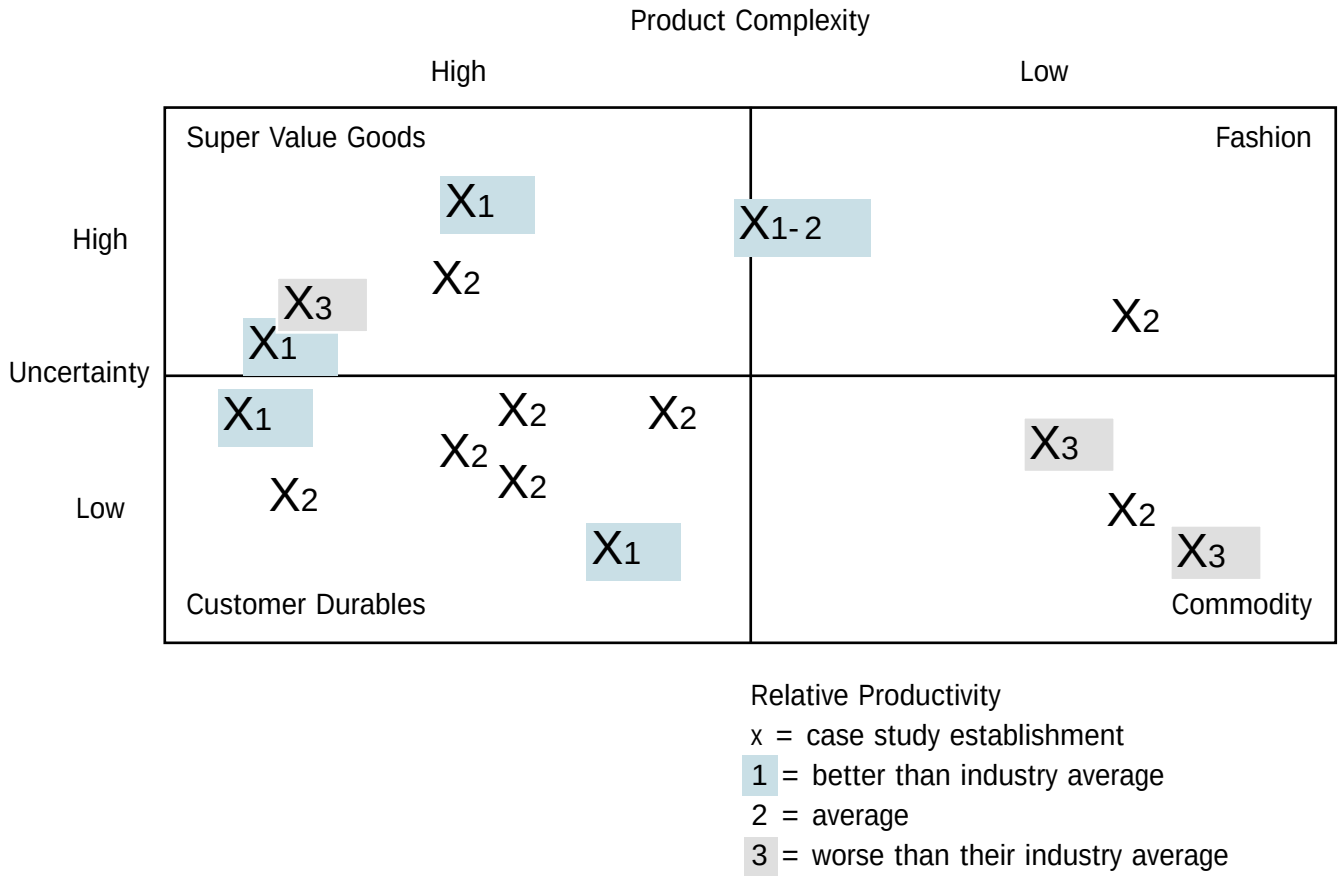
The concept of the framework, is that engineering and manufacturing companies can broadly be categorised into four basic types of product/market situation with quite different characteristics and requirements if they are to be more competitive than their rivals (see Figure 3.1). These are:

- "Super Value Goods" in the top left quadrant of the grid are typified by highly complex products such as aircraft or complex machines that consist of a large number of components, probably carrying a high value but in an uncertain market of small size (by numeric volume). Fitness for purpose and technical superiority is critical to success in this quadrant and relies on the skills and competencies required to work with high technology solutions.
- "Fashion Goods" in the top right quadrant are typified by relatively simple products by number of components because they are products in markets that are fickle with short product life cycles. Many toys and products produced for the three-month Christmas window of opportunity fall into this category. Market vision and the time that it takes to introduce new products and services are crucial.
- "Commodity Goods" in the bottom right quadrant are usually engineered for, and manufactured, in high volumes from dedicated process lines at minimal cost. They tend to be simple products and warrant the high capital investment required for the relatively dedicated production systems. Continuous flow manufacturing productivity is typical and low cost per piece is vital to gaining and not losing an exceedingly tight margin.
- "Value for Money Goods" in the bottom left quadrant includes many of the consumer durables that we have in our homes that are of moderate complexity (compared with super value goods) but are in much high volume markets of lower uncertainty. Balanced processes are the key to success and techniques such as cell manufacturing and the ability to flex production are important.

Figure 3.2 illustrates the distribution of the case study establishments on the Puttick Grid in terms of both product - market Grid position and in terms of the performance of the establishment at a particular point in time (i.e. at the time of the case study). The performance of the establishment has been estimated above or below average relative to contemporaries. For the operational establishments (the majority) this nominally reflects relative productivity but for some group establishments the relative performance effectively reflects profitability. There are one or two case studies which are not positioned as expected within the Grid because the Grid position reflects the focus of the establishment rather than the focus of the company as a whole or other operating establishments within its Group.

The majority of the case studies examined are located in the bottom left hand corner of the Grid producing relatively complex goods in product markets with low levels of uncertainty. Given the relatively large size of the case study establishments studied it is not surprising that they are skewed away from the top right quadrant where the speed of response associated with 'fashion' type products suits small business units with short lived product opportunities.

Figure 3.2: Case study establishments



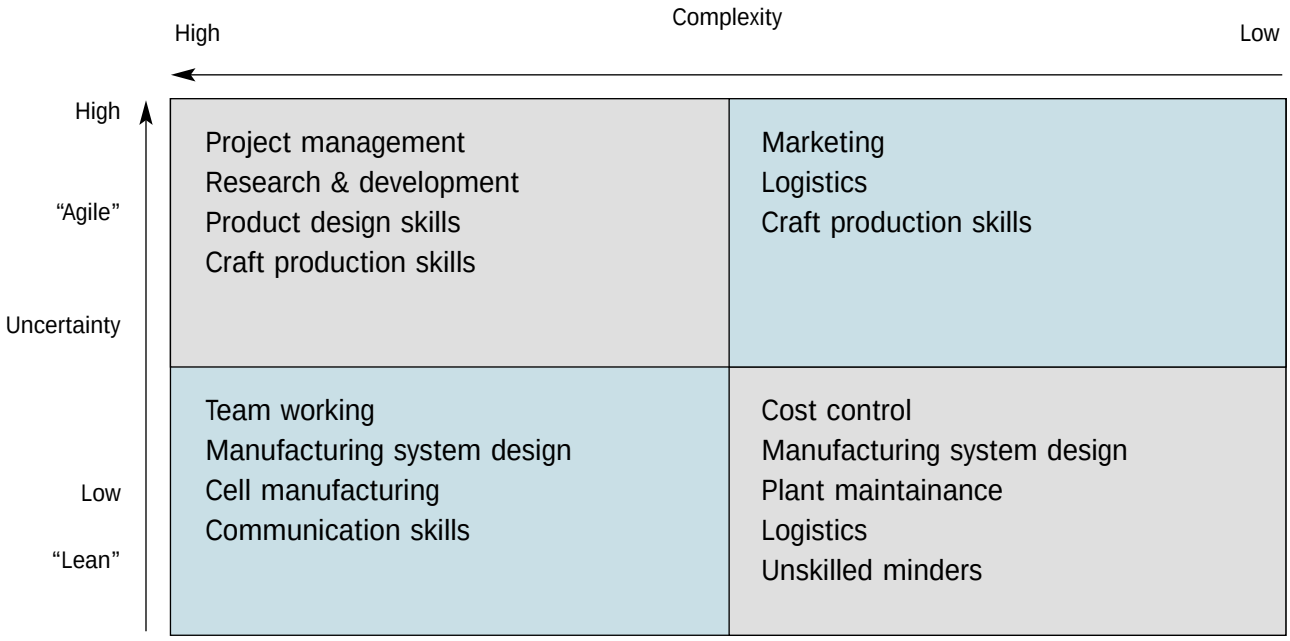
Relative Productivity
x = case study establishment
1 = better than industry average
2 = average
3 = worse than their industry average

3.3 Skill Implications

The Puttick Grid is also a useful tool through which to link product strategy, competitive performance, and skill requirements (see Figure 3.3). The skills implications of each quadrant are as follows. The successful company in the top left 'super value goods' quadrant is likely to have good project managers trained in complex risk assessment and able to consider and assess conflicting information and potential outcomes. In addition, it is likely to have a research and development programme and an organisational regime that allows freedom for innovation and creating novel solutions. Manufacturing staff within these firms need to be adaptable to change and accepting of new materials and different working practices. There is also likely to be a pool of time served skilled craftsmen and technicians who are able to accept and utilise new training and solve novel engineering problems. The case study companies demonstrate a number of these facets and are discussed more fully in section 3.6

Companies in the top right 'fashion' quadrant, meanwhile are more likely to have a dynamic management team that is able to respond to new ideas and to adapt to a new opportunity with a workable blend of skills that they can resource quickly. Understanding how the market works and what it expects is crucial to success within this quadrant. Within these firms there may not be time for the design of sophisticated systems and there is probably too much uncertainty to risk high levels of investment. Adaptability of skills is again crucial to success and is more likely to come from motivated skilled people. Logistics may be the make or break factor in keeping control of costs and will increasingly involve information management, ICT technologies and skills at all levels from simple data input and management skills to more complex information exchange systems.

Figure 3.3: Skills



Companies in the bottom right 'commodity' quadrant will, whenever possible, employ unskilled rather than skilled employees in order to keep costs down. They typically invest in process lines and systems to reduce running and product costs. Preventative maintenance and rapid system fault diagnosis are all crucial to success. While four of the case study establishments display a set of these characteristics, two in particular give rise to discussion in section 3.6 because of mismatches.

Companies in the bottom left quadrant need to offer a balanced solution to what are often conflicting customer expectations and system demands. Flexibility of technology and people to address a complex catalogue of variants and options is often the key. In order to achieve this cell manufacturing techniques and technologies need to be married up with good teamwork involving a mixture of skills and skill levels to achieve a 'right first time' lean manufacturing 'no waste' approach. The production skills required are more about technician skills, product changeover, re-setting, and re-programming than creating it for the first time.

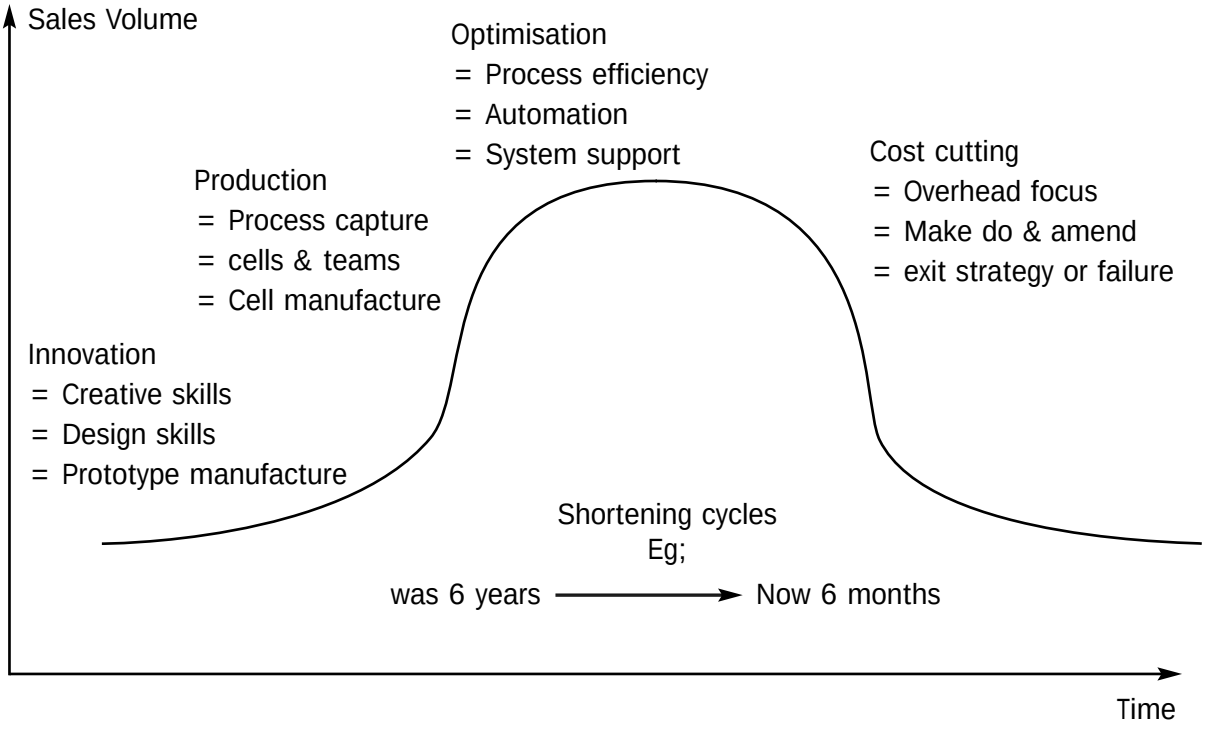
3.4 Dynamic Change

Products may, and often do, migrate between quadrants in the Puttick Grid, typically as the product life cycle changes. New, high technology products for example may well begin by commanding high margins from low volume, specialist manufacture in the top left quadrant. As the market matures the product may be strategically moved or be driven by market forces into a consumer durable position before being forced into a low cost based commodity product. Mobile phones are a good recent example of a type of product that has visited most if not all four quadrants from the early bulky and expensive radio phones to multi - coloured fashion accessory mobile phones to consumer durable variety and now to a low price commodity item. Global Positioning devices were once the expensive prerogative of pilots and yachtsman but they are now to be found in the cyclist's and the rambler's pocket.

3.5 Product Life Cycle & Skill Set Responses

There are a number of analogies, and similarities in implications, that can be drawn between the concepts of the Puttick Grid and the concepts embedded in the more traditional Product Life Cycle curve (see Figure 3.5). Migration between Grid quadrants may take place for a number of reasons, but a very typical one, is that which is generated by the natural progression of the product through its life cycle.

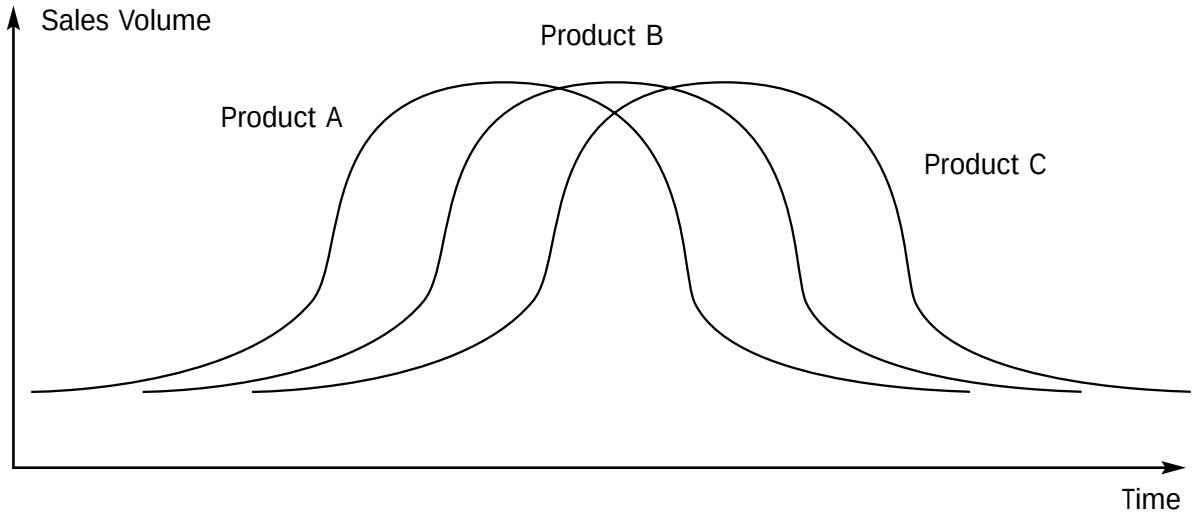
Figure 3.5: Product Life Cycle



A key advantage of viewing that particular issue as a life-cycle is that it is easier for many people to understand the changing volume of activity that takes place against a time frame, as the service expands, matures and then reaches the end of its life. All products and services go through a similar life curve, however extended or unusual that curve might be, and as such, it is also easier for many people to draw comparisons between quite disparate products and services in different sectors of the economy. Different companies respond differently to the issues of innovation, product life-cycle and the different skill set requirements that are brought about as a result of such changes.

Some companies understand the life-cycle process very well and have well developed processes to either migrate their skill sets as an establishment, or to migrate their product ranges through different types of team or business unit within the larger operation. It is these companies that are most likely to have a sustainable mix of products and services in different stages of development, growth, and maturity (see Figure 3.6).

Figure 3.6: Sustainable multiple product life cycles



The majority of companies, unfortunately, find it very difficult to maintain an optimum match between their product market life cycle position and the skill sets that they have and can deploy. The situation is made even more difficult by the rapidity of change in some market sectors where some products and services may grow, mature and be replaced, within a matter of two or three months.

3.6 Issues in the Case Study Establishments

The Puttick Grid has been applied to the case study establishments in order to develop a better understanding of the relationship between market strategy, corporate performance and skill mix. In doing this, the hypothesis that firms with higher value-added market strategies and well developed skill deployment and training strategies achieve better economic performances will be developed.

Profitability can be a very crude measure of business performance and frequently arises out of phase with the development and growth of the opportunity; nevertheless, a high level of profitability is crucial to the sustainability of the business. In turn, profitability is closely linked to the relative productivity of the establishment in its sector. Relative productivity is particularly important to establishments that are operating in the bottom right commodity quadrant as several of the case study companies are. Figure 3.2 plots the relative productivity of the case studies vis-à-vis other competitors operating in the same product market at the time of the case studies. The case studies reveal the complexity of the relationship between product strategy and economic performance, however, there is a good correlation in a large proportion of the case study establishments between their grid position, their relative performance, and their expected skill sets.

Three case study establishments displayed below industry average performances compared to other firms operating in the same market at the time of the study. Two of these establishments are located in the bottom right quadrant whose products were low in complexity and product market uncertainty. These case studies, which are both operating as mass production establishments, were struggling to be cost-effective in the production process and had relatively high labour cost bases, which were preventing them from being able to compete effectively in a global market. The third under-performing establishment had, primarily due to poor strategic management, failed to innovate and bring new products to market. The introduction of financial investment from a new, overseas parent company should enable the company to refocus its operation and ensure that its performance is commensurate with its market position in the future.

Whilst a significant proportion of the case study establishments with better than average performance, are to be found towards the upper left quadrant producing highly complex goods in volatile markets, this third case study mentioned above was a notable exception. The firm produces a high value product, but following a period of poor strategic thinking, management had given insufficient consideration to its product market strategy and the manner in which the goods are produced. Consequently, the firm experienced a mismatch between the price positioning it could command and the production efficiency that could be achieved by the firm. The management team is currently undergoing considerable change, which is being introduced simultaneously with a new product strategy based upon re-emphasising design and product development. This change has partly been brought about by the funding and stimulus provided by the new overseas parent Group, which should facilitate a much better fit with its target Grid position and should result in improved performance. To implement the new strategy, the company will need to develop better market research and product planning capability as well as its professional engineering design and development skills capacity, Project management skills will be crucial to successful new product introduction as will the related technical skills that will be required to implement the use of new materials, components and related production processes

Not all companies located in the bottom right quadrant achieve poor profitability, as there are notable UK firms that are operating successfully and achieving good performance within such product markets. There are, however, many more engineering firms with products at the end of their life-cycle that have been 'forced' into this quadrant. One of the under-performing case study establishments mentioned above, that is located in this quadrant, is likely to cease their current operations in the next two to three years. This is principally because their product life cycle is concluding and management cannot achieve the required quality standards and cost controls that other establishments within their Group can achieve. When this is coupled with a lack of strategic development at the establishment, and possibly limitations from the overseas holding company, it means that the parent company will develop their new products elsewhere in their global operations. One new product development is currently helping to extend the life-cycle curve a little but there is no sign of the multiple product life-cycles needed to provide sustainability.

All of the case studies located in the bottom right quadrant need to carefully examine their options to avoid arriving at the position of the one case study described above, where closure is highly likely. Product life can often be extended and lower cost competition beaten off for a period of time, by continually cutting labour costs and introducing higher levels of efficient automation. Long term sustainability, however, is unlikely to be possible without a strong innovation strategy to keep refreshing old products and to introduce new products using the skills described above.

For our case study company example, the introduction of higher levels of automation, imply the need for professional level skills in the design and development of the automation. It also implies the need to continue to move even further away from the use of craft skills and the use of labour as operators. Instead, the company needs to make greater use of technicians (proportionately far fewer than operators replaced) with diagnostic and problem solving skills and with people who have the ability to interpret the sensor and control information that the automation systems are providing. Planned and preventative maintenance skills become far more important for highly automated plants that are running 24 hours per day, 7 days per week and there is a trend towards the greater use of "hot change" elements - that is the replacement of components without stopping the equipment. Personal responsibility and self motivation skills become as important as team working skills in this scenario where small

numbers of people are distributed through a large plant. As described above, if it was allowed to by its Japanese owners, this case study company would need to develop better strategic management skills, together with the new product development skills needed by an aspiring top left quadrant company. Overall those case study establishments with better than industry average performance had well developed, clear, and appropriate product market strategies which management considered would provide them with competitive advantage in the market place. More importantly, management had developed a clear and valid sustainable strategy to achieve their goals and typically had a clear understanding of the required skills and competencies to drive the strategy forward.

One case study establishment located in the top left hand quadrant had taken the conscious decision not to manufacture lower tier goods but concentrate on assembly and producing the systems to run their goods (i.e. they were concentrating on their core competencies whilst adding value to the consumer). In order to facilitate the implementation of this strategy the firm developed a proactive, long-term approach to skill deployment and were actively developing all levels of their employees. The combination of these strategies was paying dividends as the firm was achieving better than the industry average levels of performance.

Many of the firms which are achieving better than the industry average are located in the bottom left-hand quadrant. Again these case studies had developed and implemented clear, long-term appropriate product market strategies and had a clear understanding of the competencies required to successfully carry out these strategies. One establishment with above industry average profitability was located on the boundary of the upper and lower left quadrants. This firm had undergone a conscious shift in product strategy and had begun introducing more product models and moving towards mass producing a lower priced product aimed at a slightly different consumer. This shift in strategy was accompanied by changes in the production processes, which were funded by its new, overseas parent group. These changes were accompanied by a shift in emphasis on training including a move away from concentrating on the manufacturing process per se and towards management and technical training. Management and professional level technical personnel, were recognised as the main competencies required in the long-term, and areas where the firm currently had skill gaps.

The case studies revealed the importance of adding value for the customer, either directly through the product or through adding value in the supply chain. Case studies reported that profitability was increasingly being determined by the service add-ons that firms could provide, which differentiated them from their competitors. There was some evidence to suggest that those case study establishments that were consciously adding value for their customers as part of their long-term strategic planning, were acquiring competitive advantage and securing higher levels of profitability.

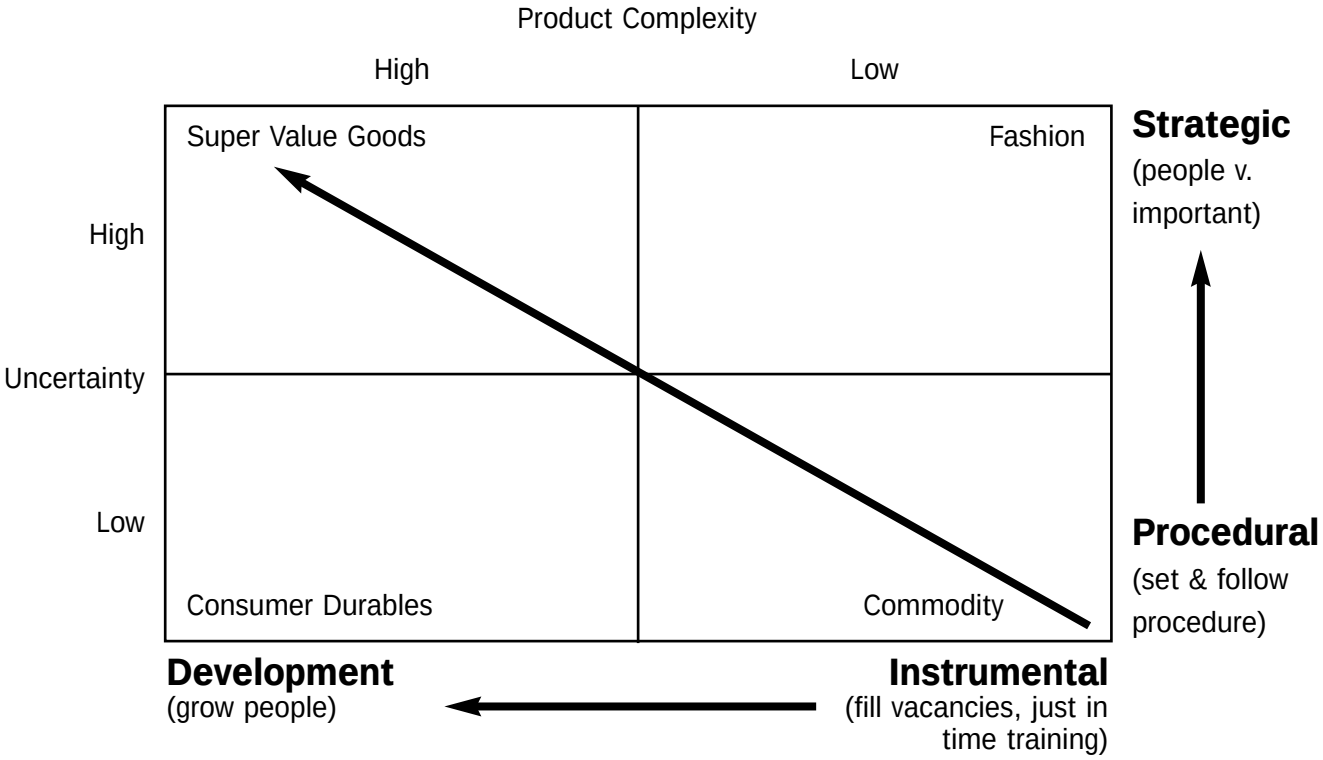
The case studies reveal a correlation between a well-developed, sustainable corporate strategy, above average performance and better management capabilities. Those firms with average and below average performance had less well-developed strategic vision stemming ostensibly from a lack of vision accompanying poor management skills. Whilst some companies in the report recognise that they have gaps in management skills, such as communication and coaching capabilities amongst both people employed as professional engineers and team leaders, few firms highlighted a lack of strategic vision amongst their management team. It is therefore suggested that lack of strategic vision is an unreported skill gap pervading engineering firms with below average performance. What is highlighted by the Grid grouping of establishments on a comparative basis in this study, is at least

three types of apparent mismatch between an establishment's Grid position and the skill sets that you would expect to find for good business performance. In some cases the mismatch reflects a shortage of particular skills relevant to that quadrant, in others the impact of latent skill gaps, e.g. in management, and in others the mismatch is between skill sets and strategy, either consequentially or by default.

The concepts of product life-cycle are particularly evidenced by the companies in the bottom right 'commodities' quadrant where two of the four are struggling for survival with very mature products. In addition, a number of the better performing case study companies have production ranges displaying multiple product life-cycle characteristics, but insufficient data is available for individual products to enable a more detailed view.

Just as there are some possible linkages between grid position and probability of profitability amongst the case study establishments, so there are also some possible linkages between grid position, performance and the level of proactivity of the human resource (HR) function and policy at the establishment. This is developed further in Figure 3.7.

Figure 3.7: Human resources practices



Another hypothesis is proposed stemming from the evidence gained from the small number of establishments in this study. That is, that the more complex the product strategy, and the higher the level of performance, then the more sophisticated the HR policy in operation at the establishment level. There is some evidence that those case study establishments, whose product is located within a relatively unsophisticated mass produced market have an instrumental HR policy in operation at the establishment. Within these establishments the HR function basically ensures there are enough 'hands on deck' to keep production flowing smoothly and training is typically supplied in a just-in-time fashion. HR policy tends to be reactive, and established in order to ensure employees effectively follow procedures, rather than being part of a long-term strategic vision. Often the recruitment of shop-floor staff, who are typically undertaking unskilled work, is hived off to a third-party, external agency in order to keep labour costs down. This situation was evident at the two establishments achieving below average profitability.

The evidence from the case studies suggests that the further to the left within the Puttick Grid that an establishment is located, and the more complex the products that they produce, the more likely it is that the establishment's HR policy is proactive and concerned with developing people to ensure that they possess the appropriate competencies to drive the business forward. This can take the form of internally developing people or subcontracting out professional level occupations, sometimes on a global basis. What seems to differentiate these firms is that they have a long-term strategic plan for resourcing the competencies they require to successfully implement their product strategy.

Firms with above average performance in these quadrants are typically in the process of developing a long-term strategic view to skill resourcing. Those firms that then implement the strategies to develop the required competencies, are more likely to achieve a higher than average industry level of profitability. Again, the distinction lies with the management team in having the appropriate strategic vision to ensure that their directives, or those driven by head office, materialise at the establishment level. The case study evidence therefore highlights that the capabilities of senior management in driving the processes to achieve productivity targets and add value in order to achieve competitive advantage are crucial in achieving above industry average levels of performance. There is evidence of shortfalls in the capabilities amongst senior management teams in achieving these goals in the UK engineering sector. Rather more worrying, is the fact, that in many instances, these skill gaps are unnoticed and unreported at the establishment level.

4. PRODUCTION PROCESSES

4.1 Identification of Critical Functions

The research was designed to identify critical functions in the engineering establishments, but in practice respondents found it exceedingly difficult to differentiate between critical and non-critical functions. Only when establishments were faced with making redundancies was there a sharper appreciation of the non-critical components of the overall production process. Respondents, however, felt most comfortable discussing the following aspects of the business:

- the manufacturing process (or the service process in one case);
- marketing and customer relations;
- research, development, and design for manufacture.

The principal drivers relating to each of the above, as outlined in the discussion of product market strategy, were efficiency, quality, and customer relations. Meeting customer needs had increased substantially in importance in a sector where some managers openly admitted that production schedules were run for the benefit of the company rather than the customer. One establishment, for instance, reported that only 70 per cent of output left the factory on or before the date the customer was expecting delivery.

The deployment of knowledge and skill was, in several establishments, in a state of fluidity. Changes in working practices, managers reported - confirmed by other research such as the Workplace Industrial Relations Surveys - endured a radical shift in the early 1980s as a deep recession affected the manufacturing sector. Once many of the industrial relations obstacles to effecting on-going change in working practices - essentially introducing a greater degree of functional flexibility into the workforce - were removed, management had a greater degree of control over the deployment of labour on the shop floor. Managers were now in a process of a continuous improvement to the organisation of labour through incremental change

4.2 Technology and Work Organisation

The main changes in technology and work organisation were largely associated with improving the production process through fixed capital investment and organising work to increase flexibility. Many of the changes identified were not new concepts but modifications or incremental improvements to existing systems. In other instances, and much less commonplace, the introduction of working practices such as cellular manufacturing and multi-machining were new concepts and new ways of working that represented a radical shift in the way that work was traditionally organised.

One case study company from the consumer electronics sector, for example, had instigated a Total Quality Management (TQM) awareness programme right across its shop floor, operating at different knowledge levels from practitioner to technician, team leader and manager. Their underlying objective was to try and improve their relatively high reject and rework rate that they suffered at a late stage in the value adding process. The programme was spurred on by the relatively poor comparison between the UK plant and other overseas establishments in the Group - together with the criticism that the UK plant was not good at systematic problem solving.

Radical change tended to emerge where establishments were experiencing product market difficulties (see panel).

Case study:

To ease its dependency on one main customer, which itself operated in a highly cyclical market, one precision engineering company had diversified its product range and introduced a completely new product. Its successful development and manufacture was dependent upon investment in new process technologies and the introduction of new working practices, such as cellular manufacturing which shifted the skills requirement on the shop floor from semi-skilled to skilled. These changes were driven by the managing director and the newly appointed works manager rather than the HR function.

Implementing the introduction of new working practices was very much the responsibility of the HR function. This proved to be a sensitive matter given the resistance of the workforce to the proposed changes. In part, resistance stemmed from a feeling of insecurity from existing staff that was assuaged by the commitment to provide development and training to the existing workforce.

It is evident that the human resource function is not the initiator, but rather the facilitator of changes to working practices and technologies. Operational managers, at both senior and middle levels, are taking a much more proactive role in the design and implementation of these types of changes. The responsibility for changing working practices is increasingly being spread across a variety of manufacturing-led functions as firms try to reduce costs within the manufacturing process. Effective management and employee development are seen as critical components in achieving the efficiency improvements associated with the implementation of a lean manufacturing culture.

Technology was not only being introduced to facilitate improvements in the production process but also used as a mechanism to allow better target setting and identify the productivity improvements achieved. This process was evident in an aerospace manufacturer, where information technology was driving the business improvement programme. Continual investment in technology was perceived as necessary to achieve and maintain competitive advantage in cost, flexibility, and quality. Technical change was often directed towards standardising production processes, which in turn assisted with quality maintenance.

The introduction of technology into the production process had two consequences: (i) there was a reduction in the number of people required to work on a process at four establishments; and (ii) skill content of jobs was changed. Previous research evidence has demonstrated that the introduction of new technology did not always feed through to the introduction of new working practices. It was only when there was a critical mass of new technology on the shop floor with a degree of mismatch between technology and work organisation such that the production process had become dysfunctional, that new working practices were introduced. It was apparent that technical and organisational change now goes hand-in-hand.

The main types of organisational change introduced were project working in two companies, team working at three others and various forms of cellular manufacturing in others. One of the key impacts has been on the role of the team and project leaders as shown by the case study from the defence sector (see panel).

Case Study:

Changes in the nature of the product market meant that rather than people working on large-scale projects in large disciplinary teams, people were moved into smaller, multi-disciplinary business units based around the new project areas. This afforded the company flexibility and improved productivity, as people were more responsible for the entire consultancy and service process. Project leaders were established who ran the newly appointed teams and who were responsible for all project management activities. This introduced a requirement for new skills including tendering, budgeting, people management, customer liaison and time management skills - many of which were new to the post holders. Individual team members also had to develop good customer liaison skills as much of their role now consisted of working with customers to develop solutions. The role of the team and effective team working were thus critical factors in business performance.

Certain companies had experienced problems instigating changes in working practices and grading structures due to strong resistance either from the shop floor employees directly or through the trade union. This was particularly evident at three establishments where resistance was related to perceived threats to the establishment's 'craft' skill base. The case studies had all found mechanisms of overcoming such resistance and ensuring that change was adopted.

Changes in work organisation have had a significant impact on the production process. The majority of establishments in the study were in the process of restructuring organisation of work usually through the introduction of improvements to existing working practices. Overlaying this was an attempt in several establishments to create a human resource strategy that developed staff responsibilities (especially in relation to team work). Several of the case study establishments were part of multi-national corporations. Though the focus of the study is upon the single establishment, developments at a parent company level can have a swingeing impact on how work is organised at establishment with repercussions for the deployment of knowledge and skills. In one case, the company had established at a multi-national level, a degree of expertise that could be deployed globally (see panel).

Case Study:

The parent company to which the establishment belongs has a turnover of £4bn. The management structure of the company as a whole operates as a matrix with HQ based nominally in the UK, responsible for vertical functions including information systems, human resources, and engineering, and with horizontal direction of three regional groupings, which span Europe, Asia/Pacific, and the Americas. Some of the major horizontal businesses have a turnover of around £300m.

The aim is to centrally retain much of the knowledge that guides the worldwide business by developing a team of people who foster a greater level of knowledge development and management processes. This team is comprised of around 150 individuals who are on the move most of the time to shift information across the group. The result, if the process in the end proves to be successful, is to avoid potential skill gaps and recruitment problems at the highest levels amongst the company's establishments by developing a core of expertise.

Similarly, at a Japanese multi-national the aim was to retain much of the production knowledge in Japan and to dictate to the UK establishment the product range and the production system for manufacture. Again, a whole set of skill and knowledge issues are removed at the establishment level.

At a more routine level a whole set of organisational changes were evidenced across the case study establishments, such as improvements to team working. Here, the production process is broken down into small units, which operate as a team with a number of specialist skills involved but with one person with overall responsibility for its effective functioning and resourcing. In this way, engineering firms are passing the responsibility for productivity, efficiency and quality down to these individual teams and their team/cell/business unit leader. In two companies, for example, cellular manufacturing had recently been introduced with team leaders replacing the traditional supervisory/foreman role to occupy a quasi-middle management position. Similarly, at two other establishments, employees had been re-organised into multidisciplinary and multi-functional project teams, which were more able to effectively cover all the aspects of the work to be undertaken.

A wider knowledge base and more flexible deployment of skills are now vitally important. Flexibility was largely being sought by changing the work roles of operative level employees. Rather than employees being recruited and trained to undertake a particular role (at whatever level) in the production process, employees were increasingly expected to be able to work on more than one machine concurrently and possess a wider set of competencies. This was not a radical departure from previous working practices; rather it is a desire to further changes that were initiated in many instances during the 1980s. One also has to be careful in suggesting that multi-skilling was being undertaken from a job enrichment perspective where a higher set of conceptual skills was being acquired. In many instances what was being observed was a process of job enlargement without any concomitant heightening of skill levels.

In further developing team working there has been the need to improve the exchange of information on the shop floor, especially between manual workers and management. Team leaders, for instance, at one company, were encouraged to challenge design engineers relating to how the product was manufactured, when they, the team leaders, were held responsible for production times (see panel).

Case Study:

This establishment produced pumps and valves with a turnover of £80m a year. A team leader explained that she had responsibility to meet daily targets and record and monitor achievements. The team leader had previously been a production worker and was now expected to motivate and discipline this group as necessary. Communication skills were required to inform various levels of management of the problems that were occurring and offer suggestions as to how they might be remedied.

The company had set up ‘brainstorming’ meetings where team leaders and management could discuss how changes could be made to the production system. This had been facilitated by a new Works Manager who operated an ‘open door’ policy. Nevertheless, obtaining the exchange of information on the shop floor between different levels of employee was not without its difficulties.

As the case studies also reveal, some of the companies have been looking critically at the processes for getting essential work done. Although in most cases, not yet advanced, there is some thought about the possible alternatives to traditional working practices. For instance more than one of the case study establishments has set up software departments abroad where the supply (and sometimes the cost) of appropriate skills may be more favourable. Another of the establishments was now considering whether they could further develop the idea of taking work to where the suitably qualified people were, rather than the old model of recruiting people to move to an established site. Clearly this new approach has its limitations, but facilitated by technology, it is likely to have an increasing place in the future.

4.3 Efficiency and Supply Chains

Supply chain pressures complemented by more sophisticated and professional buying practices are tending to expose companies much more to the ultimate market than in the past. This in practice tends to mean more production to order or that production needs to flex to suit the market conditions being experienced by the ultimate customer. Thus, instead of long production runs most suppliers now need to be able to undertake shorter runs with many more changes of product or specification to reflect ultimate sales.

Many establishments are supplying their customers on a daily or even more frequent schedule, which may change at short notice. Part of this is driven by continuing cost pressures (one of the customers of a case study establishment has expressed a target of price reductions of 20 per cent a year) and part is driven by the increasing tendency to share risk down the supply chain.

Also evident was the possibility not only of passing risk and responsiveness down the chain, but also of buying in greater added value. This was seen in a number of areas where the supplier had been given the opportunity (or had generated it through innovation and new product suggestions) to supply a larger and more valuable package to the customer. Thus more sub-assemblies might be contracted out to suppliers, and more complete systems are sought so that the customer higher up the supply chain simply plugs in a complete system to their product.

In some cases, the new production technology was simply imported direct from elsewhere in the company, but in others - even though they may be part of a group with a number of similar manufacturing units world-wide - the changes and developments have been made purely on a local basis, even though there may have been a sharing of best practice with other plants. There is also evidence of the value of partnerships with machinery and equipment suppliers, consultants and others in achieving this change. There is no doubt that the ability to make such changes in manufacturing processes is an important one, and greatly dependent upon the leadership and skills available to do so.

Customer care has become an increasingly important part of the manufacturing process - including customer participation in the research and design process. The extent to which the customer influences the working practices of the firm will depend on the firm's position in the supply chain. For instance, where the OEM changes its work organisation, production techniques, and product specifications the component supplier may be pressed to take on board similar processes. Several establishments were increasingly linking their manufacturing strategy and their working practices to

coalesce with those of their principal customers on the next link of the supply chain. One company engaged in instrument engineering, had invested in video-conferencing technologies so that they could simultaneously work with their customers throughout the manufacturing process. Similarly, another company, an aerospace manufacturer, had made customer service a priority, establishing it as one of its key values and a measure through which to benchmark its performance. As a consequence, good project management, communication and customer service skills were becoming more paramount.

Similar processes have also been evident within the research and design function. Research, development and manufacturing design now tends to occur through multi-disciplinary teams working on small projects. The aim being to accelerate product design stemming from global competition to shorter product cycles and the need for rapid prototyping. The research, development and design for manufacture process have therefore gained in importance as a greater number of new products and variants have been developed due to this shortening of the product lifecycle. In turn, this has given rise to a demand for engineering professionals and specialists to possess both high level technical and project management skills.

4.4 Conclusion

Understandably, case studies were not thinking through their production processes and skill sets in Puttick Grid terms and relating particular functions as critical to their success. It was more worrying that many establishments did not seem to be aware that they did have some processes that were more important than others in terms of the skill sets that would be more likely to lead to business success. However, it was more reassuring that many of the companies that were located in the bottom left Grid quadrant (see Figure 3.2) were focusing on issues such as cell manufacturing and team working, germane to their quadrant (see Figure 3.3). Many of the skill set requirements that the OEM had, are being migrated down the supply chain as more responsibility is passed to lower tiers. This includes higher levels of customer contact skills and in some cases, design skills.

5. SKILL NEEDS, RECRUITMENT PROBLEMS AND SKILL DEFICIENCIES

5.1 Organising the Human Resources (HR) Function

In the majority of case study establishments the HR function was fulfilling a wide ranging brief relating to the development of staff rather than a more limited one of providing personnel services (i.e. dealing with contracts of employment, or disciplinary problems), or simply concerned with the provision of training. Previous evidence has demonstrated that policies designed to foster skill and knowledge development work best when embedded within an HR policy that seeks the wider development of employees.

The organisation of the HR function varied between establishments. In one case it was directed globally from the head office with a brief to troubleshoot on a world-wide basis. In other instances the balance of HR decision-making was at the establishment level. The location of the HR function indicates the level of control being applied from the top and the degree of autonomy that establishment based staff have for dealing with local HR issues or for managing technical or organisational change. It also sometimes reflected the position of the establishment in the supply chain. The smaller the engineering establishment, often with a concomitant lowly position in the supply chain, the less established and influential the HR function. However, in some situations the OEM HR strategy is passed down the chain from customer to supplier. In this sense, knowledge transfer can be an important function of the human resource activities of OEMs, especially where they are demanding annual cost savings from their suppliers. On the whole, however, the role of the HR function at the establishment level was to ensure that the current staffing was adequately equipped to allow the successful maintenance of the production process, rather than associated with long-term, strategic planning.

Within the establishments there was evidence that the HR function was becoming spread across other functions. Typically team leaders and production managers had increasing amounts of responsibility for the development of their staff, although usually this was mediated through the structures established by the HR department at the establishment or at the parent company.

5.2 Translating Product Market Strategy into Skill Needs

The model that emerges from the case studies is that of product market or business strategy being conceptualised with respect to manufacturing capability. Decisions are made about, for example, new product development or efficiency gains and articulated with respect to the engineering processes required to manufacture the product. This feeds through to the design of processes that need to be put in place and then the organisation of employees throughout those processes. HR strategy often appears to be of second or third order importance when product market strategies are articulated by management, although in practice the supply of skills is vitally important to realising product market strategy.

Rarely did an appreciation of an establishment's skill base affect business strategy and when it did so it was with respect only to the most senior of staff. For instance, one company's decision to introduce a new range of luxury cars was contingent upon being able to develop a design function and recruit or second a number of senior designers. It should be borne in mind that business strategy was often constructed at some distance from the case study establishments. In another case, the detail of the establishment's business plan was made in Japan with only a limited amount of autonomy at the local level. The amount of business strategy information that is passed down from the parent company can often be limited and treated confidentially by establishment management.

5.3 Meeting and Identifying Skill Needs

Management of change was on going in the majority of establishments: whether this referred to the development of new products, new processes or more efficient working practices. Globalisation was one of the key drivers in this respect. Several establishments recognised that in order to effectively manage change they needed the support of employees and their agreement to take on new roles and possibly new skills. One company involved in aerospace exemplifies this approach (see panel).

Case study:

Human resource planning was fully integrated into the strategic decision making process through its incorporation as one of the key values driving the business. Its 'People Value' activity encompasses a wide range of employee development activities designed to facilitate personal development and organisational change which the company hopes will drive the business forward in the desired manner. It is recognised that without effective human resource development and planning the company will not be able to achieve its long-term strategic goals.

This policy was required because it was recognised that without support of employees the establishment could not operationalise its new business objectives. Management relations had previously been the strained and considered autocratic and it was therefore difficult to get employees to buy into new strategies. Changing the skills profile of the workforce, if it was to be effective, required changes in management culture and the development of human resource policies that would foster employee commitment.

The case study establishments in the main identified skill needs in terms of those skills required to sustain production targets which in turn are dependent on the economic cycle. Several case study establishments reported that they were at the trough of the economic cycle - blaming the strength of sterling as the principal cause of their business difficulties. In certain case studies this had led to redundancies, particularly on the shop floor. One case study (in the lower left quadrant of the Puttick Grid) had recently issued compulsory redundancy notices to nearly a fifth of its production workers. For others, the downturn in business demand coupled with the drive to achieve greater efficiencies had halted recruitment.

The recruitment taking place was largely for managerial and professional occupations rather then production based positions. The stage of the economic cycle for the engineering industry is one of the underlying reasons why recruitment of engineering craft workers was not being cited as a major problem. This coupled with the drive for efficiency in the production process - via new working practices and continued automation - meant that the number of shop floor operatives required was

falling in several establishments. This was clearly evident at several aerospace plants where the introduction of state of the art technologies and flexible production teams had reduced the number of shop floor employees required.

Despite the pessimistic business picture portrayed by certain establishments, there were individual establishments that were experiencing an increase in demand and were actively recruiting employees. One precision engineering case study had recently recruited a significant number of skilled employees as setter-operators on the shop floor in response to raised demand following the diversification of its product range. To effectively manage the introduction of the new product range the decision was taken to restructure the skill base on the shop floor through up-skilling. Up-skilling was achieved through recruiting new employees and retraining existing employees. One defence-related engineering firm had also undergone a significant recruitment drive in response to increased market demand and rising sales. This company had recruited one hundred professional engineers during the past twelve months, increasing its workforce by around 15 per cent.

Respondents suggested that the payroll was now so tightly controlled that it was difficult to hoard skilled labour when work was unavailable and so recruitment usually coincided with an increase in product demand. Several case studies controlled cyclical fluctuations in demand for goods by using temporary agency workers who could be recruited and disposed of in response to market demands. This was evident at several case study establishments where the manufacturing process deployed utilises unskilled labour that is economical to substitute.

Where recruitment was occurring there were several underlying factors driving it:

- an increase in demand for products (i.e. business expansion);
- to bring in new young people into the organisation through apprenticeships and graduate training schemes in order to meet future skill requirements;
- to replace skills leaving the firm through employee turnover, although turnover was very low amongst the case studies, the exception being those which employ a large number of low skilled employees;
- to introduce new skills associated with qualitative changes in the job content following the introduction of new products or working practices.

Amongst the case studies recruitment tended to be reactive, with recruitment occurring mainly in response to rising product demand or changes in the engineering processes utilised. Much of the recruitment drives undertaken were fire-fighting exercises to ensure that current production demands could be met. There was very little evidence of long-term planning for future skill needs. Larger establishments were more likely to employ mechanisms to determine which skills and human resources they were likely to need in the long-term; although this was typically very general and was not undertaken at the occupational level.

5.4 Replenishing the Skills Base

Part of the process of managing change was identifying the competencies and skills that the establishment required as it underwent the restructuring process. This, in part, was related to the recruitment of apprentices and recent graduates with several organisations recognising the need to have a supply of new recruits.

An important aspect of recruitment was the ability of companies to present themselves as the 'company of choice for the best staff', offering secure, progressive, career opportunities. The recruitment process generally remains the responsibility of the HR function at the establishment level. In contrast, identifying the skills required is part of a much broader process of management. Recruitment drives were often the result of operational level management noticing that they did not possess the human resource capacity required to fulfil their production targets. Similarly, identifying those skills, which had become obsolete was the responsibility of production managers with HR often acting in an advisory capacity.

The flattening of traditional management hierarchies means that there are few layers between the shop floor and the works manager. The function of the first line manager has gained in importance in ensuring that production objectives and targets are met. As a result, the works manager (or equivalent) is increasingly involved in the selection process of team-leaders (or equivalent). The rationale being that these employees have a vital role to play in rolling out the changes on the shop floor. In one establishment for example, the works manager wanted to be involved in the selection process for his cell-leaders as he felt he knew the attributes he was most closely looking for to allow the effective implementation of the production strategy. This development was evident, whether team leaders were recruited internally or externally. One company for example, had recently recruited their team-leaders from the shop floor and the operations manager noted that he wanted to be involved in the selection process because he knew exactly the characteristics he was looking for and wanted to put hypothetical situations to potential applicants.

Recruitment of professional and managerial level engineers tends to be nationally and even, in certain instances, internationally focused. Recruitment for shop floor and team/cell leader type positions tends to be undertaken locally. Recruitment was becoming increasingly formalised and systematised: more stringent aptitude testing for the shop floor applicants was common. Again, at the shop floor level, establishments were actively moving away from recruitment merely through word-of-mouth and by family association, which had been important in the past, and were setting more stringent recruitment criteria.

The use of third parties to recruit employees and solve recruitment problems was reported as being on the increase. This was particularly evident in engineering establishments where shop floor work was largely unskilled, assembly work and where there was high staff turnover. At three establishments there was a high proportion of agency workers on the shop floor, which acted as a buffer to counter fluctuating production demands. The temporary agency used by one company - final assembly of consumer electronics - had an office on the factory site. At another, the recruitment of permanent personnel was outsourced to a recruitment agency.

5.5 Recruitment Strategies

Recruitment of Apprentices and Graduate Trainees

Engineering has traditionally been engaged on a cyclical pattern of apprenticeship training associated with the fortunes of the economic cycle. Ostensibly, apprenticeship training coincides with positive economic conditions and is withdrawn during economic troughs. This pattern of cyclical engagement with apprenticeship training is a characteristic which has perhaps traditionally been more prevalent in the UK engineering sector than found amongst competing countries engineering industries and has diminished the number of young people entering the industry. The parent group of a car manufacturer included in this study, for example, had abolished apprenticeships across the group in an effort to contain costs. Similarly, several establishments had traditionally offered apprenticeships but had recently halted them - only to start them, albeit on a much smaller scale. Other engineering establishments reported that the demand for apprenticeship training had decreased because of the trends in automation outlined in previous sections. One engine manufacturer had abolished its apprenticeship scheme because much of its manual work had become semi-skilled and its demand for engineering craft workers could be satisfied by recruiting fully experienced workers. The way in which apprenticeship training is undertaken has changed within several of the establishments. One car manufacturer for example had outsourced the recruitment and training of its apprenticeships to a local college who had control for the entire apprenticeship process from recruitment through to certification. This strategic move had allowed the car manufacturer to enjoy a significant cost saving whilst ensuring consistency of training delivery.

Where apprenticeship schemes existed, establishments reported few difficulties obtaining recruits - typically through Modern Apprenticeships. Only one case study a precision engineering plant noted any difficulties recruiting young people onto its apprenticeship scheme. Although there appeared to be little evidence of firms experiencing problems recruiting apprentices, establishments reported, as is usual, that the standard of applicant and recruit was falling. In addition, establishments were utilising different recruitment criteria in the selection process based around problem solving skills rather than just an aptitude for engineering.

Four case study establishments had their own graduate recruitment programmes. These establishments did not report any significant difficulties directly recruiting graduates and all had well-established links with university engineering departments. These links had largely developed to ensure that the establishments were able to directly recruit graduate engineers with the specialist skills they required which had been problematic in the past. One case study for example had strong links with a leading engineering oriented university which produces candidates with their exact skill requirements. Another case study meanwhile was developing a MSc programme with a local university in order to ensure that they could recruit graduates with the appropriate skills. In all cases these establishments were located toward the top left of the Puttick Grid. While the employment of good graduate-level employees (particularly in engineering) was seen as important by most of the establishments, many of them did not have sufficient resources to undertake their own training and development programmes for graduates. Not only was this decision associated with the immediate costs of such programmes - in an environment for those at the bottom right of the Grid where cost pressures are both intense and intensifying, but also with the difficulties of providing a sufficiently broad development programme, and of retaining trainees beyond their initial 1-2 yr training period.

Although the majority of case studies reported few problems with the quantity of engineering graduates there were concerns raised about the quality of engineering graduates; particularly given the larger numbers of people passing through higher education. One case study in particular noted that they had noticed a fall in the basic mathematical capabilities of graduates and had had to instigate training to rectify this problem.

The case studies did reveal that there were differences in the extent to which the establishments were able to access graduates taken in via the company graduate training schemes. Those establishments which were head office sites or the main manufacturing site were less likely to note any problems acquiring graduates than those establishments which are considered more peripheral in the company structure. Two establishments for example noted that it was extremely difficult to attract graduates who were recruited via head office noting that they were like 'gold dust' at their particular sites.

Recruitment of Experienced Employees

Recruitment of semi-skilled and unskilled shop floor workers was carried out largely through word-of-mouth, advertisements in the local press, and advertisements in Jobcentres in the local labour market area. Word-of-mouth was recognised as an important means of recruiting for shop floor workers. However, there was some evidence that certain establishment's were looking away from this informal method of recruitment and were employing more systematic recruitment strategies to ensure that new shop floor employees had the prerequisite skills. Two establishments for example had introduced stringent selection procedures rather than merely employing people on the recommendations of existing employees. These new procedures included such factors as aptitude tests and mechanical assembly tests.

The wage rate for the job was set in nearly all instances by the establishment or company level bargaining. For many companies reputation was important in attracting applicants. One precision engineering plant, for example, had never had to advertise for its skilled shop floor positions as the HR department had a good supply of speculative applicants from which it could draw because of its reputation as a 'good employer'. Despite the fact that an engine manufacturing case study only offered new shop floor employees three month rolling contracts they had few problems attracting employees due to their reputation as an employer with good pay and conditions in their local area.

Certain case studies had decided to subcontract out their recruitment of shop floor people to temporary employment agencies to reduce costs and ensure maximum flexibility on the shop floor. One component supplier case study used a temporary employment agency to screen prospective candidates who would then, following a trial period, be taken on a permanent basis if the business environment allowed it and they displayed the appropriate skills and mindset. This 'try before you buy' approach to recruitment was particularly appropriate when much of the shop floor work undertaken was unskilled in nature and there was a higher than average rate of labour turnover. By utilising this form of recruitment the case study reported that it was able to lower its rate of employee turnover and make significant cost savings as it reduced its recruitment and induction training budgets.

Professional level employees were drawn from national and increasingly international labour markets. Conventional recruitment means were reported as being of little use for this group of employees because there was perceived to be an absolute shortage of suitably qualified and experienced

professional engineers. New forms of recruitment were being used in order to try to secure the required skill base including head-hunting, word-of-mouth between specialists and utilising subcontractors. The consensus was that experienced professional and managerial level engineers are becoming increasingly difficult to recruit; particularly those with a high level of combined technical and managerial competencies.

The engineering sector has for some period of time used temporary subcontractors to undertake specialist and professional engineering activities such as design and research and development. The rationale behind the growth in the use of this type of employee was that they were only required periodically and it was more cost effective to bring them in to undertake specific projects and then release them without cost once the project was complete. An automotive manufacturing case study, for example, has subcontracted a large proportion of its design function out as it believed this to be an extremely cost effective method of managing human resource costs and keeping the company as lean as possible.

The growth of subcontractors within particular engineering areas such as design has escalated significantly during the latter 1990s as professional engineers have recognised that they can earn significantly larger salaries by pursuing this employment option. Several establishments employed a large number of consultants on lengthy projects. This was not thought desirable because it created problems of containing knowledge - often of confidential processes - within an organisation.

It also meant that recruitment problems intensified because as more professional engineers become sub-contractors rather than wanting to be direct employees the pool of potential applicants is shrinking. In certain instances, establishments were faced with employing subcontractors merely because the pool of people with the appropriate specialist skills had diminished. This was clearly the case at one defence engineering case study which has now consciously limited the proportion of agency and subcontractor workers employed within any project team so that quality of work can be assured and labour costs contained.

At a professional level there was a recognition that a given level of labour turnover is of benefit to the company since it often relieves bottlenecks in the occupational hierarchy and allows new people, with new ideas to enter the organisation. Companies however expressed concern that they felt they were more likely to lose employees who had excellent technical, managerial and innovative skills rather than attract them. Losing them either to consultancies or to rivals paying higher wages. The shortage of professional engineers with the desired mix of specialist technical and managerial skills had in certain instances stimulated wage inflation as employees move between firms to bid up their earning capacity. One case study noted that this was becoming a problem because of the highly competitive market in which they operated they felt that they were unable to raise wages significantly higher as this would undermine the cost base when tendering for projects. This was therefore putting the establishment at a disadvantage when recruiting such individuals.

These issues are more likely to affect companies in the top left Puttick Grid quadrant and to potentially limit their capacity to take full advantage of their position in that quadrant. They will also impact companies that may be aspiring to a higher level of innovation and which may be trying to move products or services into that more innovative quadrant.

5.6 The Nature of External Recruitment Problems

The majority of establishments reported some recruitment difficulties but these were on the whole limited and represented only a small proportion of the total people employed at the establishment. Hard-to-fill vacancies were mainly found when recruiting professional engineering specialisms. This problem was largely associated with difficulties recruiting experienced professional engineers rather than the recruitment of new graduates. The most difficult to fill vacancies were for established graduates with around 4-5 years commercial experience with the appropriate mix of technical, commercial awareness and managerial competencies. Establishment's lamented that professional engineers were often good technically and could produce engineering solutions to technical problems but often had weak business and managerial acumen. The key problems related to:

- the fact that the labour market is extremely tight nationally for particular engineering specialisms and wage inflation is high in these occupations;
- the increasing importance of the pre-production phase of the manufacturing process e.g. research, development, design and systems analysis, has raised the demand for the number of people required in these higher level occupations;
- the rapid growth of subcontracting in many parts of the engineering sector has drawn people out of permanent employment in order to reap the financial rewards of being a self employed consultant and;
- the qualitative shift in the skill portfolio required of professional level engineers in order to meet the evolving needs of the business. This essentially has involved the need for project management, commercial awareness and people management skills coupled with up-to-date technical skills.

The case study illustrated in the panel highlights the difficulty of recruiting professional engineers.

Case study:

This case study was involved in the nuclear and defence industries. The company had been trying for twelve months to recruit around 100 professional engineers (mainly mechanical engineers and structural analysts) in order to keep up with the amount of design and consultancy work the establishment had captured. This was a slow process and the firm experienced difficulties recruiting structural analysts because of the specialist nature of the skill and the fact that there are a finite number of people in the UK with this skill and they tend to move between companies in order to command higher salaries.

The company had had to turn to 'head-hunters' to identify prospective employees. This was considered an expensive recruitment strategy, as the positions they wanted to fill were relatively junior. Other tactics included introducing overseas employees, however this was causing problems due to language problems stemming from the high level of customer contact required during project work. The company also utilises agency workers to overcome recruitment difficulties - which in fact perpetuates its recruitment difficulties.

A large proportion of recruitment difficulties associated with professional engineers were not temporary but well entrenched and were considered to be intensifying as the demand for these employees continues to rise and outstrips the available supply. One aerospace engineering case study for example had long established entrenched problems in recruiting and retaining software engineers to work on its aerospace systems. This was principally attributed to the fact that there were not enough people with the right skills being produced through the education system. The demand for these particular employees had risen across the engineering sector per se and the establishment felt unable to compete with other industry sub-sectors due to its geographical location in the West Midlands and the salaries it was able to offer. In order to resolve the problem it had created a new software engineering function near to what it perceived to be a good supply of these engineers in Belfast and begun re-grading its professional engineers in order to give them better career opportunities within the firm.

The case studies did not report any significant difficulties in recruiting shop floor, traditionally craft skilled employees. Indeed, it would appear that the trend is for the number of such workers to decline in the sector as a whole and whilst particular establishments may experience recruitment difficulties from time to time, on balance the picture is one of few recruitment problems for the sector. The drive to reduce costs within the manufacturing process had lead to the continued introduction of new working practices and investment in more sophisticated technologies outlined previously which have reduced the number of employees required to successfully operationalise the production process. Recruitment difficulties associated with shop floor level employees were only apparent in tight local labour markets where competition for this type of labour was very fierce or where labour turnover was very high when the nature of the work is unskilled.

5.7 Responding to Recruitment Problems: Training and Development Policies

The larger engineering companies had separate training departments, built largely around and for their apprenticeship schemes. The view of these establishments was that the successful implementation of their chosen product market strategies depended upon having a workforce with the appropriate skills to effectively carry out their jobs and to grow with changes in their job roles. Training was supplied throughout all the case studies examined, although it was usually undertaken largely on a reactive basis to fill an immediate skill need rather than proactively considering what skills the company will need for the future.

The extent to which the establishments were aware of the exact skills and competencies held by their employees was mixed. Mainly, the establishment's reported some basic form of skills matrix which had fallen into disuse or was not kept up-to-date either in terms of the changing competencies associated with evolving job roles or as people received training. Skill matrices were not used to assist with identifying training needs or skill gaps. This situation was changing in some establishments with skill matrices being re-introduced and re-developed. The responsibility for ensuring skills matrices were completed was in some cases being passed down to the cell/team leaders. This was the case in one engine manufacturing company where skill matrices were placed on the team board and the ownership of them passed onto the individual teams.

Skill matrices tended to be limited to technical competencies and often ignored softer skills, such as team-skills, communication skills, and management skills. Intriguingly, it was the softer skills where deficiencies were often reported by establishments. This situation has been recognised by one company which used to spend 80 per cent of its training budget on the manufacturing process but has now fallen to 30 per cent with the emphasis shifting towards management skills training. Another had introduced an employee development programme incorporating an on-site open learning resource centre facilitating life-long learning and linking people's personnel development plans directly to the core values of the company.

One consumer electronics company for example had recently developed a competency matrix for its engineers spanning five grades from 'engineer' to a 'senior manager - engineering'. This matrix specified role, accountability, performance indicators, knowledge/skills/experience and competencies. The last included:

Flexibility	Conceptual Thinking	Initiative
Expertise	Concern for Order & Quality	Creativity
Customer Focus	Developing Others	Teamwork & Co-operation
Analytical Thinking		Problem Recognition

One of the forces driving employee development initiatives, reported by HR management, was the need to more effectively pinpoint where skill gaps are emerging and where training needs to be focused. Part of this process involved passing some of the responsibility for learning and development back to the employee, making the process one of partnership between employer and employee. The responsibility for undertaking appraisals and identifying training needs was not exclusively the role of the HR function but has been devolved down throughout the organisation - often down to team leaders on the production line.

These examples tend to inform and re-inforce our suggestion elsewhere that the more sophisticated and comprehensive approaches to HR and resourcing are more likely to be associated with those establishments nearer the top left quadrant of the Puttick Grid, or those consistently striving to move up the value chain.

5.8 The Impact of Recruitment Problems on Production Strategy

In one sense a recruitment problem is only a problem if it affects production capacity. In practice, employers have a range of options to stop recruitment problems becoming production problems using the external and internal labour markets. Firms in the study were seen to:

- invest greater efforts into the recruitment process in order to secure the employees they require;
- buy-in skills in the form of temporary employees as a reactive solution to overcome threats to production;
- invest in the long-term development of their employees in order to ensure that their labour forces will accurately meet the needs of their long-term production strategies;
- invest in their workforce to try to ensure that their employees are not lured away by rival engineering firms so that recruitment in order to replace employees who leave through turnover is diminished;
- subcontract out areas to third parties so that recruitment is not necessary;
- extend the working time of existing employees via overtime in order to meet production demands.

The evidence from the case studies suggested that establishments used a combination of the above strategies in order to ensure that recruitment problems did not impinge upon the production process and that manufacturing capacity was not undermined. Several case studies had widened their recruitment activities by staging high cost recruitment drives in order to overcome the problems of recruiting professional engineers. These high profile recruitment drives were often considered expensive for the returns that they produced. One case study noted how one such recruitment drive was disappointing and had produced few applicants which they considered below standard and without good technical and commercial skills or without the specialist knowledge they were looking for. They overcame their recruitment difficulty by recruiting people without the particular specialist knowledge but a sound management base and internally developing people with good specialist knowledge but a lack of commercial and managerial experience.

Heightened recruitment drives was not a suitable solution for every establishment, especially where the aim was to recruit staff of a type which was not commonplace in the establishment. Here establishments had little scope to develop these people internally because the establishment itself was unsure of the competencies required to fill a new role until the person with the right qualifications and experience was in place. One car manufacturer faced a problem along these lines (see panel).

Case Study:

This establishment was a car manufacturer that had not introduced a new model for many years. The then parent company had little intention of investing in a new product: as a result both the fixed and human capital in the establishment had waned. With its sale to a multi-national that was keen to see the establishment's product as the pinnacle of its automotive engineering design capacity over the medium-term, capital was made available to introduce a new model with a view to a new model coming out every three years.

The challenge for the company was to reinvent its engineering design facility. This required the hiring of a new design team. This proved exceedingly difficult to achieve because of the shortage of suitably qualified staff both in the UK and abroad. After exhausting traditional avenues of recruitment (e.g. headhunting) and changing its salary structure to attract high fliers, the company decided to (i) obtain assistance from its parent company; and (ii) develop stronger links with automotive design consultants who could be brought onto site as an almost permanent fixture. The plan is not considered ideal because it relinquishes control over the design function and is viewed as something of an experiment whilst the company copes with the change brought about by the introduction of a new product.

Other establishments merely managed recruitment problems through outsourcing functions where recruitment problems proved particularly tenacious. Certain of the case studies had experienced severe recruitment difficulties in aerospace specific activities related to systems analysis, software, and structural design. These establishments did not consider that they had a recruitment problem, but, in their language a 'resourcing' one. They had solved these recruitment difficulties by outsourcing their labour requirements to India, Malaysia, Romania, Australia and Ireland where the required skills were readily available. Technological advancements in ICT technology facilitated these developments. Indeed, one car manufacturer outsourced nearly all of its design engineering abroad and has developed

strategic relationships with subcontractors around the world in order to secure the knowledge and skills they need. In this sense, there has been a globalisation of the labour market for engineering professionals.

Subcontracting and the use of temporary agency workers have become a common solution for engineering firms facing recruitment difficulties. These methods of solving recruitment problems provide quick fixes to the daily running needs of the firm but whilst they may temporarily plug the symptoms they do not necessarily erode the underlying causes. In order for there to be an increase in the supply of appropriately skilled professionals, engineering firms must invest in the long-term development of their employees to create an internal pool of suitably skilled employees with the right combination of skills to allow the business to move forward.

There was evidence amongst the case studies of firms beginning to adopt this approach and 'grooming their own', by employing people with sub-optimal skills and developing them in order that they meet the long-term needs of the organisation. Such strategies may in certain circumstances reduce the need for subcontracting. One car manufacturing case study was investing significantly more of its training budget on developing its managerial capabilities with respect to their commercial awareness, team-leading skills in order that they internally had a management team with the correct mix of competencies.

On the whole the case studies did not report that recruitment problems caused any significant problems which adversely affected production capacity or the corporate trajectory of the firm. On the whole firms considered that they were able to overcome recruitment problems. This conclusion may actually be rather misleading. The limited number of hard to fill vacancies as a proportion of total employees actually could be due to the fact that the case studies utilise a wide array of strategies that provide solutions. Those that are hard to fill, tend to be very tenacious, particularly amongst professional engineering specialisms.

The underlying cause of recruitment problems therefore can sometimes be disguised i.e. the absolute shortage of certain skills particularly at the higher level. Many engineering firms are therefore 'muddling through', which whilst satisfactory in the short-term, may impede upon their long-term competitiveness if the necessary skills are not developed in-house.

The preceding sections have highlighted that the main drivers impacting upon product strategies are mainly cost and quality issues. Recruitment problems must therefore be seen in this context. The direct costs of initiating extra recruitment drives, utilising subcontractors, agency workers and overtime can be quite easily quantified. All these strategies can impose significant additional costs onto the manufacturing process, which are being borne in an era of cost reduction. These costs are going to continue to occur until the case studies establish an internal long-term solution to the problem, which can only really be solved through investment in the development of employees. The combination of the skills required by many of the case studies are extremely establishment specific and it is therefore clear that whilst a certain degree of their needs can be met in the external market, long term investment needs to be made to ensure the firms have the correct skill mix to drive the firm forward.

There may also be hidden costs associated with the strategies employed to overcome recruitment problems. These include factors such as the sub-optimal allocation of resources in the production process or the degree of quality control companies are able to reign over subcontractors and temporary workers who have no particular loyalty to the long term aims of the organisation and whose solutions may merely provide the company with a short-term fix to their problems. These concerns were clearly evident at one engineering company working in the defence sector, which was trying to limit the number of subcontractors they use. To a degree the case study establishments were blind to these types of effect flowing through from a recruitment problem because a solution of sorts had been already found.

As noted at the end of Section 5.5 and with some case studies in these last Sections, recruitment difficulties in design and innovation skills are likely to restrict the capacity of companies to be effective in the upper left Puttick Grid quadrant. But many of the recruitment problems discussed in these last Sections are in relation to production engineers and skills and carry an implication of higher costs, either of employment or recruitment or both. Many of the affected case study companies are in the lower Grid quadrants where cost/price tends to be more critical to business success and which can ill afford such additional costs.

5.9 Summary

Recruitment difficulties identified in the case study establishments related in some cases to purely local factors, such as the proximity of competing employers, or the lack of a well-developed local engineering occupational base in the area.

In general, however, some of the more critical deficiencies include:

- professional engineers in design, development and manufacturing systems. For companies in the bottom right of the Puttick Grid, the main focus is on the development and operation of production systems and facilities; at the diagonal extreme (high value, high complexity), the emphasis is on design, innovation, and customer partnering;
- technician and technical - particularly relating to the operation and maintenance of increasingly complex and automated production and diagnostic equipment. (The routes to these skills are varied - they may be via craft apprenticeship, but may alternatively be from in-house training schemes for ex-operators, for instance.);
- people management and coordination skills - both at the shop floor and professional levels;
- commercial awareness, coupled with good technical understanding and a sound, systematic approach to problem-solving. This was identifiable as a need at all levels, but mostly evident at team leader and engineer level;
- real-time application software development. Two of the case studies (both situated on the left of the Puttick Grid) had found difficulty in meeting skill needs in this area. Their needs were quite specific, and would be difficult to generalise across the industry on the basis of these case studies, as would some of the specific manufacturing engineering requirements;
- IT systems development. In some cases, expressed deficiencies in this area were limiting the abilities of companies to move forward. However, the situation as reported did not seem particularly severe or widespread. Of note, however was the absence of any reference to Internet applications development, an area likely to be of increasing and accelerating concern to many of the establishments and companies in this study.

6. SKILL GAPS, DEFICIENCIES AND COMPETITIVENESS

6.1 Identifying Current Skill Gaps

The hidden skill gaps within the case studies were based largely around the capabilities of the existing professional and managerial level engineers. This may relate to the fact that the HR function often had little responsibility for the recruitment or professional development of senior managers. The fact that very few of the case studies identified that they were experiencing management skill gaps is perhaps indicative of the fact that these crucial skill areas may well remain unnoticed at the establishment level. The weaker skill base of UK senior manufacturing managers vis-à-vis their overseas counterparts such as the Japanese, has been demonstrated in four of our case studies and may in part account for why certain key functions are being withdrawn out of the establishment's control.

6.2 Identifying Skill Gaps on the Shop-Floor

The changes to shop floor workers job roles have largely involved job enlargement so that employees are able to multi-task, albeit usually at the same level. This typically means that production operatives are able to operate more than one machine at once. Such changes in job roles are typically associated with investment in advanced technologies in the manufacturing process and the introduction of new working practices designed to raise productivity and make efficiency savings. Management made few complaints about the average capacity of shop floor workers to meet the performance standards required of them.

Management, however, identified skill gaps with respect to 'soft skills'. A significant number of the case studies noted that there was a gap between the ideal set of team-building and communication skills required of production workers and those they actually possessed. Again, in several instances this was being addressed through seminars and training sessions. Realistically, management regarded the development of these skills as a long-term goal. People employed as operatives or engineering craft workers were recruited because of their technical competency, the other skills required by the establishment could be supplied in-house through training.

Case studies noted that skill gaps at the production operative level are relatively easy to identify as they have a direct impact upon the production process through falling productivity, poor quality control, additional rework etc. Many of the establishments were utilising skill matrices on the shop floor in order that technical skill gaps in production teams could be identified and rectified through training. Certain of the case studies had restructured their skill matrices in order to begin to try to incorporate the softer skills that are increasingly recognised as vitally important for the successful operation of the manufacturing process such as communication skills and team-working. Skill matrices were often displayed on the shop floor so that all team members can see which team members possess which set of skills. Several case studies had skill matrices visible on the shop-floor.

The case studies highlighted that the job roles of people employed at intermediate or team/cell leader levels have qualitatively changed. Ostensibly, the work roles of a large proportion of these individuals have been both enlarged and enriched. The flattening of management hierarchies and the movement to team/project working has broadened the job roles of the team/cell leaders and

many engineering managers to incorporate a significant number of non-technical skills i.e. project management and team-building. This role is now increasingly responsible and accountable for the production process with respect to target setting and productivity increases. The qualitative shift in the jobs undertaken by individuals in these roles has led to skill deficits as people are undertaking roles which were once the prerogative of their superiors and for which they may have been given little training. The main skill deficits of team/cell leaders included, team-building skills, people-management skills, inter-personal and communication skills, the ability to interpret strategic information and the ability to forward plan. Poor effective communication and people-management were seen as particular skill deficits. Communication of the changes being introduced, the business improvements required and achieved were not being effectively cascaded to shop floor operatives because cell leaders and supervisors did not have the ability or the confidence to do this. Additionally, they did not have the appropriate motivational skills to obtain the most from their teams. A similar situation was evident at a component supplier case study outlined in the following panel.

Case study:

Recent restructuring within this medium sized component supplier had made the team-leader position the vital role for obtaining business performance on the shop floor. This restructuring had taken place without properly defining their role or assessing the skill and effectiveness of the team leaders in place. As such the team leaders have had to learn to mange their teams without having the appropriate skills to motivate or lead staff. The team leaders reported that they lacked leadership skills and the confidence to communicate effectively with team members and coach them etc. Management recognized that they had a significant skill gap between the abilities of their team leaders and what they were now required to do. The reason for this was mainly due to a lack of training. The team leaders had been recruited from semi-skilled operatives on the shop floor, and promoted largely on the basis of their technical abilities. In order to remedy this skill gap a significant team leader training initiative was being undertaken which it was hoped would equip the team leaders with the necessary skills to undertake their roles effectively.

Intermediate level employees therefore often lack the management skills that were once the domain of their superiors. In this sense, the management skills referred to include:

- the ability to manage and motivate employees to work within teams;
- the ability to effectively manage and communicate administrative and manufacturing data down to the shop-floor;
- the ability to set and achieve productivity targets and improvements; and
- the ability to forward think and plan.

The reasons why some skill gaps had emerged were related to the way in which employees have been promoted in the past. Progression up through the ranks from the shop floor has typically been related to the technical ability of an individual. For example, the person who produces the most parts or has the best grinding skills is most likely to be rewarded through promotion. The first role people progressed into was a supervisory role and then a lower management one reporting directly to the Works Manager. This process effectively occurred without any assessment of the person's leadership management qualities and without any systematic examination of skill needs.

6.3 Management Level Skill Gaps

The above trend was also evident amongst some engineering management positions, especially so in the small and medium sized establishments. One engineering manager at a component supplier reported how he had been promoted to his current position because he had displayed good technical abilities on a particular project. He considered, however, that he did not have the necessary skills to effectively manage his team of around 30 people and did not feel able to deal with the HR issues that were emerging into his daily work role. One response by an engineering firm, which did not participate as a case study, was to employ an industrial psychologist to examine the suitability of is employees to their job roles, by exploring their personality traits. This resulted in around half of the management team being re-deployed and the firm has since raised its performance.

The case studies revealed that people employed in highly skilled professional engineering occupations were expected to possess a wider range of skills than previously. In essence, professional engineers require a combination of technical and non-technical competencies to successfully under take their current job roles, leading to job enlargement. These non-technical competencies are largely related to shifts in the product market strategies of the case studies and the need to be able to effectively interface with customers and suppliers. This is shown clearly in the case of the case study outlined in the panel below. Many professional engineers have had their job enlarged and need to be increasingly flexible in their approach to work utilising:

- project management skills: these include factors such as the ability to tender for contracts and the ability to work in and manage multi-disciplinary teams
- people management skills: including facilitating effective communication between and motivating team members, dealing directly with customers and suppliers; and
- having a wide level of business acumen and commercial awareness about the company and the sector as a whole. Often professional engineers knowledge is contained within their area of technical expertise. Sound commercial awareness was considered necessary to facilitate better decision making in order to drive the business forward in the most appropriate manner.

Similar comments were made about the “Team Leader” role, which had developed with a significantly broader set of competencies than had the role of traditional engineering supervisor. Principal amongst these new skills were those of effective communication and motivation, strategic thinking, and much more customer interaction.

The centrality of these skills to the successful implementation of the chosen product strategy means that if the necessary skills are not available or take a long time to develop they are subcontracted to national and increasingly foreign-based companies. Sometimes these skills were required on a short-term basis and it proves cost-effective to subcontract rather than acquire their own suitably skilled staff. From a longer-term perspective, as noted in the previous section, subcontracting can lead to a loss of control of important parts of the business. In other words, this is not a strategic choice but one a decision that is forced upon the establishment.

Case study:

This engineering plant had just radically altered the way in which it undertakes its business following a period of enforced diversification into new product areas based on customised products rather than offering a standardised product. This involved a move into contract manufacturing, which is a totally new way of undertaking business and radically affected the manufacturing process, which has meant the introduction of completely new skills. The technical ability of the professional engineers at the plant facilitated this change in product market strategy but these individuals are now faced with having to utilise new skills, which were not required for the successful operation of the previous product strategy. Professional and managerial staff employed at the plant now need to have excellent project management, customer service, supply chain management, communication and purchasing skills which were never previously required when the firm offered a standardised product to one principal customer. These skills are being introduced through training and through the bringing in of new skills into the organisation.

Skill gaps amongst the professional and higher-level engineers are perhaps the hardest area of skill deficiency to both identify and rectify. When companies do recognise the existence of a skill gap they tend to 'plug it' directly by buying in skills in the form of subcontractors to allow the company in the short-term to overcome this deficiency. It is suggested that whilst subcontractors will provide the organisation with the high level of technical expertise they require, the dearth of professional engineers with the required combination of technical and non-technical skills in the wider labour market place means that these skill issues remain unresolved. This may lead to a perpetuation of the skill gap with a chance that it may become a permanent skill deficiency of the firm, and perhaps even the industry at large. This clearly has implications for the competitiveness of the firm and its ability to successfully rollout its market strategy.

6.4 Shifting Skill Deployment and Emerging Skill Gaps

The evidence gained from the case studies suggests that evolving job roles, associated with changing technologies, product strategies and working practices have created skill gaps which the establishments are filling by a variety of mechanisms i.e. training and recruitment. These skill gaps are found at various levels of the establishment hierarchy but were perhaps most evident amongst the intermediate and professional levels where employee roles have undergone a number of qualitative shifts.

At a shop floor level the principal change has been, and will continue to be, the greater deployment of automation. Craft skills are still required for production systems, especially where there is a continuous flow of production, for monitoring and correcting of the system. There is some debate about whether the level of responsibility that engineering craft workers acquire in this role comprises a heightening of skills or reduces them to machine minders. Linked, in several instances, to the greater use of automation is the provision of multi-skilled team working. If a judgement is required here about the impact on skill levels, it points towards job enlargement rather than job enrichment: employees are acquiring a greater number of tasks of the same level of difficulty. This can stimulate productivity gains at the early stages of a new team working system being introduced as employees welcome a change of routine. Whether some of the productivity gains that establishments sometimes claimed could be sustained over the medium-term where jobs are essentially repetitious is a moot point.

The shortening of the product life cycle and the drive to move up the value-added spectrum have increased the importance of the role of the professional engineer: especially in the pre-production phase i.e. research and development, design of the manufacturing process. This shift has led to a rise in the number of people needed to work in these roles; but equally there has been a change in the way that these people are expected to approach their work.

Case Study:

One company was involved in the nuclear and defence industries providing largely an engineering design and consultancy role. The key skills required of its professional engineers were changing. Not only were these engineers expected to be increasingly proficient technically and keep up to date with the latest technological developments they were expected to possess project management skills and good customer relations skills. The reason for this being that the firm now operated on a small project basis and engineers were now expected to deal directly with clients and take part in the tendering process. This was a radical shift in the way in which work and skills were deployed in the firm.

Employees working in the research, design, and development phases of the manufacturing process are increasingly working on short projects, which bring with them the increasing need for budgeting, time-management, and customer service type skills. Project management and more commercial-type expertise are now considered fundamental skills for these types of roles. At one establishment, professional level employees were expected to be proficient in a wide range of project management skills (see panel). Likewise, management skills in firstly selecting an appropriate and sustainable business strategy, and then in identifying the necessary skills required to drive and sustain it also appeared to be somewhat deficient.

What has been most striking finding is the amount of importance attached to the role of the professional engineer. This appears to stem from three causes: (i) the need to accelerate product development; (ii) the need to offer a degree of customisation in a standard product; and (iii) the need for greater management of the production process to obtain greater cost control. It is probably amongst this group that there is greatest scope for the emergence of a skill gap that is not readily rectified.

6.5 Unreported and Latent Skill Gaps

In a large number of the case studies, it appeared that, even where the organisation had set out a clear strategic direction, there were difficulties in defining precisely what that meant for skills. Some case studies had been more successful than others in this, but the overall impression was one of uncertainty as to whether case studies had adequately and appropriately defined the critical skill areas. Moreover, in some cases management, or some parts of management did not have a clear view of the strategic direction of the company. This might have been because they were unaware of it, or possibly because no such clear strategic direction had been set. In these cases, there was clearly no view of the skills necessary to move the company forward. This was also indicative, in some cases, of a lack of strategic direction skills in the senior management of the establishment (although some establishments were purely operational, the strategy being set elsewhere).

This led to the conclusion that some of the most critical, and typically under-reported and latent skill gaps were at the management level. One such skill gap was the ability to clearly articulate business strategy and identify the prerequisite skills needed throughout the establishment to take the chosen strategy forward. Management may have on occasion under-reported senior management skill gaps. The fact that a firm is not performing optimally is not necessarily directly the result of senior management skill gaps, but is likely to be indicative of it. The deficiencies in senior management i.e. the lack of coherent strategic decision making, may also lie beyond the establishment and could therefore remain under-reported. The under-reporting of management skill gaps is clearly vitally important as the decisions made by such individuals ultimately shape the strategic trajectory of the firm.

Also notable was the total absence of any reference to web site or electronic business development skills in our case studies. It is somewhat surprising, given the explosive growth of business-to-business web-facilitated procurement and supply chain management, that not one of our respondent organisations mentioned web development skills (as opposed to more general IT skills) as critical or even important. These skills are likely to be of importance for companies at any position in the Grid, but perhaps where the skills and interest may be most lacking is in the bottom right quadrant, in part because in this area are those establishments most severely resource-limited. Those establishments in this sector are the most likely to be affected in the immediate future by internet-based electronic trading exchanges and related approaches to increasing supply-chain efficiency - which while they have the potential to drive prices down even further, may become the most important market place of the future for their products.

For an establishment to be successful in each of the quadrants of the Puttick Grid, requires different types and combinations of skills (with some overlap between quadrants - and recognising that a company or even an establishment may operate in more than one of the quadrants). At the bottom right is the need for lowest cost operation, speed of response, and the flexibility to meet customers demands and delivery schedules. The challenges in this sector are rapidly increasing as it becomes subject to internet exchanges and internet-based supply chain processes, which tend to drive down obtainable prices further and faster.

As establishments seek to move upwards and to the left of the Grid, they increasingly need product design skills, customer relations and project management skills, as well as the need for technical and process innovation. Increasingly the best of such companies will tend to partner with customers and work closely with them on new developments and opportunities. As the most successful of UK engineering-based companies have shown, innovation, design and marketing, have frequently been the key to successful moves out of the bottom right grid position. Moreover, as life cycles tend to shrink, these skills are in required to be exercised more frequently and ever more effectively. Our case studies tend to show that any establishment can easily become prey to the life-cycle of its product - especially where a foreign (or even UK) owner is prepared to see the establishment decline with the product. In a few cases only have the establishment's management had the necessary skills, vision and resource, to propose and espouse alternatives likely to ensure a more prolonged future by the addition of value to the product and thereby an extended life-cycle.

In all cases a clear strategy backed up by a strong vision is necessary; this may be lacking where the management has not consciously carried out an analysis of their operations and formed a clear view of their position on the Puttick Grid or similar model. The ability to then drive the establishment forward depends on the clear view of the immediate and longer-term opportunity together with the confidence and background (experience, education, industry appreciation, customer understanding) to formulate, promote, and implement an appropriate action plan. Some of these characteristics and skills are part of the latent skill deficiencies in the sector.

6.6 The Impact of Skill Gaps on Product Market Strategy

The principal skill gaps identified throughout the case studies were attributed to 'softer skills' such as people management, team-building, communication, innovative capacity, commercial awareness and project management skills which more indirectly impact on the manufacturing process per se. These skills are however necessary to successfully facilitate the successful implementation of emerging product market strategies and to drive the business forward. Without them it is possible that establishments whilst relatively effective in their current product strategy might find difficulties in securing efficiency increases and allowing companies to move up the value added spectrum. These softer skill gaps are perhaps the hardest to identify.

It is suggested that the case studies may have under reported 'strategic thinking' skill gaps amongst senior management. The reason for this may be twofold. First, because senior management at the establishment level is no longer responsible for strategic thinking but for ensuring the efficient running of the current production strategy. Second, HR personnel have no remit for senior management recruitment or professional development and, as such, are unaware of such gaps. The persistent inefficiencies vis-à-vis industry competitors currently rife within certain UK manufacturing establishments would suggest there could be latent senior management skill gaps which if not challenged could undermine the long-term viability of these UK establishments.

On balance however, establishments reported that the impact of skill gaps on business performance was limited, at most there was a delay to planned changes whilst solutions to a particular recruitment problem or training need were sought. There was little evidence that skill gaps at the establishment level were adversely affecting the actual manufacturing process as any gaps were solved via one of the various strategies identified earlier. In the short-term therefore the case studies appear not to have any problems with meeting current market demands. Where additional human capital was required it was often satisfied internally through overtime or externally by bringing in extra capacity on a temporary basis. Such solutions are perhaps easiest to achieve at the production operative level where the costs associated with acquiring and releasing this level of skill are relatively low.

7. CONCLUSIONS

The number of people employed within the engineering sector in the UK has fallen significantly and the case studies in this report exemplify many of the reasons behind this fall. Changing market opportunities, enhanced competition, shifting corporate strategies and productivity improvements brought about by the continued automation of the manufacturing process and the continued introduction of information technology have all been observed in the establishments surveyed. Use of more effective labour scheduling, through the introduction of new methods of work organisation such as cellular manufacturing, has not only reduced the number of people needed for particular parts of the manufacturing process but also changed the types of skill required by people working on the shop floor. Technological advances in the materials used in the production process have also shifted the skills needed across the engineering sector.

One of the most significant factors affecting the engineering skill mix in the UK, exemplified in several establishments in the study, is the continued globalisation of the engineering sector and the influence of their holding groups. At the beginning of the twenty first century the typical global engineering company enforces control of finance, marketing and engineering processes and is less concerned about the structure of its manufacturing operation or, in many cases its location. Thus, the increasingly common trend found in several of the case studies is the concentration of key, generic business functions (i.e. marketing, finance) at the head office location. Likewise, strategic decisions concerning future product and market direction are rarely made at operating plant level, as is the case with many of the surveyed sub sectors.

The implications for the UK can be seen in the many establishments that have an overseas headquarters location, and which tend to favour the development and growth of their marketing knowledge and engineering capability outside of the UK. These UK plants are increasingly liable to wholesale changes driven by strategies that are defined overseas. The events unfolding in the UK car industry during Spring 2000, exemplify these trends. Amongst the case studies there were examples of overseas parent companies taking decisions concerning the long-term future of UK plants. One example was a Japanese company taking decisions regarding the potential closure of its UK operations. Others include, American and German companies shifting the product strategies of their UK sites.

Strategies at UK plant and establishment level are also likely to be built primarily on customer requirements. The case studies found that a clear understanding and effective response to market changes and engineering needs tends to take precedence over human resource issues. The number of UK companies with well integrated, long term, human resource development programmes were in the minority; most operate on far shorter horizons, usually driven by the needs of comparatively focused projects. This situation tends to be exacerbated when the establishment is not the company's head office. Rather, human resource management at the establishment level tends to focus on day-to-day personnel and training needs in order to facilitate the successful maintenance of the manufacturing process.

The UK engineering sector is still operating from a productivity base that does not compare favourably with its European or overseas competitors. This has attracted significant focus in recent years but the feeling is, that the mix of craft, technician, managerial and professional engineering skills and competencies deployed is still not closing the competitive productivity gap[3]. The issue has been highlighted for example by reference to the comparative expectations between the case study Japanese owned plants and UK owned plants. Within one Japanese branch plant there was the recognition that the parent group believed that the Japanese manager spends much more time and effort in developing the manufacturing system so that it produces the product efficiently and reliably. Conversely, a UK manager's approach would typically entail less front-end planning and correspondingly more day-to-day fire fighting activity. This scenario had left the UK site at a disadvantage to those operating outside the UK.

Many of the companies that have a truly global position are now operating with a matrix of skills that are mapped across their operating locations worldwide. The case studies reflect holding groups with this approach and component suppliers operating in the same way. The nature and speed of the customer response requirement that typically drives them means that it is often more economic to move their skilled players around the chessboard to the required location when needed, than to have all the skills required in any one location. If the skills are not available, or not in the quantity required, the 'norm' response is often to contract that skill from external sources. This is particularly true at the professional and managerial occupational level.

Technological changes and the introduction of new working practices are also profoundly influencing the skill structure of the engineering sector - lowering the total volume of craft level skills in some manufacturing processes and changing the nature of skills in others. In particular, the case studies found an increasing need for technician support, and an increasing emphasis on a variety of "team leader" skills. This includes the use of Information and Communication Technologies (ICT) that are permeating all aspects of engineering.

There are major issues relating to the timing of the changes as they sweep across the sector on different axes and many points of change could be observed in the case studies. Globalisation tends to bring major "vertical" changes down through the supply chain companies together with the restructuring of business processes and skill requirements as a result. The changes in markets and product opportunities tend to migrate across organisations and their competitors as well as generating new methods and skill structures; exemplified by a couple of the non-automotive case studies in particular.

Evidence from the Skills Task Force Employers' Survey reveals that the composite picture is complex. It identified that approximately 25 per cent of engineering establishments had a least one skill related hard-to-fill vacancy, compared to around 20 per cent across the economy as a whole. The largest number of hard to fill vacancies were located in the craft and related occupations. Around 21 per cent of engineering establishments reported a skill gap in at least one occupational area, compared to 20 per cent of all establishments. Skill gaps were reported mainly in relation to (i) plant and machinery operatives, and (ii) craft and related occupations.

In order to unravel the complex skill requirements of the UK engineering sector, this study has examined, at plant level, some of the linkages between issues such as product and market development and technology and the resulting accumulated effect on the skills requirement, deployment and development.

3 "Our Competitive Future: building the knowledge driven economy": UK Government White Paper, December 1998

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