Manufacturing Strategy, Product Customisation

and the

Marketing/Manufacturing Interface

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'Once a certain degree of insight has been reached,' said Wylie, 'all men talk, when talk they must, the same old tripe.'

Murphy, Samuel Beckett

Abstract

The manufacturing strategy literature is reviewed and it is found to centre on content and process models. However, a number of other issues are present in the literature whose relationship to the central process and content models is less clear. These include the trade-off, focus, flexibility, and generic manufacturing strategies. It is noted that the manufacturing strategy literature does not fully address product customisation. The literature relating to the interface between marketing and manufacturing is found to concentrate either on the identification of conflict areas, or on strategic reconciliation between the functions. Writers in this field do give greater emphasis to product customisation.

A case-study method is adopted for the research and the design involves four firms in varying industries. The firms manufacture fork-lift trucks, microswitches, telephone switching systems and diaries, respectively. The case-studies comprise quantitative and qualitative data, and each case chapter includes case-specific analysis.

The analysis of all the cases finds that customisation has a very important effect on manufacturing performance. The firms have inconsistencies within their manufacturing strategies, but these are found to rest not only on the firms' manufacturing products with different volume requirements in the same plant, but also on the fact of some of the products being custom-designed. The interface between marketing and manufacturing is found to be more complex and variable than the literature would suggest. The role that customised products play in relationships with customers also varies, although this is inconsistently recognised by the firms.

Based on the case-data, a model of product customisation is proposed. This incorporates customisation, flexibility, product architecture, the manufacturing strategy trade-off and the competitive criteria.

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This is dedicated to the memory of my father, Frederick Arthur Spring.

Declaration

I, Martin Spring, declare that I am the sole author of this work. None of the material has been included in another thesis.

Martin Spring

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Chapter 1

Introduction

1.1 Subject and Motivation for Research

This research concerns product customisation. The initial motivation for the research was personal experience of working in the manufacturing functions of firms where marketing personnel appeared all too ready to say to customers 'Yes, we can do that.....', to accept customers' orders for unusual products, and to leave the manufacturing function to live with the consequences.

This appeared to represent an instance of manufacturing not being aligned to other parts of the organisation, notably marketing, in terms of its priorities. This raised questions about the strategic role of manufacturing and, consequently, the manufacturing strategy literature forms the main theoretical foundation for the work. However, although centred in the operations management field, the research takes an interdisciplinary stance, examining the interface between marketing and manufacturing in attempting to understand the research problem.

1.2 Outline of the Thesis

Chapter 2 is the literature review. It starts with a brief review of corporate strategy concepts, as corporate strategy tends to be associated with, amongst other things, the scope of a business (i.e. what a business in fact does - what it may or may not be able to do well). It then reviews competitive strategy, before moving on to one of the two main areas reviewed - manufacturing strategy. This section concentrates in particular on those aspects of the manufacturing strategy literature having potential bearing on the product customisation issue. The other major part of the review addresses the marketing-manufacturing interface and the role and significance of product policy in that interface. Drawing all these together with recent interdisciplinary work, the final section of the review identifies important issues to be examined.

Chapter 3 discusses the research method to be adopted. Alternative resarch designs are reviewed, both in general terms and as they relate to the specific research question. The conclusion of this is that a case-study method is appropriate, and the issues of case selection, data collection and data-analysis are discussed. An Appendix contains the details of the data-collection instrument used.

The next four chapters, Chapters 4 to 7, each comprise a relatively self-contained, single-firm case-study. Each of these chapters contains some brief analysis devoted to the individual case. For reasons explained elsewhere, the last of these case-studies is rather briefer than the other three.

Chapter 8 contains the cross-case analysis, developing some of the single-case analyses from the preceding four chapters, and relating them more systematically to the literature reviewed in Chapter 2. It examines manufacturing strategy and product customisation issues in the firms and develops a novel model of the product customisation process which incorporates the concepts of product architecture, process flexibility, the competitive criteria and the trade-off. The model is then used a a basis for developing operations strategy prescription.

The final chapter, Chapter 9, revisits the research questions, briefly comments on the wider applicability of the findings of the research, and discusses the method adopted. It then explores, in a rather more speculative way than Chapter 8, some of the other implications of the work. Finally, it makes a number of recommendations for further research, both to build directly onto the findings of this work, and to explore new avenues suggested by some of the cases.

Chapter 2

Literature Review

2.1 Introduction

Manufacturing strategy is the focus of the literature review and, indeed, of the whole thesis. However, the literature review begins by reviewing some more general concepts from the business literature, of what strategy is and how it is formed. This serves a dual purpose. First of all, it provides some of the basic language that is useful in discussing the more specific issue of manufacturing strategy. Secondly, the business literature's concern with scope and competitive emphasis is one that informs later discussions of the scope and competitive emphasis of manufacturing. This first section then, discusses corporate strategy, business (or competitive) strategy and then functional strategies.

The next main section of the review concerns manufacturing strategy. It presents a short general review of the manufacturing strategy process and content literature, but concentrates its attention on a number of themes emerging from the literature that seem particularly contentious or related to product customisation, the product-range and the marketing-manufacturing interface. One aim here is to identify the extent to which the manufacturing strategy literature explicitly or implicitly addresses these issues.

The interdisciplinary nature of the research is developed in the next section of the review, which concerns the marketing-manufacturing interface. A number of areas are reviewed, some dealing with the interface *per se*, others with subjects that link the two functions. This section includes discussions of the notion of the product, product-range, product customisation and the product life-cycle.

The review concludes by drawing together the substantive elements of these three main bodies of literature to formulate the scope and objectives of the present research.

2.2 Strategy

There are many conceptions of what strategy is. Many writers avoid definitions of the term, preferring to identify typical characteristics of strategic decisions (Mintzberg, 1987; Johnson and Scholes, 1993:5-10). Manufacturing strategy is the main subject of this review and so this introduction to strategy in general is intended to provide a framework for discussion and, in particular, a way of locating functional strategies, of which manufacturing strategy is one type. This does not imply that the view of strategy adopted is seen as exhaustive. Hofer and Schendel (1978: 27-29) described three levels of strategy:

Corporate strategy:	What set of businesses should we be in?
Business strategy:	How to compete in a particular industry or product/market segment
Functional area strategy:	Maximising resource productivity.

Progressing downward through the hierarchy, the emphasis shifts on a number of dimensions, as shown in Table 2.1

Table 2.1 Emphases of Corporate, Business and Functional Strategies

Selected Issues		**Corporate**	**Business**	**Functional**
Distinctive Competence		+	+++	+++
Competitive Advantage	Emphasis	+	+++	++
	Comparison	v. Industries	v. competitors	v. products
Scope	Emphasis	+++	++	+
	Nature	portfolio/ diversification	product/market segment matches	product/market revenue, product forms and brands

Note: Emphasis: + = occasionally important; ++ = important; +++ = very important (Adapted from Hofer and Schendel, (1978: 28))

2.2.1 Corporate Strategy

Defining the business was seen by Hofer and Schendel (1978) as a matter of identifying the product/market segments in which to operate. Ansoff's approach to identifying the firm drew on a number of other factors:

> 'Some firms are identified by the characteristics of their product-line.....Others are described by the technology which underlies the product line.....Firms are also described in terms of their markets.

Here it is useful to make a distinction between customer and mission. A *mission* is an existing product need; a *customer* is the actual *buyer* of the product....' (Ansoff, 1965: 106)

Further on, Ansoff defines possible growth vectors in a two-dimensional matrix (Ansoff, 1965: 108-109), using the two dimensions of product and mission: the mission in turn can be defined in terms of its product characteristics, technology, or similarity of needs (Ansoff, 1965: 107). There appears to be some inconsistency in these dimensions: based on these definitions, the two are by no means orthogonal. When Ansoff addresses the more advanced stage of building portfolios of activities, he simply refers to 'product-market scope' (Ansoff, 1965: 172) and it is his two-dimensional diversification matrix that has endured (e.g. Johnson and Scholes, 1993: 222).

Abell (1980: 169-173) found two dimensions inadequate and, based on a number of case-studies in industrial goods firms, identified three dimensions by which to define the scope of a business: customer groups, customer functions and technologies (usually product rather than process technologies, although this is not explicitly stated).

A more recent development from this is by Mc Tavish (1995) who adds to Abell's three dimensions the fourth dimension, albeit a less convincingly orthogonal one, of stage in the value chain[1] (Porter, 1985: 33-61), which is effectively the degree of vertical integration. Abell is not unaware of such considerations, making it clear that his work is not about vertical integration but '..questions of how a business should be defined at the stage at which it sells its final product' (Abell, 1980: 6). Ansoff also considered this aspect, from the more macroscopic perspective of whether to diversify by acquisition or internal growth (Ansoff, 1965: 196-198).

Porter (1985: 233) reverts to something similar to Ansoff's two dimensions, adopting those of product varieties and buyers:

> 'An industry is a market in which similar or closely related products are sold to buyers...'

Kay (1993: 128) considers that the question 'What business are we in?' is a badly formulated one because the word 'business' conflates the separate ideas of market, industry and strategic group. He cites examples of firms in oil exploration redefining their business as 'energy supply' and finding that managing coal mines is very different from managing oil exploration: there is an energy supply *market,* but not an energy supply *industry* or, at least, the difference between the two ideas was what caused many of these diversifications to be unsuccessful (Kay, 1993: 129). Kay re-formulates the question and in so doing combines both perspectives:

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[1] Mc Tavish actually mis-appropriates Porter's terminology, as the value-chain consists, by Porter's definition (Porter, 1985: 33-35) of the activities that the firm is involved in and the value-*system* is the aggregate of the value-chains of all the firms in the sequence. Thus the issue is to determine which stages in the value-*system* should constitute the firm's value-chain.

> 'The question "What is our core business?" should be redefined as 'What markets are those which best enable us to translate our distinctive capability into competitive advantage?'' (Kay, 1993: 132)

Even the use of the word 'core' itself suggests a looking inward, by implication at that which cannot be dispensed with. This was to some extent a product of its times: Ansoff was primarily concerned with diversification (Ansoff, 1965: 127-138); Abell wrote at the beginning of a period of corporate retrenchment after years of diversification into unrelated activities, particularly in large companies. Although Abell did not use the term 'core' business, his work is identified by Kay (Kay, 1993: 143) as seminal in the drive for reversion to core business subsequently popularised by Peters and Waterman (1982: 292-305) as 'sticking to the knitting'. Kay's definition links the emphasis on scope of corporate strategy with the emphasis on competitive advantage of business strategy (to adopt the terms proposed by Hofer and Schendel). It also introduces the ideas of distinctive capability and competitive advantage. Kay does not seek to define orthogonal, exhaustive variables by which to 'define the business', but identifies product and geographical factors as the essence of defining most markets.

Along similar lines, Thorelli (1986) suggests that a firm's mission may be defined in terms of its domain, and the objectives to be achieved within that domain. The domain is defined in terms of: product, clientele, functions performed, territory and time. This adds space and time to other dimensions used by the authors already reviewed.

These definitions involve various combinations of inward- and outward-looking elements. Abell (1980: 11-12) summarises these two approaches as resource-based and programme-based (where, in the latter, programmes are defined 'conventionally in terms of products offered and markets served') and is quite explicit about addressing solely the latter in his work. His concern is with developing the three- as opposed to two-dimensional basis for defining the programme. Table 2.2 summarises the dimensions used by these writers to 'define the business'.

Table 2.2 'Defining the Business' - Five Versions

Author	Dimension/Bases	Emphasis
Ansoff (1965)	Mission Customer	Diversification and growth into new businesses - external orientation
Abell (1980)	Customer groups Customer functions Technologies	Understanding what the 'core business' is: external orientation
Porter (1985)	Product varieties Buyers	Defining terms for analysis of competition: external orientation
Kay (1993)	Products & Geography define markets	Market definition: external orientation based on distinctive competence (internal)
Thorelli (1986)	Product Clientele served Functions Territory Time	'Domain' defined to identify potential network members

It is apparent from Table 2.2 that the overwhelming emphasis is an external one. This, in part, is because corporate strategy as a concept or technique grew out of the need for multi-divisional corporations to manage, from the centre, increasingly large, complex and diverse activities. An important development of the 1970s was the use of the Boston Consulting Group (BCG) Growth-Share matrix in the planning of a portfolio of businesses. Interpretations vary as to the application of the technique: most see it as a corporate strategy tool for managing, from the centre, a portfolio of businesses (Henderson, 1979; Hofer and Schendel, 1978: 28; Kay, 1993: 344-345; McKiernan, 1992: 1-3); some adopt it for managing products, which may or may not be congruent with Strategic Business Units (Day, 1977; Wind, 1982: 119-121). The BCG matrix and other similar devices concentrate on balancing the propensities for cash-utilisation and cash-generation of various products/businesses and needed clear definitions of markets for the analysis of market shares, growth rates and projected revenue streams.

Having examined some approaches to defining businesses, the review now summarises some prominent theories as to how, once defined, these businesses compete. This is the second level of the Hofer and Schendel hierarchy - business or competitive strategy.

2.2.2 Business Strategy

According to Hofer and Schendel, business strategy is concerned with how each strategic business unit competes in its particular industry or product/market segment (Hofer and Schendel, 1978: 28). A good deal of the strategic management literature is devoted to this subject, so this section will review a few key authors in the area, as well as identifying concepts that may be useful to the more specific concerns of this research. Two basic issues will be touched upon: first, *what* a business' competitive advantage is; and, secondly, what the *source* of this competitive advantage is. The former is rather outward-looking, the latter more inwardly-directed. These issues are both present in Kay's defining question (above) and show that the clean distinction between scope as a concern of corporate strategy and competitive advantage as a concern of business strategy, implied by the hierarchies of Hofer and Schendel and other writers, is not always helpful.

Whilst the work of Ansoff, Abell and others provides a number of sets of dimensions by which the current and potential scope of activities may simply be described, they also, in varying degrees, provide *rationales* for determining the most appropriate scope for the business, given its goals, objectives and circumstances. This aspect of the corporate strategy literature potentially provides a macroscopic context for the more detailed product scope decisions that this research addresses.

Kay's concept of 'distinctive capability' is essentially the 'distinctive competence' of Selznick (1957: 42-56) and used by other authors since (e.g. Hofer and Schendel (1978: 25) use the term as an alternative to 'resource deployments'). Selznick's conception of competence is associated with patterns of organisational behaviour: 'we look beyond the formal aspects to examine the commitments that have been accepted in the course of adaptation to internal and external pressures' (Selznick, 1957: 42). Although his concern was principally with public bodies and Government agencies, he applies the concept to industrial firms (note that the term 'distinctive capabilities' has been adopted here):

> 'The assessment of industrial firms also requires a study of distinctive capabilities and limitations. For example, a commitment to quality of product may be an important determinant of organizational character or institutionalization.
>
> *The first boats made by Gar Wood were high quality craft, made of the finest materials by master boat builders. Later, the company decided to mass-produce a comparatively low-cost speed-boat for wide distribution. It developed that the entire organization found itself unable to cope with the effort to shift commitments. Workmen and shop supervisors alike continued to be preoccupied with high cost quality craftsmanship. Members of the selling staff, too, could not shift the emphasis from 'snob appeal' to price appeal. The quality commitment was so strong that an entirely new division - operating in a separate plant hundreds of miles away and therefore recruiting from a different labor market - had to be created to do the job successfully'.* (Selznick, 1957: 53-54)

Selznick's emphasis is on the difficulty of *changing* the distinctive competence, and less on the competitive advantage or disadvantage it affords (perhaps not surprisingly given the concern with public agencies; the index of his book does not contain the word 'competition'). Nonetheless, Selznick (1957: 50) comments that '[a] somewhat more general competence may develop, as when we say that a firm is good at marketing but less successful in production'. Ansoff (1965: 97-100) developed this further and drew up a checklist, by functional areas, by which 'competitive and competence profiles' might be developed. From this, the firm could identify its 'strengths and weaknesses relative to the present product-market posture' (Ansoff, 1965: 100). (Incidentally, Ansoff also suggests that comparisons be made, where possible, with firms in other industries altogether - benchmarking is nothing new.) Christensen, Andrews and Bower (1978: 130) emphasised that distinctive competence was more than what an organisation could do, it was the set of things it did particularly well, *relative to its competitors*. Hofer and Schendel soft-pedal this aspect, simply equating distinctive competence with 'the level and patterns of the organisation's past and present resource and skill deployments that will help it achieve its goals and objectives' (Hofer and Schendel, 1978: 25). Snow and Hrebniak (1980) categorise distinctive competences solely along functional lines e.g. production, applied engineering.

Day and Wensley (1988) note how the subsequent work on distinctive competences 'add[s] little other than longer lists of factors to consider'. They combine these so-called 'competitor-centred' approaches with customer-focused methods in a structured approach to assessing strategic advantage. In so doing, they make in some detail the connection between distinctive competence and competitive advantage that is outlined by Kay in his definition of core business (Kay, 1993: 132). Kay's emphasis is on the use of an understanding of the sources of competitive advantage to help determine which markets to compete in. Day and Wensley take the market definition issue as read and develop understanding of how most appropriately to measure performance and adjust strategies to best effect.

Porter (1985: 11) states that there are only two basic types of competitive advantage:

low cost and differentiation. Other writers similarly summarise competitive advantage as essentially cost or non-cost (e.g. Day and Wensley, 1988; Pettigrew, Whipp and Rosenfeld, 1989). Porter (1980: 34-46) combines cost and differentiation with the scope of activities to arrive at three generic strategies, previously detailed but not explicitly derived from the types of advantage. These generic strategies are (definitions summarised from Porter, 1985: 12-15):

Low cost	'a firm sets out to become *the* low-cost producer in the industry...a low-cost producer must find and exploit all sources of cost advantage. Low-cost producers typically sell a standard, or no-frills product and place considerable emphasis on reaping scale or absolute cost advantages from all sources... If a firm can achieve and sustain overall cost leadership, then it will be an above-average performer in its industry provided it can command prices at or near the industry average.'
Differentiation	'a firm seeks to be unique in its industry along some dimensions that are widely valued by buyers...It is rewarded for its uniqueness with a premium price.'
Focus	'[t]he focuser selects a segment or group of segments in the industry and tailors its strategy to serving them to the exclusion of others..[c]ost focus exploits differences in cost behaviour in some segments, while differentiation focus exploits the special needs of buyers in certain segments'.

These are shown in Figure 2.1.

		Competitive Advantage	
		Lower Cost	Differentiation
Competitive Scope	Broad Target	Cost Leadership	Differentiation
	Narrow Target	Cost Focus	Differentiation Focus

Figure 2.1 Porter's Generic Strategies

Firms in any industries who adopt none of these strategies will, according to Porter, perform less well than those who adopt one. He characterises those adopting none as 'stuck in the middle'. Porter is inconsistent in his expounding of this categorisation (Cronshaw *et al,* 1994): it varies from a prescription to a descriptive classificatory scheme; it is unclear whether firms (taking the prescriptive view for now) should adopt *only* one or *at least* one of the strategies; it is also unclear as to whether the scheme refers to the strategic orientation of the whole firm or simply to product positioning (i.e. a firm could have a number of products, each with different generic strategies). The empirical support for Porter is contradictory and there are examples of firms successfully 'stuck in the middle' or adopting both low cost and differentiation strategies (Murray, 1988; C.Hill, 1988; Cronshaw *et al*, 1994). As taxonomical scheme, it is fundamentally flawed (Chrisman, Hofer and Boulton, 1988). Nonetheless, the generic strategies have been widely adopted and, for example, taken more or less unquestioningly as the starting-point for many manufacturing strategy theorists (Kotha and Orne, 1989; Samson, 1991: 18; Schroeder, 1993: 33).

Recent developments in strategy research have challenged a number of tenets of both corporate and business strategy. The core competence literature, popularised in its present form by Prahalad and Hamel (1990), takes considerably farther the move away from the largely outward-facing concern with products and markets and towards a resource-based view of the firm (Wernerfelt, 1984). Also, as Rumelt (1994) notes, it builds on the well-established but essentially static view of distinctive competence in which capabilities are givens, with which an environmental fit must be made by the strategist. Rather than 'givens' to be exploited as well as possible through competition between products in markets, competencies are increasingly being seen as the true locus of competition, with products 'but the momentary expression of a corporation's core competencies'; Prahalad and Hamel (1990) characterise product-to-product competition as the last 100 yard sprint of a marathon. Rather than acting as some kind of conceptual plumber, fitting the distinctive competences to the environment, the strategist proactively selects, builds, deploys and protects core competences (Hamel, 1994). Competition over competences is not about the sort of optimisation of resource-allocation characterised by, say, the BCG Matrix but about 'a search for new ways to challenge traditional competitive logics' (De Leo, 1994). The core competence idea is an appealing re-statement and development of some of the ideas of the resource-based view of the firm. As elaborated by Hamel and Prahalad (1994: 5-9), it also represents an exhortation not to destroy potential sources of long-term competitive advantage in misguided attempts to improve short-term financial performance by restructuring and outsourcing.

2.2.3 Functional Strategies

The third of Hofer and Schendel's levels of strategy is the one to which most consideration will be given, in that the central body of literature to be reviewed is that of manufacturing and operations strategy. This section will briefly consider some general issues relating to functional strategies *per se*: the manufacturing strategy literature will be reviewed in detail in section 2.3.

Hofer and Schendel provide a convenient stepping-off point (although they do not devote any of their book to a detailed consideration of functional strategies). They comment as follows in relation to functional strategies: the 'principal focus of strategy is on the maximisation of resource productivity'; the characteristics and scope of strategy components are 'product/market development and product forms and brands'; competitive advantage is 'vs specific products'; that manufacturing system design, product-line policies and market development policies are included in *business strategy* rather than functional strategy. (Hofer and Schendel, 1978: 28).

Consideration of functional strategies *per se* causes some questioning of what constitutes 'strategy' anyway. Mockler (1995: 3-5) notes that the discipline previously known as strategic planning, which centred on strategy formulation across the whole enterprise, has become more and more concerned with implementation and less the exclusive preserve of planners at the centre of corporations. As the focus 'shifted to managing strategically at any level of management where enterprise-wide strategies are implemented' (Mockler, 1995: 4) the discipline became known as strategic management. Mockler suggests that the shift is one to '*integrative enterprise management*, that is, management at any level within the overall context of overall enterprise....strategies'. Pettigrew, Whipp and Rosenfeld (1989) regard the term 'strategic' as simply referring to magnitude and the presence of second-order effects.

Here is not the place to consider all the definitions of 'strategy' that have ever been made. What Mockler points to though, is that either the meaning of the term has changed, or there are more activities that are 'strategic', or both. Successive functionally-based disciplines have taken on the mantle: marketing (e.g. Day and Wensley, 1983) manufacturing (Skinner, 1969), Human Resource Management (e.g. Storey, 1991), research and development (e.g. Loveridge and Pitt, 1990). Not only, as Mockler sees it, have managers within these functions 'managed strategically', but the explicit strategy-formulation process previously only the concern of central planners has become part of functional management. Functions, departments and even smaller subdivisions of organisations have strategies that are written down or otherwise explicitly-defined, and internally-generated rather than handed down to them from central planners.

Because there is no longer the single strategic 'architect' (Christensen, Andrews and Bower, 1978:19-21), or a plan that is centrally and, presumably, consistently written (Ansoff, 1965), it is increasingly necessary to understand the relationship between functional strategies and business strategies and between various functional strategies. As such, there has developed a growing concern that there should be consistency or 'fit' (Venkatraman and Camillus, 1984) between different levels of strategy and between the strategies of the various functions. Business strategy has, for many years, been concerned with contingency theories of matching internal resources with external opportunities and threats in the business environment. In particular, contingency theorists have concentrated on identifying the organisational structure most appropriate to environmental conditions or to other business characteristics (Burns and Stalker, 1961; Chandler, 1962; Woodward, 1965 and, slightly more recently, Donaldson, 1987).

Although the functional strategies of manufacturing and marketing will be discussed in some detail later, it is important at this stage to raise the more general question of what the nature of a functional strategy is. Should functional strategies be developed to fit, in the way contingency theorists (e.g. Donaldson, 1985a) discuss, with the competitive strategy? Or should the emphasis be on the consistency between the various functional strategies? Certainly, the shift toward strategic management identified by Mockler implies an increase in managerial agency or choice (Child, 1972) at lower levels in organisations.

2.2.4 Strategy Process

The review so far has concentrated on the content of strategy i.e. what the issues that concern strategists are and, to some extent, what arguments there are for adopting particular courses of action. The other major concern of the business strategy literature is the process by which strategy - corporate, business or functional - is formulated. This section briefly reviews the predominant views on this subject.

Christensen et al (1978: 131) outline a sparse model of the strategy process. This consists of:

- evaluation of opportunities and threats
- appraisal of internal strengths and weaknesses
- creation of strategy
- consideration of stakeholder values and responsibilities
- evaluation and choice of strategy
- implementation

Mintzberg (1990) extracts the following 'premises' of this so-called Design School model (and the term 'Design School' will be adopted in what follows):

- strategy formulation is a controlled, conscious process of thought
- it is the responsibility of the head of the organisation - The Strategist
- it is best represented by a simple and informal model
- an organisation's strategy should be unique
- a strategy should emerge from the formulation process fully developed
- it should be simple enough to state in a sentence or two
- it must then be implemented.

Insofar as he speaks of 'the strategic problem' which is to be 'solved', Ansoff (1965: 100) also represents strategy formulation as a rational, controlled and conscious process. However, he differs very markedly from the Design School in the way that he attempts to 'programme' the formulation process by an elaborate decision process flowchart. There is next to no consideration of implementation of the strategy. The various analytical steps proposed by Ansoff depend on the availability of a great deal of detailed, accurate information about, amongst other things, the future. This will be termed the 'planning' approach.

Whittington (1993) categorises strategies according to the extent to which the formulation process is deliberate, and upon the presence of objectives other than profit-maximisation. It is the former of these that has become the most heavily-debated aspect of the strategy process. Mintzberg (1994) is the most thorough and devastating critique of the strategic planning approach, but it has been subject to questioning for much longer (Mintzberg, 1978; 1979; Quinn, 1980, Mintzberg and Waters 1985; Hayes, 1985; Mintzberg et al, 1990; Mintzberg, 1990). Mintzberg's key criticisms of the planning approach are:

Predetermination	the environment is assumed to be predictable, strategy formulation can be programmed to happen, and strategies can be implemented on an acquiescent organisation;
Detachment	it is held that strategy formulation is best carried out by people without day-to-day involvement in the business;

Formalisation	it is held that the strategy formulation process can be institutionalised and programmed: that 'systems can do it'.

The ultimate criticism by Mintzberg is his so-called Grand Fallacy of planning:

> 'Because analysis is not synthesis, planning is not strategy formation.' (Mintzberg, 1994: 321)

Pettigrew (1985, 1989) is also critical, but emphasises internal politics, the past and present context of strategic change, and organisational culture. Kay (1993: 357) sees Pettigrew's view as nihilistic - that organisations are what they are and that all we can do is describe, not prescribe. This seems somewhat unfair: Pettigrew avoids simplistic conclusions, but by no means dismisses managerial agency.

The deliberate-emergent continuum of Mintzberg and Waters (1985) is perhaps the best summary of many of these aspects of the strategy process. A strategy has been defined as 'a pattern in a stream of decisions' (Mintzberg, 1978) and subsequently as a pattern in a stream of *actions* (Mintzberg and Waters, 1985). Based on these patterns, strategy types have been identified on a continuum from pure deliberate to pure emergent. Deliberate strategies require that (a) the organisation has precise intentions, (b) these intentions are common to all the actors and (c) the intentions are realised exactly as planned. Emergent strategies exhibit a pattern with some consistency - otherwise they would not be strategies by Mintzberg and Waters' definition - without intention. The authors acknowledge that neither of these pure forms are likely to exist and thus propose a number of strategy types on the continuum between them. Their view is that there is much value in the strategies tending toward the emergent end of the continuum, that only by taking actions to see what works can viable strategies be identified. They emphasise that:

> 'emergent strategy does not have to mean that management is out of control, only - in some cases at least - it is....willing to learn. Such behaviour is especially important when an environment is too unstable or complex to comprehend, or too imposing to defy.....[management can] respond to an evolving reality rather than having to focus on a stable fantasy...Our view is that strategy formation walks on two feet, one deliberate, one emergent.'

Hayes (1985) characterises this as reversing the 'ends-ways-means' sequence and, in a similar conclusion to that of Mintzberg and Waters, suggests that a combination of the two - bottom-up and top-down - is appropriate. In terms of prescription, this amounts to a need to develop low-level expertise - expertise *at* low levels in the organisation in problem-solving skill and the like (Hayes and Wheelwright, 1984: 341-343).

Johnson (1988) notes that, although it views strategy formation as a process of learning by trying, rather than of rational design followed by implementation, Quinn's logical incrementalism (Quinn, 1980) still makes some claim to being 'logical'.

Johnson's empirical work has demonstrated that managers will go to considerable lengths to ignore evidence from their business environment that does not fit their 'paradigm' of their organisation or industry. This may mean that, although some incremental change is effected, it is inadequate because a large proportion of the data is screened out and 'strategic drift' takes place (see Figure 2.2). Johnson even goes so far as to suggest that the paradigm-contradicting data may provoke management to reinforce the paradigm, making radical change even *less* likely. Miller and Friesen (1980) found that organisations exhibit long periods dominated by 'momentum', where continuity is the rule and merely incremental change take place, alternating with occasional periods of 'revolution', where many trends and norms are reversed within a short time. These may come about due to the type of 'drift' that Johnson identifies, or to major external changes.

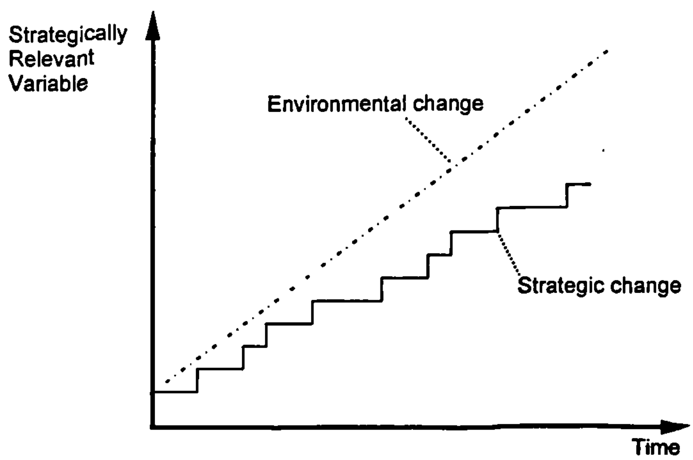


Figure 2.2 'Illogical Incrementalism' and Strategic Drift (from Johnson, 1988)

All the foregoing work assumes that, in some form or another, albeit that they may be inappropriate or emergent, strategies are present. One further possibility is proposed by Inkpen and Choudhury (1995). This is the concept of strategic *absence*. If, as Mintzberg and Waters (1985) suggest, strategy is a pattern in a stream of actions, it seems perfectly conceivable that there may be no pattern at all and hence no strategy. According to Inkpen and Choudhury, this can be due to failure i.e. a strategy would be desirable but none exists, due to a period of transition, or be seen as a virtue. One notable way in which strategic absence is considered potentially virtuous is that it does not build the kind of restrictive paradigm that Johnson (1988) describes; this is close to Mintzberg's suggestion that too much strategic consistency can leave a firm exceedingly inflexible.

A recently-evolved alternative view of strategy process and content is the network concept. This developed from empirical work, mostly carried out in Europe, on business-to-business marketing. The network view of marketing and innovation is more fully-developed (e.g. Håkansson (ed), 1982; Ford, 1980, 1984; Håkansson, 1987; Biemans, 1992), but its extension into business strategy is not well established. However, it does offer some potentially useful alternative concepts, particularly for industrial markets. In its sharpest contrast to much of the business strategy literature (e.g. Christensen et al, 1978; Hofer and Schendel, 1978; Porter, 1980), the network view does not conceive of an organisation as one of a relatively large number of passive entities reacting to the contingencies of an uncontrollable business environment. Organisations, particularly in concentrated business markets (Blois, 1980a), are often among a few principal actors who are involved in various relationships of a continuous nature, rather than in a succession of many discrete transactions in an external 'market'. As such, the identity is created in its interactions with its major counterparts and '[a]n organisation's performance is therefore largely dependent on whom it interacts with' (Håkansson and Snehota, 1989). As such, network-oriented marketing strategy is much more concerned with analysing individual customers or portfolios of customers (e.g. Campbell and Cunningham, 1983) than in aggregated 'sales' of 'products' in 'markets'.

The network view also questions the sharp divide that much strategy theory makes between the organisation and its environment. Rather than having distinctive competences *inside* the boundary between organisation and environment, which it uses to compete in markets *outside* the boundary, the firm on the network view has relationships - by definition spanning that boundary - that constitute a valuable resource in themselves. Linking with some of the ideas of the resource-based view of the firm, Håkansson and Snehota (1989) stress that it is largely within such relationships that important assets such as knowledge, abilities and reputation are created. The concept of strategy then, becomes less one of 'fit' with the environment at any one time, and more one of the process of relating to other actors over time. This is held to be most effectively managed by 'framing the context' in which relationships evolve, 'rather than by designing (planning) a future pattern of activities' (Håkansson and Snehota, 1989).

2.2.5 Conclusion

This brief review of some key ideas in the strategy literature has identified a number of concerns for the present research. First of all, it has been possible to contextualise functional strategies in general, and manufacturing strategy in particular. This provides a background for the discussion to come in following sections. However, this is not unproblematic, as there are large overlaps between corporate, business and functional strategies as to the domain of decision-making about scope, distinctive competence and the competitive advantage to be sought. The shift from strategic planning to strategic management observed by Mockler (1995) also complicates this.

The review has also identified a number of approaches to defining the business, including outward-looking ones based on products and markets, inward-looking ones based on resources, core competences and distinctive competences and, furthermore, the network view which concentrates on the very relationships that link these two.

Finally, the review has outlined some of the more widely-known theories of the processes by which strategies are formed. Much of this can apply to functional strategies as well as to business-level strategies, and so provides background for the process aspects of manufacturing strategy which is included in the following section.

2.3 Manufacturing Strategy

Selznick's 1957 vignette of the Gar Wood boat company (Selznick, 1957: 53-54, quoted above), although used to illustrate 'distinctive competence', will have a familiar ring to anyone who has some knowledge of the manufacturing strategy literature. However, although it was clear to Selznick (and probably to many more before him) that it was difficult for a manufacturing organisation to be good at everything, it is Wickham Skinner who is credited with identifying manufacturing strategy as a separate area for study.

In the context of a 1960's USA manufacturing industry dominated by large corporations who had been struggling with the 'productivity problem', Skinner's (1969) views that manufacturing firms (a) could and should have objectives other than productivity and low costs; (b) should make explicit choices about their objectives and design their manufacturing systems accordingly; and (c) should give a prominent strategic role to the manufacturing executive in developing strategy, were something new. Skinner set out his vision of 'a kind of "top-down" manufacturing' in which manufacturing policies were derived from the company's competitive strategy and summed up in terms of the 'manufacturing task' - productivity or service, quality or ROI (Return on Investment) for example. Central to Skinner's visions were a formalised planning procedure, very similar to Ansoff's corporate strategy model (Ansoff, 1965: 202-203), and the concept of the trade-off. This fundamental idea is that, in various decisions required in the design of a manufacturing system, there is always a trade-off between one capability and another. For example, production equipment can be general-purpose, flexible, but with high variable costs, hence suitable for high-variety production where price is not a priority, or it can be special-purpose, with low unit-costs but limited flexibility, hence suitable for high-volume production where price is a priority. The key point is that, in Skinner's view, in choosing the production equipment 'you can't have it both ways': production equipment cannot provide, say, both high flexibility and low unit costs. The same argument was applied to other decision areas such as planning and control systems and organisation structure. These themes were reiterated and extended in Skinner (1974), where the concept of the focused factory was introduced. Focus, just like the trade-off, has been an important theme in the manufacturing strategy literature, and this review will return to consider both in some depth.

Skinner's 1969 article considered manufacturing strategy content - the manufacturing task and decision areas - and the manufacturing strategy process. These issues have dominated subsequent work in the field, and the review will continue by briefly presenting notable contributions to the literature under these headings. This will provide a backdrop for the following sequence of more narrowly-focused sections. These will consider several issues of a more over-arching nature, taking in both process and content, as well as a few strands in the literature of a more specific nature that relate particularly to the present research.

2.3.1 Manufacturing Strategy Content

The content of manufacturing strategy is typically considered in two parts. First, there is what Skinner called the 'manufacturing task', and what has subsequently been redefined as competitive criteria (Wheelwright, 1978), competitive priorities (Leong et al, 1989), competitive-edge criteria (New, 1992), operations objectives (Wild, 1980: 55-71; Schroeder, 1984; Slack, 1991), content variables (Adam and Swamidass, 1986), order-winning criteria (Hill, 1985; 1993) and manufacturing objectives (Schroeder, Anderson and Cleveland, 1986; Mills et al, 1995). The term *competitive criteria* will be adopted here. The other part of the content of manufacturing strategy, which has more consistently maintained the term used by Skinner, is the range of *decision areas*. These two, competitive criteria and decision areas, will be considered in turn.

2.3.1.1 Competitive Criteria

Skinner did not consistently specify an exhaustive set of variables that defined the manufacturing task. They were: ' 'lowest total cost'....time and customer satisfaction' (Skinner, 1969: 140) (which are almost exactly those of Wild's elegant scheme (Wild, 1980: 60)); 'costs, deliveries, lead times, quality levels and reliability' (Skinner, 1969: 144); 'cost, quality, lead times, reliability, changing schedules, new product introduction, or low investment' (Skinner, 1974: 115), to give a few examples. Other writers have attempted to be more categorical and parsimonious, and a summary of the various schemes are presented in Table 2.3. This tabulation of competitive criteria shows some general trends over the years of theory development. Notable amongst these are:

- delivery speed has only intermittently been included
- some of the criteria have been elaborated considerably e.g. flexibility and quality
- there has been a broadening from steady-state concerns to progressively take in more dynamic issues i.e. innovation
- service aspects have been added latterly.

Figure 2.3 attempts to capture the broad thrust of this development.

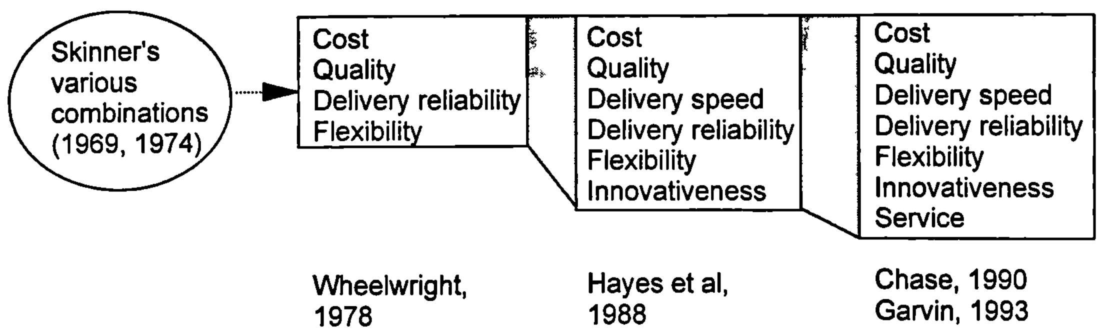


Figure 2.3 The Competitive Criteria: Evolution

Table 2.3 The Competitive Criteria in Manufacturing Strategy

Authors	Cost	Quality	Delivery Speed	Delivery Reliability	Flexibility	Innovation	Service
Wheelwright (1978); Hayes and Wheelwright (1984)	Efficiency	Quality		Dependability	Volume and product		Dependability
Fine and Hax (1985)	Cost	Quality		Predictability	Product and volume		
Hill (1985)	Price	Quality	Delivery Speed	Dependability	Range	Design leadership	
Hayes et al (1988)	Cost	Quality		Dependability	Product and volume	Innovative-ness	
Leong et al (1989)	Cost	Quality	Delivery speed	Delivery reliability	Mix and volume	New product and process	
Fitzsimmons et al (1991)	Price	Eight dimensions (Garvin,1984)	Delivery speed	Delivery reliability	Flexibility		
Chase(1990)	Cost	Quality	As part of 'narrow' service concept	As part of 'narrow' service concept	Range - product and process; customization		Information, problem-solving, sales and support
Garvin (1993)	Cost	Quality	Delivery speed	Delivery reliability	Product, volume, process		Service

Although it is not suggested that the successive writers have built neatly on one another's schemes, it is fair to say that attention has shifted toward the dynamic and service aspects as indicated. The inconsistency with which delivery speed has been included is puzzling; it was one of Skinner's various criteria and there seems little reason to suspect that it has not always been of prime concern to manufacturing management. Wheelwright's scheme (1978) included speed of delivery under the 'quality' heading. The broadenings in emphasis though, do reflect a change in the perceptions of manufacturing management and academics alike as to the scope of their discipline. Hayes, Wheelwright and Clark (1988) are perhaps the most notable examples of this, and Wheelwright and Clark have subsequently shifted their focus to product development as their main research concern (Wheelwright and Sasser, 1989; Wheelwright and Clark, 1992a, 1992b). Chase and Garvin's inclusion of the service component in manufacturing strategy content has been one aspect of the attempt to develop a genuine concept of *operations* strategy, rather than simply substituting the word 'operations' in place of 'manufacturing' in theory that has been developed from an empirical base firmly planted in manufacturing. The observation made by Anderson et al (1989) that service operations strategy 'is virgin territory - almost nothing has been done' remains true.

Noticeable in some of the schemes is the apparent willingness to add factors in a fairly ad hoc manner - Hill adds 'colour range' (Hill,1985: 41); and 'customer relations' (Hill,1990: Appendices C1-C3); Fitzsimmons et al (1991) add Garvin's (1987) eight dimensions of quality; Chase (1990) adds various service aspects. Whilst these may be relevant factors to the complete competitive offering of some firms, it appears that the rationale for identifying the factors in these schemes has been forgotten. Based on Skinner's original concept, the reason for identifying these criteria is that they are supposed to conflict with one another and, as such, the list needs to be confined to those for which there are reasonable grounds to suspect that such a conflict exists.

Another distinctive development is in the work of Hill. He emphasises in particular the link between manufacturing and marketing and proposes the concept of order-winning and order-qualifying criteria (Hill, 1985:45-52) as essential to making this link. A close reading of the development of these concepts indicates that they started out as a convenient way of communicating the idea of competitive criteria (Hill, 1990: 72). Hill's earlier version of the framework had 'performance criteria to compete' instead of order-winners (Hill, 1981). But the order-winner has ended up as an appropriation of buyer behaviour theory (Berry, Hill and Klompmaker, 1995). Along the way, the useful presentational device became built into ever more detailed and prescriptive audit methods and tools (e.g. Berry, Bozarth, Hill and Klompmaker, 1991) without, it is contended, adequate recognition of the implications. This process is reminiscent of the corruption of the Boston Consulting Group Growth-Share Matrix from 'purely a presentational device' to 'the much used (abused?) device so commonly found in marketing and strategy textbooks' (McKiernan, 1992: 7-9). It also has parallels with the elaboration, by Ansoff (1965), of the Andrew 'Design School' strategy formulation model (Christensen et al, 1978).

Elaboration of the original Hill concept runs considerable risks. First, if order-winners are indeed different to competitive criteria, they are different by virtue of encroaching on marketing 'territory': they describe an area of decision-making and performance mediated not only by manufacturing but also by marketing. Secondly, the emphasis on the *order* implies that what we are interested in is merely an aggregation of many atomistic purchase decisions, taken out of the context of the relationships with the customers making the purchase. Whilst this may be the only realistic approach to consumer buyer behaviour (at least prior to the advent of scanner-data (Cooper, 1991)), it also forms the foundation of much of the literature in industrial buyer-behaviour. Two empirical studies which tested the Robinson, Faris and Wind (1964) Buying Process Model have implicit in their research design that the useful unit of analysis is the individual purchase decision (Ghingold, 1986; Anderson *et al*, 1987). There is, however, a growing body of evidence that, in industrial marketing (and, recently, even consumer marketing), buying behaviour is more usefully considered not in terms of isolated decisions made by passive buyers, but as part of a relationship. The interaction approach sees both seller and buyer active in the relationship, and sees any particular 'decision' as influenced by, and influencing of, the relationship between the organisations. 'The marketer's and buyer's task in this case may have more to do with maintaining these relationships than with making a straightforward sale or purchase' (IMP Group, 1982).

On the interaction view, a relationship consists of a series of *episodes* over time. There are four types of episode - product/service, financial, information and social (IMP Group, 1982). These might be seen as a stream of events as in Figure 2.4.

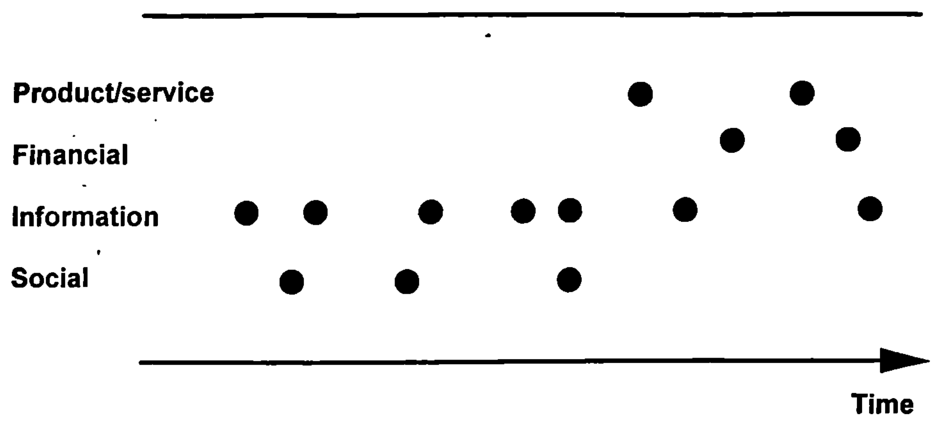


Figure 2.4 A Graphical Representation of Episodes in a Buyer-Supplier Relationship

How each episode is handled depends on aspects of the episode itself - how complex it is for example - but will also depend on the history of the relationship (Gadde and Håkansson, 1993: 60-61). By implication, it will also depend on what the expectations are of *future* episodes. Episodes can strengthen or weaken a relationship, particularly in the way they affect the degree of trust between parties. As business transactions are carried out in an atmosphere of greater or lesser uncertainty, of one sort or another (Ford, 1980; Håkansson, Johansson and Wootz, 1976; Gadde and Håkansson, 1993: 71), the level of trust is important in determining how episodes are handled, in that a high level of trust can greatly mitigate potentially problematic uncertainty. Trust is seen as an important factor in determining the power of any firm in a relationship or, indeed, in a supply network. It is based on 'reputation and, more importantly, on past performance' (Thorelli, 1986).

Whilst these 'softer' aspects of buyer behaviour are not completely lost on the traditional business marketing literature, there are tendencies (a) to relegate them to secondary considerations (e.g. Hutt and Speh, 1992: 83-84) and (b) to separate them from the 'rational' criteria such as price and delivery. As Thorelli (1986) suggests, however, trust (for example) is to a great extent founded on past performance on such quantifiable criteria as delivery and quality. The reliable delivery to a customer of one product on one occasion, if the interaction view is accepted, will not only satisfy <u>them</u> on <u>that</u> occasion,in respect of <u>that</u> product, but also modify the relationship. Such an episode might improve trust and reduce the perceived risk involved in placing future orders. When the time comes to place those future orders, for the same or other products, decision-making will be based in part on trust and perceived risk and will hence be influenced by previous manufacturing performance. This may outweigh the immediate 'rational' criteria (e.g. this is precisely the basis for awarding 'the order' in so-called black-box design projects as advocated as part of a lean supply relationship (Womack et al, 1990: 138-168)). Hill's approach invites the abstraction of the criteria from the potentially very important context of the relationship. The implicit assumption is that current performance specific to the product to be purchased is all that matters, hence ignoring the transfer of experience on the part of the purchaser both over time and between products.

In the detailed strategy-formulation process advocated (Hill, 1993: 44-52), order-winning and order-qualifying criteria for individual products considered to be representative of particular product-market segments are allocated relative importance in terms of weightings out of a total of 100. Wheelwright (1978) advocated something similar but, importantly, in Hill's approach this is to be done based on past production and sales data giving, for example, volumes and leadtimes requested by individual customers for individual orders. (Again, this is adopted in the process described by Platts and Gregory, 1990.) This contrasts with the competitive criteria approach, which does not descend into the detailed consideration of individual products, individual orders, and individual customers. In this literature, manufacturing strategies are usually determined at Strategic Business Unit level (e.g. Leong et al, 1990).

Many of the competitive criteria approaches (i.e. those other than Hill's) are very sketchy about the process by which the criteria are determined. Indeed, a dissatisfaction with the general nature of much of the writing in strategic management is at the heart of Hill's approach, for example in this thinly-veiled swipe at Michael Porter:

> '...researchers, writers and advisors have proffered generic statements concerning corporate strategy formulation with expressions such as "low cost", "differentiation" and "critical success factors"' (Hill, 1993: 60)

Whilst this may be a valid criticism, it does not necessarily follow that Hill's approach, particularly in the way it has become operationalised, is any better. In conclusion, the term 'order-winner' is accepted as perhaps a more readily-grasped construct for interviewing purposes but, for the reasons set out here, it is considered dangerous to collect data on weightings out of 100 or to adopt any similar procedures.

2.3.1.2 Decision Areas

Just as Skinner was less than categorical about the 'definitive' list of competitive criteria, so he also only claimed to identify 'some' important decision areas (Skinner, 1969). Nonetheless, he did stress the need to consider both structural and infrastructural issues (Skinner, 1971). As with competitive criteria, many writers have developed their own lists of decision areas and these are summarised in the Table 2.4. Because there is not the same implicit requirement for orthogonality or parsimony as with the competitive criteria, there is less controversy over the decision areas. The areas are defined so as to ensure that all aspects of the operation are explicitly considered, and to enable assessment of consistency between various aspects of the manufacturing system. Many writers have adopted the structure/infrastructure split - again a Skinner concept (Skinner, 1971).

Hayes and Wheelwright (1984: 31) note that the infrastructural decisions are often considered more tactical in nature, but contend that 'their cumulative impact can be just as difficult and costly to change (if not more so)' than the structural decisions. Berry and Hill (1991) stress the need for manufacturing planning and control systems appropriate to the priorities of the plant. Neely et al (1994) examine the consistency of performance measurement and competitive criteria and find that there may be considerable use of surrogate measures, although there are relationships between competitive criteria and the measures adopted.

Although there is broad agreement in many areas, there are one or two deviations.

Perhaps the most notable, in view of the concerns of this research, is that Fine and Hax (1985) include 'scope and new products'. Although other writers e.g. Hayes *et al* (1988), Platts and Gregory (1990) include new product development in their decision areas, their emphasis is on the organisation and procedures by which new product development is carried out. Fine and Hax, although they also include the new product development process in this sense, are alone in giving manufacturing management a role in determining product-range policy:

> '*Scope and New Products:* The degree of difficulty of the manufacturing management task is strongly influenced by the range of products and processes...In well-run organisations, manufacturing management has significant input in decisions about product scope and new products. Firms with rapid and frequent product introductions or broad product lines must develop flexible, responsive, efficient manufacturing organizations. Its *(sic)* product designers must understand what demands product design will place on manufacturing, and design, marketing and manufacturing must be in close communication.' (Fine and Hax, 1985)

Although Fine and Hax do not draw attention to this difference in their framework, it is quite distinctive in that it gives manufacturing management a role in product policy. The purpose of manufacturing strategy is not just to design a manufacturing structure and infrastructure that can cope with the products that marketing determine that they should manufacture and develop, but also to proactively influence what products are included in the product-range. This is a quietly radical step.

Table 2.4 The Decision Areas in Manufacturing Strategy

	Skinner (1969,1971)	**Hayes and Wheelwright (1984: 31)**	**Fine and Hax (1985)**	**Hill (1985: 41)**	**Platts and Gregory (1990)**
Structural	Plant and Equipment	Capacity Facilities Technology Vertical integration	Facilities Capacity Vertical integration Process Technologies	Process choice: - process type - trade-offs - role of inventory	Facilities Capacity Span of process
Infrastructural	Production planning and control Organisation and management Labour and staffing Product design/ engineering	Production planning and control Quality Organisation Workforce	Scope/new products Human resources Quality management 'Manufacturing Infrastructure' Vendor relations	Function support Manufacturing systems Controls and procedures Work structuring Organisational structure	Human resources Quality Control policies Suppliers New products

2.3.2 Manufacturing Strategy Process

Skinner is clear that what he is advocating is 'top-down' manufacturing. His model for manufacturing strategy formulation is very much in the planning mould of Ansoff (1965: 202-203); it is similarly heavy on analysis and light on strategy formation and issues of implementation. After several pages of his classic article (Skinner, 1969) relating to analysis, one paragraph mentions strategy formation, noting that:

> 'Management must decide what it is going to make and what it will buy; how many plants to have and how big they should be, and where to place them; what processes and equipment to buy; what the key elements are which need to be controlled and how they can be controlled; and what kind of management organisation would be most appropriate.'

And even less is given over to implementation:

> 'Next come the steps of working out programs of implementation, controls, performance measures, and review procedures'.

Skinner also represents his process in the same form as Ansoff's, i.e a decision flow-chart.

Although the hard-systems flowchart - at least of the minutely-detailed type employed by Ansoff and Skinner - is less fashionable now than it was in the late 1960's and 1970's, the strategy formulation process advocated in much of the literature contains similar elements. As in the strategy formulation model of Hofer and Schendel (1978), the process begins by definition of the Corporate Strategy and the Competitive Strategy for the SBU, (Skinner, 1969; Wheelwright, 1978 ; Hayes and Wheelwright, 1984: 28-29; Fine and Hax, 1985; Leong et al, 1989; Tunalv, 1990; Marucheck, Pannesi and Anderson, 1990; New, 1992; Garvin,1993; Stonebraker and Leong, 1994: 35). From these the functional strategies, of which the manufacturing strategy is one, are derived. Dissenting voices here are few. Hill (1981, 1985, 1993, 1995) maintains the centrality of the marketing strategy and links it upward to corporate (not competitive) strategy and 'downward' to manufacturing strategy. Pronchno and Corrêa (1995) advocate the use of a pilot project to drive a 'middle-down-top-down' approach, but the process set out is entirely deliberate.

Platts and Gregory (1990) present a more balanced consideration of the extent to which the strategy formation process is a deliberate one of design or planning as opposed to an emergent one, noting the views of Mintzberg, Quinn and others, but in the end devoting most of their article to the design of a classic formal planning-style audit tool. Most of the models referred to here involve some form of iteration, indicating that the manufacturing strategy is not simply 'handed-down' to the manufacturing function once the competitive or business strategy is decided, but that the two are developed with regard to one another.

The next stage in the process is, almost invariably among the authors cited, to determine the competitive criteria necessary for manufacturing to support the business or competitive strategy. From these are determined the appropriate decisions in the various decision areas. The exact means by which this is achieved is, in many instances, less comprehensively spelled out than other aspects of the strategy process. Certain stages of the process are assisted by tools and frameworks, many of which are embodiments of the trade-off principle (the product-process matrix, Hayes and Wheelwright, 1979a; product profiling, Hill, 1985; the manufacturing strategy audit workbook, Platts and Gregory, 1990 are three examples). Perhaps this is a reflection of Mintzberg's concerns - 'planning's grandest assumption of all' - as to how synthesis can result from analysis (Mintzberg, 1994: 223). Garvin (1993) notes that the consensus view of the manufacturing strategy process fails to carry projects down to the lowest levels of the organisation and 'focuses more on the broad direction and the content of manufacturing policy and far less on detailed programs and the process of *selecting* initiatives' (emphasis added). Gunn (1987: 74-87) proposes a classical planning approach which follows the Design School steps and sets out how to break down the plan into ever-smaller parts of a five-year programme. Although Gunn's method includes 'obtaining commitment' as one of its stages (after formulating the plan), it is still essentially top-down. It also seems to imply that all manufacturing strategy programmes consist of local variations on the three 'tools': Computer-Integrated Manufacturing, Total Quality Control and Just-in-Time. Apparently, these are all that are required to become World Class, regardless of industry or competitive strategy.

Hayes and Wheelwright (1984) are at pains to stress, on a number of occasions, a Mintzbergian concept of strategy:

'It cannot be overemphasised that it is the *pattern of decisions* actually made, and the degree to which that pattern supports the business strategy, that constitutes a function's strategy, not what is said or written in annual reports or planning documents.*'

'* Some writers and managers distinguish between an 'enunciated' (or planned) strategy and an 'implemented' strategy. We do not make that distinction because it suggests that developing a strategy then implementing it are somehow separable. As will become apparent in subsequent chapters, we think the development of a manufacturing strategy is an interactive process involving planning and execution at various levels and in a variety of areas. In the end, it is the pattern of decisions actually pursued that determines the firm's manufacturing capabilities'. (Hayes and Wheelwright, 1984: 30, italics in original)

However, those who would write management books find it difficult to resist defining staged processes e.g. in one of the 'subsequent chapters' on capacity and facilities planning:

Capacity and Facilities Planning Projects: Eight-Step Procedure

1. Audit and evaluate existing capacity and facilities
2. Forecast capacity/facilities requirements
3. Define alternatives for meeting requirements
4. Perform financial analyses of each alternative
5. Assess qualitative issues for each alternative
6. Select the alternative to be pursued
7. Implement the chosen alternative
8. Audit and review actual results

(Hayes and Wheelwright, 1984: 126)

Here are the classic Design School stages: audit, forecast, define alternatives, evaluate, choose, then implement. Roth, Giffi and Seal (1992: 43) are similarly confused:

> 'The [written] strategy...must be a blueprint for action: a pattern of decisions <u>to be</u> executed over time' (emphasis added).

The use of the future tense here shows that, even though they use the phrases of Mintzberg, Roth et al are still planners at heart.

Mills, Platts and Gregory (1995) provide an integrative, contingency-based framework which attempts to capture manufacturing strategy content and process, the qualities of the process outcome as well as the internal and external contexts. In the event, the process at the heart of their framework reverts to a three-stage one of audit, formulation and implementation. Despite considerable discussion of various strategy processes, and suggestions that various strategy 'modes' such as the 'entrepreneurial' mode (Mintzberg, 1978) may be supportive at certain stages in formation, it is essentially a Design School process overall. Mills et al note the lack of tools to support anything other than a major or 'big bang' strategic review; they also comment that 'in no case yet seen has the audit stage included a systematic means of looking at past manufacturing strategy'. They summarise the strategy mode (based on Mintzberg, 1978) they see as appropriate to each stage of the process:

Audit	**Formulation**	**Implementation**
Planning	Entrepreneurial	Planning
	Adaptive	Adaptive
	Grass Roots	

The framework still has little by way of an answer as to how analysis can lead to synthesis - i.e. where strategies come from. The section supposedly on formulation is largely devoted to how to assess strategies once they *are* formulated. As Mills et al (1995) note:

> 'No techniques.. have.. been found in the strategy literature in general that assist strategy development as part of the normal management process.'

Kinnie, Staughton and Davies (1992) carried out longitudinal case studies in a number of firms implementing changes in manufacturing strategy. This type of work is unusual because so much of the manufacturing strategy literature concentrates on content and process modelling. Kinnie et al found that firms successful in achieving the aims of their change programmes adopted a proactive approach during implementation and understood and made provision for the wider implications of the change. However, the work is disappointing in a number of ways and does not, in the final analysis, give any new insights not available from the change management literature (e.g. Burnes, 1992). The projects chosen by Kinnie et al were all technology-based, with five out of the seven projects (the five deemed 'failures') being information-technology-based production planning and control systems - OPT (Optimised Production Technology) or MRP (Materials Requirements Planning). Furthermore, the research examined the change process adopted *given* the decision to effect the particular change i.e. no connection is made between strategy formation and implementation. The potentially interesting question of what the problems are with a change in manufacturing strategy in the classical Skinnerian sense of, say, shifting from cost to delivery speed emphasis is not posed. There is, though, a distinct question to be addressed here, particularly as this shift is at the heart of the 'new' manufacturing strategy of, for example, Hayes and Pisano (1994).

In summary, the manufacturing strategy process literature concentrates heavily on strategy formulation and, although concessions are made to bottom-up initiatives (or at least to the potential for strategy to be modified after consultation), has little to say about truly emergent strategies. It is sketchy in its translation of broad strategic directions into concrete action and very, very vague about implementation - many are the articles and books with only the last five or ten percent devoted to 'implementation'. If strategy formation, as Mintzberg and Waters (1985) suggest, walks on two feet, manufacturing strategy formation appears to be limited to hopping or, at best, limping.

This short review of the manufacturing strategy process literature concludes the general overview of manufacturing content and process. The remaining sections will discuss a number of themes running through and around this basic literature. These are included either because they are the areas of most contention and/or because they relate particularly to the present research.

2.3.3 The Trade-Off

One of the most contentious aspects of manufacturing strategy theory is the trade-off, arguably the 'Big Idea' of Skinner's early work and certainly the foundation of much that was to follow (e.g. Wheelwright, 1978; Hayes and Schmenner, 1978; Hayes and Wheelwright, 1979a; Hill, 1981, 1985). It is the basis for the product-process matrix, the whole of Hill's framework, and of much of the 'focus' literature (see 2.3.6 below).

Wheelwright (1981) called the trade-off into question. This article articulated what was becoming apparent to Western manufacturers - that the trade-off was not a universal law. Japanese manufacturers were able to produce high quality products at low cost: contrary to the trade-off theory that these objectives are mutually conflicting, the high (conformance) quality helped cost-reduction through elimination of scrap, rework, inspection and over-scheduling. Indeed, the article contained much of the argument of Ferdows and De Meyer (1990) and Bolwijn and Kumpe (1990) - that the objectives of flexibility, dependability and cost built cumulatively on a foundation of quality, not as an alternative to it. Schonberger popularised the idea of World Class Manufacturing which, amongst other things, dismissed the trade-off theory completely (1986: 203-204). He derides the idea that firms should find their 'distinctive competency' and holds that World Class Manufacturers are good in all the areas of quality, cost, response-time and flexibility. However, a close reading of his evidence by New (1992) results in apparent vindication of the trade-off view, albeit in modified form. Wild (1980: 69) 'speculates' that the key trade-offs are in the time-related dimensions as they interact with particular capacity management strategies - a fast delivery can only be guaranteed by having spare capacity or large inventories. The conclusion of New is that certain trade-offs still exist; Slack (1991: 11) introduces the time element again, holding that, whilst trade-offs certainly exist in the short-term, in the longer term they can be reduced or eliminated. Indeed, that is increasingly seen as a key part of manufacturing strategy (Slack, 1991: 12; Corbett and Van Wassenhove, 1993; Hayes and Pisano, 1994).

As well as the trade-off in general being subject to criticism, particular pairs of objectives have been scrutinised. Cost and quality have already been mentioned. Cost and variety is another pair to have been examined. From a process technology starting-point, Goldhar and various co-workers have been among those pointing out the implications of microprocessor-controlled process technology for manufacturing strategy in general and the variety-cost relationship specifically. Goldhar and Jelinek (1983a) capture this with the idea of economies of scope, indicating that production that combines high variety and low volume need not carry a cost penalty if the potential of computer-controlled process technology is exploited. This is one aspect of manufacturing flexibility (see 2.3.8 below) and will be revisited in the section on customisation.

With a less purely technological emphasis, the emerging literature on mass customisation further questions the trade-off between variety and cost. There is relatively little empirical work in the field so far, and the literature consists of a very few cases in a limited range of clothing and consumer durables markets. Mass customisation takes in the possibilities of process technology and allies it to marketing (Kotler, 1989, was an early advocate) and organisational developments (Pine, 1993; Boynton, 1994). Again, this will be assessed further in the section devoted to product customisation (section 2.4.4.5)

The debate about the manufacturing strategy trade-off recalls a very similar debate in the business strategy literature. Voss (1992: xi) suggests that Porter (1980) stole his generic strategies concept from the manufacturing strategy theorists; whether this is true or not, the parallels are strong. Murray (1988) suggests that the low cost and differentiation strategies are in conflict only under certain circumstances; C.Hill (1988) also maintains that both are possible together. A closer reading of Porter e.g. by Cronshaw, Davis and Kay (1994), as already indicated, shows that Porter himself is by no means consistent in the way the theory is applied and interpreted. However, if we take Porter at his most categorical and prescriptive i.e. as advising firms to pursue one objective and one only and not to be 'stuck in the middle' (Cronshaw et al, 1994), there is an inconsistency between this and the classic manufacturing strategy trade-off. The latter doesn't appear to recommend adopting an extreme position, just that as performance in one area is improved, performance somewhere else will suffer - will be traded off. This continuity, rather than discontinuity, is at the heart of such tools as the product-process matrix of Hayes and Wheelwright (1979a) and profile analysis of Hill (1985: 89-95)

Despite these reservations, inconsistencies and non-isomorphisms - as well as the existence of a number of other generic strategy schemes (see section 2.2) - a number of manufacturing strategy theorists take Porter's generic strategies unquestioningly as the starting-point for their particular versions of the basic manufacturing strategy model (Samson, 1991: 18; Stonebraker and Leong, 1994: 38).

2.3.4 'Best Practice'/'World Class Manufacturing'

As discussed above, the trade-off is seen by, for example, Schonberger (1986) as a fallacious and dangerous concept. This is an example of what Professor Nigel Slack has called the 'fundamentalist wing' view. The role of the 'best practice' techniques such as Total Quality Management, Just-in-Time and Lean Manufacturing in relation to Skinnerian manufacturing strategy is a contentious issue. The fundamentalist view - the view of Schonberger, and of Womack et al, perhaps - is that any firm in any industry must forget the trade-off and adopt best practice techniques such as those mentioned here. Gunn (1987) sees any manufacturing strategy programme as a judicious blend of JIT, CIM and TQC. The only issue to debate is how fast to implement and what the implementation priorities are.

Other, almost exclusively UK-based writers see the issue differently. First, as discussed, New (1992) detects gross inconsistencies in the Schonberger argument anyway. The broad thrust of a number of writers (Slack, 1991: 17-19; Berry and Hill, 1992; Voss, 1995; Mills et al 1995) is that these techniques should not be seen as panaceas, and a number of contingency theories are proposed. For example, in relation to production planning and control systems, Slack (1991: 180-181) suggests that choice of system depends upon a number of factors such as volume/variety, leadtime variation and the level of control; Berry and Hill (1992) do much the same within a framework of marketing and manufacturing factors. Voss (1995) notes that 'best practices' may depend on industry (although this appears to be a surrogate for the types of factors that Slack, Berry and Hill identify). Mills et al (1995) suggest that such 'off-the-peg' improvement programmes may be particularly appropriate to firms who are relatively poorly developed and at Stage 1 or 2 of the Wheelwright and Hayes (1985) Four-Stage model, but are neither pervasive enough nor distinctive enough to lead to sustainable competitive advantage that can be developed without external advice. Fittingly enough, this is also the conclusion of Skinner (1995) who sees such techniques merely as *part* of the means of *avoiding* competitive disadvantage, not the way to achieve competitive advantage.

2.3.5 Consistency or 'Fit'

A recurring theme in the manufacturing strategy literature is the requirement for consistency within and between strategies. Hayes and Wheelwright (1984:33) identified four types of consistency:

1. Manufacturing Strategy - business strategy
2. Manufacturing Strategy- other functional strategies
3. Among decision categories
4. Manufacturing Strategy - business environment

or, diagrammatically, as in Figure 2.5.

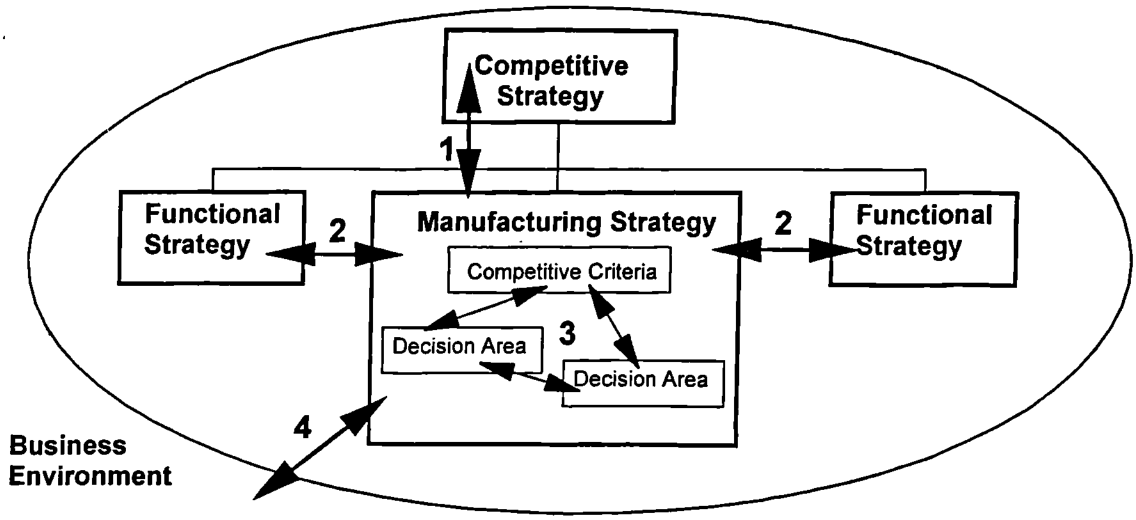


Figure 2.5 Aspects of Consistency in Manufacturing Strategy

The majority of the work in the field addresses the first and third of these. Skinner (1974) stressed the third (arguably this consistency is the essence of focus). Some authors have emphasised the second, particularly the manufacturing-marketing link (e.g. Hill, 1993). The last of these has been almost completely neglected. Slack (1991: 185-186) adds the significantly different issue of consistency *over time*, particularly noting the common phenomenon of loss of credibility when successive initiatives give the appearance of all too frequently-changing priorities. (If the Mintzberg and Waters (1985) definition of strategy as a pattern in a stream of actions is accepted, then Slack's call for consistency over time is tautological - if there weren't consistency over time, then there would be no strategy.) This is a particularly interesting point when compared with the view of Hayes and Pisano (1994) that the 'new' manufacturing strategy is precisely about developing the ability to change from one emphasis to another.

Of particular note in the research relating to the business strategy - manufacturing strategy link is the extent to which manufacturing strategy is seen as following from and supporting the business strategy as opposed to, at least to some extent, changing it. Although many writers emphasise the iterative nature of their strategy formulation process models (e.g. Marucheck et al 1990, Hill, 1993), the emphasis is still on manufacturing strategy being derived from the competitive strategy, sometimes expressed in terms of one of Porter's generic strategies (Porter, 1980), sometimes in other terms. Wheelwright and Hayes (1985) took this further with their four-stage model, in which the Stage Four organisation has a manufacturing function which moves beyond merely being consistent with the business strategy and takes on a significant and pre-emptive role in providing competitive advantage. As such, Anderson et al (1989) ask what seems the wrong question in their summary of the literature on this: 'Should operations' capabilities be adjusted to achieve corporate objectives, or should corporate objectives be confined to what operations is capable of doing?'. To some extent, this sums up the binary view, but the choice of the word 'confined' is perhaps unfortunate - in the Stage 4 company, the word 'extended' would be more appropriate.

In a somewhat idiosyncratic development, at least in terminology, a series of articles have developed the notion of 'production competence' (Cleveland, Schroeder and Anderson, 1989; Vickery, 1991; Vickery, Droge and Markland, 1993). In the terms of these authors, production competence is 'the degree to which manufacturing performance supports the strategic objectives of the firm' (Vickery et al, 1993). The original work by Cleveland et al was deeply flawed methodologically (Vickery (1991) contains a critique) but, even in its rather more carefully-designed form, such an approach requires that the data-collection instrument, a questionnaire in this case, identifies a profile of important competitive variables for the business, a weighting of the importance of the manufacturing contribution to each, and a precise measure of manufacturing performance in each area. This small strand of research though, (a) demonstrates the concern with the linkage between business and manufacturing strategy and (b) needs to be discussed insofar as it raises another usage of the word competence. Vickery et al are keen to emphasise the difference between 'production competence' and 'distinctive manufacturing competence'. A manufacturing firm may have a distinctive competence in some area, but it may not be particularly relevant to its business strategy. Distinctive competence is assessed relative to competitors or potential competitors; production competence is concerned with achieved performance against the 'current set of competitive priorities' (Vickery, 1991). Vickery attempts to extract the effect this 'production competence' has on business performance but arrives at the conclusion that a combination of a mixed low-cost and differentiation strategy (the options are Porter's cost, differentiation or both) combined with low competence gives the worst business results. This seems far from surprising and does not show whether this is inevitable (as it would be if Porter's 'don't get stuck in the middle' is 'true'.)

Swamidass and Newell (1987) are rare in examining the connection between environmental uncertainty and manufacturing strategy process and content. Their first conclusion is that more flexible firms perform better in an uncertain environment; their second, perhaps more interesting, conclusion is that there was a tendency for manufacturing management to be less involved in strategy formulation in uncertain environments, but that there was more involvement in the more successful firms. Although the research method adopted was relatively extensive, the data were mostly collected via interview rather than postal questionnaire. As such, the results can be seen as providing some confirmation of Skinner's call for a greater strategic role for the manufacturing manager (Skinner, 1969). The results also suggest that manufacturing strategy is contingent on the organisation's environment, at least insofar as manufacturing strategy can be assessed by asking questions of the senior management about manufacturing flexibility issues, which was the surrogate measure adopted.

2.3.6 Focus

In many ways, the concept of focus is indistinguishable from manufacturing strategy, particularly as Skinner (1969) first articulated it. Skinner (1974) introduced the term focus to refer to:

> 'a factory that focuses on a narrow product mix for a particular market niche will outperform the conventional plant, which attempts a broader mission'.

Hill draws our attention to Skinner's own elaboration of the focus concept:

> 'learning to focus each plant on a limited, concise, manageable set of products, technologies, volumes and markets' (Skinner, 1974)

and

> 'learning to structure basic manufacturing policies and supporting services [the structure/infrastructure split] so that they focus on one explicit manufacturing task instead of on many inconsistent, conflicting, implicit tasks' (Skinner, 1974)

and interprets this as not necessarily advocating a small number of products, merely products that have a small range of manufacturing tasks (Hill, 1993: 157-158).

Focus embraces many of the issues of manufacturing strategy - it requires that a clear choice be made about the competitive criteria for a particular operation, and that a consistent set of decisions be made in support of that strategic choice. This is based on the conventional view of the trade-off. Perhaps the distinctive characteristic of focus, especially in the context in which it was first proposed, is the extent to which it reinforces the idea that economies of scale and absorbing overhead by filling production capacity with *any product that anyone would buy* were not the only ways to compete. On the contrary, the focus position is that it is acceptable to break up the unfocused but fully-utilised large plant into smaller, less-well-utilised but more manageable factories within factories. Conceptually, focus is indistinguishable from a manufacturing strategy that has a high degree of consistency. Bozarth (1993) has summarised various other authors' work on focus as relating to consistency (a) within manufacturing; (b) between manufacturing and business strategy. If these are indeed the broad thrusts of the focus literature, then it does not offer anything in addition to the prescriptions of, for example, Hayes and Wheelwright (1984: 33) for consistency in manufacturing strategy. The distinctive feature of focus that emerges from Hill (1995: 193-197) is that it gives more weight to the advantages of smaller, more easily managed units that concentrate on a narrower range of tasks and therefore challenges economies of scale as the only rationale for designing manufacturing systems. This is a natural implication of Skinner's challenging the idea that competition need only be on the basis of cost. The other recurring theme in the rather limited focus literature is the longitudinal phenomenon that Hill and Duke-Woolley (1983) termed 'focus regression', that is, the tendency for gradual proliferation in the product range and hence loss of focus. Other writers also discuss focus in this context (Hayes and Wheelwright, 1979b; Stonebraker and Leong, 1994: 204-205).

Various sets of dimensions on which plants may be focused have been proposed. Most often these are summarised as product and process focus (Hayes and Schmenner, 1978; Hill, 1995: 201). Berry, Bozarth, Hill and Klompmaker (1991) use statistical techniques to create groups of products based on order-winning criteria.

However, despite the conceptual appeal of focus, there is no empirical evidence to indicate improved performance of focused plants, insofar as focus is an idea distinct from consistent manufacturing strategy. Probably the aspect of the focus literature most relevant to the present research is the recognition of the effect on manufacturing of product proliferation.

2.3.7 Level of Manufacturing Strategy

Most of the models reviewed have the manufacturing strategy as a functional strategy subordinate to the competitive strategy of a strategic business unit (e.g. Fine and Hax, 1985; Leong et al 1989; Schroeder and Lahr, 1990; Garvin, 1993). The focus literature discussed above concentrates on the plant level, and this is the position of New (1992), who states clearly:

> 'Manufacturing strategy is primarily about what a single *plant* is capable of doing successfully - a 'corporate' manufacturing strategy would cover only those items which would be common across all plants (not very much generally).' (New, 1992: 24, italics in original)

In fact, it is not altogether clear what the relationship is between focus and manufacturing strategy. Do plants adopt a manufacturing strategy of focusing sub-sets of their operations on different objectives or manufacturing tasks? Or does each focused unit have its own manufacturing strategy? Furthermore, even within the common conception of the plant, what of the multi-plant SBU (Strategic Business Unit)? Hayes and Schmenner (1978) address this to some extent, characterising the basic design of the 'total manufacturing system' as a balance between the single plant where the plant management task is difficult but the central coordination role is trivial and the opposite, where there are many very focused plants, making plant management easy but SBU coordination difficult. Advocating the latter, they suggest that:

> '[the central manufacturing staff] must somehow maintain the total organisation's sense of priorities and manufacturing mission, even though individual units [plants] may have quite different tasks and focuses.'

Hayes and Wheelwright (1984: 33-37) discuss the concept of a corporate manufacturing strategy. They hold that certain elements of each business strategy may be common through the whole firm, even though each business strategy is different. The type of issue that may be common are described as 'policies and guidelines' and these are noticeably different from business *strategies*. They indicate that, in each of the decision areas, there may be greater or lesser degrees in common between business units, but the emphasis is very much on bases for decision-making such as rules for capital investment appraisal, rather than on issues directly linked to the usual content of competitive strategies. However, later on, they discuss the differences between Hewlett-Packard and Texas Instruments, using their product-process matrix concept (Hayes and Wheelwright, 1979a) and distinguish between the two corporations (each with many SBUs) on the basis of their *competitive* strategies and the way their manufacturing strategies support these competitive positions *across the company* (Hayes and Wheelwright, 1984: 225, 259). This seems to indicate that there is more to corporate manufacturing strategy than rules on how to write investment proposals and the like. That is borne out by the extended discussion of facilities strategy, in which 'facilities strategy should be regarded as a proactive element of the overall manufacturing strategy, rather than a reactive one' (Hayes and Wheelwright, 1984: 109) and which also includes discussions of the facilities life-cycle concept

(Schmenner, 1983) and of the plant charter (Hayes and Wheelwright, 1984: 100-101), which contains many elements of a manufacturing strategy plus some specific quantifiable objectives such as units costs and capacity utilisation. In this context, focus is identified as a concept that can be applied to any level: industry, multiple plants, one plant over time, or to plants-within-plants (Hayes and Wheelwright , 1984: 80). Having said all that, however, Hayes and Wheelwright still set out by positioning the manufacturing strategy alongside the other functional strategies as clearly subordinate to the Business Unit strategy, in exactly the way that Hofer and Schendel (1978: 28) do. Samson (1991: 102-103) notes that focus 'can be applied across virtually any aspect of the firm'.

Insofar as, for him, developing a manufacturing strategy begins by identifying the relevant order-winners of particular market segments, Hill operationalises the manufacturing strategy process at that level. Whilst advocating the plant-within-a-plant approach to focusing within facilities (Hill, 1993: 156-182), Hill's discussion does not explicitly consider facilities decisions in the way that, for example, Hayes and Wheelwright do, at all. The concrete specificity of plants, locations and capacities is absent: the abstract idea of providing manufacturing systems matched, via order-winners, to markets is all-pervasive. Indeed, Hill's framework (Hill, 1995: 39) moves straight from corporate objectives to marketing strategy without the business or competitive strategy that intervenes in many other models. As such, it is unclear at what level manufacturing strategy is to be defined. Hill being more reluctant than some other writers (e.g. Schroeder and Lahr, 1990) to be prescriptive about written manufacturing strategy documents, perhaps the real point of Hill's work is to think strategically about manufacturing at all levels.

While manufacturing strategy is seen in the Skinnerian way as making the right trade-off choice to suit a particular market, it is possible to align a plant, say, with a particular segment. However, as this idea of manufacturing strategy is being challenged by the core competence or resource-based view (De Leo, 1994; Hayes and Pisano, 1994) an aside by Hayes and Wheelwright (1984: 35) might have increasing weight:

> 'A company may decide that it will need a certain manufacturing capability in the future, even though none of its business units has an immediate need for it. Therefore it may choose to develop an in-house capability in that technology so it will be available when needed.'

In the original source, this referred purely to R&D policy and to essentially technological capabilities. If the view of the core competence theorists is adopted, and competition is significantly about these competences and less about products, then the implication of this is that strategy is less about plants or even plants-within-plants, and more about the competences underlying and linking together all or many of the current production facilities. This may mean that the very point of strategy is not the content or process at any or all hierarchical levels, but about the architecture that links activities at various levels together.

Recent work by Wathen (1995) attempts to address this question and, to some extent, concludes that businesses, even with multiple facilities, producing all their products using one process type (small batch, large batch, continuous) perform better. The work is of dubious merit however, as it is based on the PIMS database, which is very unsubtle in its assessment of what constitutes, for example, a large batch. His research instrument would also seem to interpret the focus concept in exactly the wrong way. Skinner's original concept was that different process types should be adopted to serve different needs within the one business; Wathen defines focused operations as those adopting largely the same process type throughout the business, with no apparent assessment as to the process type's appropriateness in terms of market characteristics.

In summary then, the literature is rarely clear about what a 'manufacturing strategy' applies to. Many of the models operationalise it at SBU level; many of the concepts seem most readily applicable to the plant level; more recent views tend to indicate that the truly strategic is pervasive, across businesses and between levels in the hierarchy of strategies.

2.3.8 Flexibility

Flexibility is routinely included in the lists of competitive criteria compiled by manufacturing strategy writers (Wheelwright, 1978; Hayes and Wheelwright 1984; Leong et al 1989; Adam and Swamidass, 1989; Slack, 1991: 7-9; Swink and Way, 1995) and has attracted considerable attention as a separate issue within the literature (Slack, 1983, 1987; Easton and Rothschild, 1987; Hill and Chambers, 1991;

Chambers, 1992; Gerwin, 1987; De Meyer, Nakane, Miller and Ferdows, 1989). However, it is contended here that its inclusion as a competitive criterion alongside the others typically adopted is potentially problematic. Certainly, flexibility is extremely complicated and multi-faceted.

Wheelwright (1978) included flexibility as one of his four criteria, taking it to refer to changes in the 'product and the volume'. Other writers have subsequently identified several other types of flexibility. Slack (1983) developed an early framework for considering flexibility based to a large extent on the operations management policy work of Wild (1980). The customer service variables of Wild - forerunners of the competitive criteria - were adapted slightly and could be represented as in Figure 2.6.

Figure 2.6 Flexibility as a Second-Order Performance Objective

First Order Objective		Second-Order Objectives	
Attribute	Level	Reliability	Flexibility
Product Specification			
Product Mix			
Quality			
Volume			
Delivery			

Thus the objectives were conceptualised as first-order dimensions of customer service, and reliability and flexibility were second-order qualifications of the primary performance objectives. As Slack notes 'flexibility is the same class of objective as reliability; it is both a condition to be applied to other objectives and an inherent characteristic of the manufacturing system itself.' (Slack, 1983: 5). Thus there are five types of flexibility: New Product, Product Mix, Quality, Volume and Delivery. To this elegant conception of flexibility, Slack adds the 'dimensions of flexibility': range, cost and time. Range is the difference between the minimum and maximum value of the dimension over which the system can 'flex'; the ease with which the flexing can be carried out is measured in terms of time and/or money. Thus, for example, product mix flexibility of a machine-tool might involve the assessment of the largest and smallest diameter it could hold (range) and of how long it takes, and how much it costs, to change the machine over from one product to the next. Following empirical testing of the flexibility framework, it was modified to eliminate quality flexibility as, although theoretically logical it was not, in practice, a relevant flexibility type. Thus the types were Product, Mix,Volume and Delivery, and the hierarchical distinction between them and the first-order manufacturing performance objectives was maintained.

To reiterate, Slack comments that '[f]lexibility is different from other operations objectives. The extent to which a system meets all its other objectives is necessarily demonstrated by its operating behaviour; its flexibility, however, can remain a measure of potential behaviour'. Slack introduces the notion of 'adaptability' to refer to the softer, usually managerial and organisational issues that determine the extent to which the potential flexibility, which is determined by the harder aspects, such as process technology and layout, is achieved in practice. Upton (1994) proposes dimensions of flexibility that, to some extent, reflect similar concerns: operational (day-to-day), tactical (quarterly) or strategic (one-way, every few years).

Slack himself has subsequently fallen into line with other manufacturing strategy writers and treats flexibility as just another performance objective (Slack, 1991: 7-10). Other manufacturing strategy sources treating flexibility in this way include Wheelwright (1978); Hayes and Wheelwright, (1984: 40), Fine and Hax (1985); Leong et al (1989); Adam and Swamidass (1989) (who include it within their 'core' objectives whilst demoting delivery to the next level in the hierarchy); Tunälv (1992) and Garvin (1993). A number of alternative lists of flexibility types have been proposed but these do not differ substantively from Slack's.

As already noted, the actual flexibility achieved may fall far short of the potential. Goldhar and Jelinek (1983) and, in particular, Jaikumar (1986) demonstrate clearly the extent to which the flexibility potentially offered by computer-based manufacturing technologies is not achieved in practice due to organisational and managerial factors. Hill and Chambers (1991) make the point strongly that firms are often not clear about the type or extent of flexibility they require in their particular competitive situation, and invest in Flexible Manufacturing Systems as an act of faith, seeing 'flexibility' as a panacea. The refinement of the flexibility construct in the literature certainly makes available a fairly sophisticated array of ways of analysing flexibility. This seems at variance with the seemingly less useful way of treating flexibility as a performance objective. Slack's original conception of it as a means to the end of providing particular levels of performance in terms of other dimensions - product, quality, speed, cost - still appears more insightful. Flexibility may be a reason for developing a relationship with a supplier, but at the level of individual orders, it is a product of a particular quality at a particular time that the customer buys. Flexibility of one sort or another may make it possible for the manufacturer to provide this product, but it is the product that is bought, not the flexibility of the manufacturing system.

Easton and Rothschild (1987) consider production flexibility in terms of its relationship with marketing strategy and, as such, offer a number of insights useful to the present research. They adopt Slack's range/response dimensions of flexibility (although using slightly different terms) and, using an analysis based on economics, determine that there are discontinuities in the cost/benefit relationship; that is, flexibility over some ranges in some dimensions add nothing to the competitive advantage of the producer, yet a possibly smaller range of flexibility in another dimension may add very significantly to competitive advantage. This is essentially a static analysis but makes the case, from an entirely novel perspective, for a very discriminating and case-specific understanding of flexibility (product flexibility in Slack's typology). This 'translation problem' (Easton and Rothschild, 1987: 308), of flexibility's being seen in process terms by manufacturing and in product terms by marketing, adds to the importance of this concept for examination of the marketing/manufacturing interface.

The article also touches on the issue of customisation. Again emphasising the *discontinuous* nature of many of the relationships, Easton and Rothschild note that, as variety is added:

> '..a watershed in the marketing process is achieved. This occurs when the product changes from one which is producer-specified to one which is customer-specified. In practice this dimension is more likely to resemble a continuum than a dichotomy. At the boundary, products made to order from a series of producer-specified options (e.g. motor vehicles) come close to offering customer specification. Similarly, there occur situations where the production of 'specials' which are clustered, in product space around a set of standard products provides localised customer specification. As the proportion of specials increases, so the firm moves towards the customer-specification end of the spectrum. In doing so, it opens up opportunities to tie in customers by establishing stable, long-term relationships, which create local barriers to entry (Hakansson, 1982). It achieves this at the cost of establishing a wholly different marketing system, and one in which the management of relationships rather than the manipulation of the product mix is the key skill....An acceptable marketing strategy requires the matching of the potential of the production process with customer requirements.'

This extended quotation is one of the most carefully-considered comments on the nature of product customisation offered in the literature. It appears somewhat inconsistent in that it on the one hand sees the degree of customisation as a continuum, yet identifies a 'watershed' and then a point at which a 'wholly different marketing system' is required, neither of which suggest a gradual transition.

Easton and Rothschild go on to reflect on the 'response' dimension. The possibilities of microprocessor-based production technology notwithstanding, increased variety will still result in some additional production costs in most cases. This is arguable but, interestingly, they also note that the predictability and measurability of costs will be reduced, recalling the 'Reliability' column of Figure 2.6. The increased flexibility may also have implications for marketing communications strategy. As customer-specified products increase, so the efficacy of brand-based communication is reduced and 'image-making may have to become concentrated somewhere between the brand and corporate level.' Also noted are the needs for closer liaison with design and production and for the different selling skills demanded by selling capabilities rather than products.

The work of Upton (1994) is brought to mind in Easton and Rothschild's use of the term 'adaptability' in contrast to 'flexibility'. Adaptability is 'long-term, discontinuous and resource-expensive'; this appears the same as Upton's 'strategic flexibility'. Easton and Rothschild make the point that flexibility may inhibit adaptation - an ability to 'muddle through' makes it possible to put off fundamental change. This is a different use of these terms than Slack's (1983). To Slack, adaptability and flexibility did not differ in terms of the time-period to which they applied, but adaptability determined the extent to which the flexibility latent in the technology was actually exploited. Sanchez (1995) distinguishes between resource flexibility, which is analogous to flexibility in Slack's terms and is assessed in terms of range and response, and coordination flexibility, which relates to the way in which a firm redefines, reconfigures and redeploys the totality of resources. Sanchez holds that the latter enables firms to pursue alternative product strategies.

As far as the present research is concerned, it is notable that many of the types of flexibility identified depend on product-range issues (Sanchez, 1995). Gerwin (1987) extends the basic typology of flexibilities to include product mix, modification, sequencing, and changeover flexibilities. Subsequently (Gerwin, 1993) he relates types of flexibility to the sources of uncertainty giving rise to a need for them. Furthermore, he identifies some of these sources as marketing issues and some as manufacturing. These relationships are summarised in Table 2.5.

Table 2.5 Strategic Flexibility Types

Sources	**Type of Uncertainty**	**Strategic Objective**	**Flexibility Dimension**
Marketing	Market acceptance of kinds of products	Diverse product line	Mix
	Length of product life cycles	Product innovation	Changeover
	Specific product characteristics	Responsiveness to customers' specifications	Modification
	Aggregate production demand	Market share	Volume
Manufacturing	Machine downtime	Customer's due dates	Rerouting
	Characteristics of materials	Product quality	Material

(adapted from Gerwin, 1993)

The conclusion of this review is that flexibility is best considered as a means rather than an end in itself. In this sense it appears no different to capacity (one of the decision areas) and, although perhaps more systemic in nature, is a property rather than an objective of a manufacturing system.

2.3.9 Generic Manufacturing Strategies

A number of researchers have attempted to identify generic manufacturing strategies, either empirically (Stobaugh and Telesio, 1983;; Sweeney, 1991; Miller and Roth, 1994) or by theoretical extension of other frameworks e.g. the Porter taxonomy (2.2.2) (Kotha and Orne, 1989). Sweeney suggests that the process of determining which manufacturing capabilities are required based on the competitive positioning of the business is in need of simplification and that it may be facilitated by identifying generic strategies, which could then be adapted to the specific instance. On this very issue, Skinner comments:

> 'In my own and others' defence we have not been prescriptive because it is more art than science and there are 999 variables and 998 equations, so to speak. This is true and reasonable, but I would suggest that we could be a lot more helpful to managers and that we need to be. Until MCS ['manufacturing in the corporate strategy'] can provide more links between tasks, objectives and specific manufacturing policies, only bright students in a well-led case-method classroom will do the synthesis needed and MCS will continue to miss its potential. This is the greatest research, writing and consulting need and opportunity in the field.' (Skinner, 1992: 22)

Stobaugh and Telesio and, to a lesser extent, Miller and Roth adopt essentially a trade-off view. Their position appears to be that different firms may adopt different bases for competition and, as such, require different approaches to manufacturing. Kotha and Orne also adopt this position, although their work is entirely theoretical. The aim of identifying generic strategies in these cases then, appears to be to 'bundle up' a set of consistent policies in various decision areas and so simplify the strategy-formation task.

Sweeney's analysis identifies generic groupings but allies them to the Four-Stage model of Hayes and Wheelwright (1984: 396), thereby implying that some generic strategies are better than others. The purpose of Sweeney's process is to provide a path for every firm to the 'innovator' strategy where 'the nucleus of the innovator strategy is just-in-time production'. There is a clear divergence here from the contingency-theory basis of, for example, Berry and Hill (1992), who specifically warn against such 'panaceas'.

2.3.10 Do Formal Manufacturing Strategies Improve Performance?

The business strategy literature has long considered the issue of whether formalised planning processes actually improve firms' performance. Mintzberg (1994: 91-158) provides one summary of this and, perhaps not surprisingly, finds the evidence inconclusive. He reports evidence that planning plays a useful role in some respects, but also evidence that planning can hinder creativity by over-formalisation.

Although the manufacturing strategy literature has advocated various strategy formation techniques and processes, there is very little evidence as to whether these processes are beneficial to performance. Tunälv (1992) found, from a questionnaire survey of Swedish firms, that 'units with a manufacturing strategy were significantly..more successful in their financial performance'. Having a 'manufacturing strategy' was defined as having formulated manufacturing objectives, aligned with the competitive means (such as cost, quality etc) and with a time horizon longer than a year. A written strategy was not necessary, although there was strong correlation between the two. This type of study though, as the authors partly concede, cannot address causality, and the point Mintzberg (1994:94) makes about business strategy applies here too: do formal strategies make for success, or is it just that successful companies can afford to pay people to write strategies?

Other process modellers are vague or fail to substantiate their claims. Hill (1993: 37) claims that his approach has 'been researched and tested successfully in many industries and businesses of different sizes' but there is no empirical evidence to support this. Others concentrate on the process rather than the outcome: '[o]f particular importance was the managers' reaction to the process... If for no other reason, methodologies such as this are a valuable subject for academic study ' (Slack, 1994); 'It is difficult to measure objectively whether the approach has been successful and therefore we have relied on subjective assessments from the managements within the firms..' (Platts and Gregory, 1990). Quinn (1978) likened strategic planning processes to ritual rain-dances, in that they have no effect on what follows but those that dance believe they do; furthermore, he suggests, the prescription of academics appears to be directed at improving the dancing, not the weather.

Because of the practical impossibility of controlling for other factors, perhaps views such as those of Slack and of Platts and Gregory above are the most honest.

Identifying the success or otherwise of processes which are, by definition, supposed to have long-term and pervasive effects is likely to be best studied using a combination of techniques.

2.3.11 Conclusions on Manufacturing Strategy

This section of the review has set out some of the key issues in manufacturing strategy. At the heart of most manufacturing strategy models are the competitive criteria and decision areas. The strategy process models in the literature have not, for the most part, moved on much from early business strategy process models. There is some evidence that it is possible to pursue multiple objectives successfully: some would argue that it is essential to do so. Although a hierarchy of strategies rather like that of Hofer and Schendel (1978: 28) is often used to situate manufacturing strategy, the literature is very inconsistent on the level at which a manufacturing strategy is best defined.

Underlying many of the concepts reviewed - focus, flexibility and generic manufacturing strategies - is the original trade-off concept. Assumptions one way or the other about this basic concept determine just about everything else in the literature. While aspects of the original idea have been qualified - by Skinner (1992) himself amongst others - the current conclusion is well summed up by Skinner: 'What about trade-offs? They are just as real as ever but they are alive and dynamic' (Skinner, 1992: 20).

With reference to the present research, it is notable that hardly any manufacturing strategy models mention customisation or product-range explicitly. The product-range underlies a number of concepts in the field, notable focus and aspects of flexibility.

2.4 Manufacturing and Marketing

The manufacturing-marketing interface is of great importance to the present research. To a large extent, product policy is the domain of marketing and, if we are to consider how manufacturing strategy concepts may be used to inform product customisation and product variety decisions, then we need to know something of the relationship between the two functions in more general terms. In particular, it will also be useful to identify the extent to which customisation and product variety issues figure in general discussions of the relationship between the functions.

2.4.1 Conflict Areas

A number of writers have discussed the interface between marketing and manufacturing (Shapiro, 1977, 1979; Hayes and Wheelwright, 1979a, 1979b; Hill, 1980,1985; Blois, 1980a, 1980b, 1983; Lim and Reid 1992; Crittenden, Gardiner and Stamm, 1993; Konijnendijk, 1993). One approach to describing the problem has been to identify areas of conflict between the two functions. Two such taxonomies are summarised in Tables 2.6 and 2.7, along with summaries of the authors' prescriptions for improvement.

Of course, these are caricatures of the situation. St John (1991) reports a less stark picture in one industry. Whilst marketing and manufacturing functions agree on the general characteristics of objectives (e.g. reliable due dates or developing a 'full' product-line), the disagreement arises over specific actions or strategies to achieve

Table 2.6 Shapiro's Marketing-Manufacturing Conflict Areas

Marketing	Issue	Manufacturing
"Why don't we have enough capacity?"	Capacity planning and long term sales forecasting	"Why didn't we have accurate sales forecasts?"
"We need faster response. Our lead times are ridiculous."	Production scheduling and short-term sales forecasting	" We need realistic customer commitments and sales forecasts that don't change like the wind direction."
"Why don't we ever have the right merchandise in inventory?"	Delivery and physical distribution	"Why can't we keep everything in inventory?"
"Why can't we have reasonable quality at reasonable cost?"	Quality assurance	"Why must we always offer products that are too hard to manufacture and offer little customer utility?"
"Our customers demand variety."	Breadth of product line	"The product line is too broad - all we get are short, uneconomical runs."
"Our costs are so high that we are not competitive in the marketplace"	Cost control	"We can't provide fast delivery, broad variety, rapid response to change and high quality at low cost."
"New products are our life-blood"	New Product introduction	"Unnecessary design changes are prohibitively expensive"
"Field service costs are too high."	Adjunct services (spares and repairs)	"Products are being used in ways for which they weren't designed."
<u>Managing the conflict</u> - Make the trade-offs explicit - Make performance measures more consistent - Mixed career paths and organisational development	<u>Strengthening the Functions</u> - Segment market in line with manufacturing strengths - Develop an explicit manufacturing task - Modular design	

(Adapted from Shapiro (1977))

Table 2.7 Crittenden, Gardiner and Stamm's Marketing-Manufacturing Conflict Areas

Marketing	Issue	Manufacturing
	Managing Diversity	
Many and complex models	Product line length/breadth	Few and simple models
Customer specifications	Product Customisation	"Stock" products
Product changes immediately - high risk	Product line changes	Planned, only necessary changes: low risk
	Managing Conformity	
Constant change	Product scheduling	Inflexible
Accept all orders	Capacity/facility planning	Critically evaluate "fit" of orders
	Managing Dependability	
Immediate: large inventory	Delivery	As soon as possible: no inventory
High standards	Quality control	Reasonable control
	Prescription Organisational design Communication Evaluation systems Models Group decision support systems (preferred)	

(Based on Crittenden, Gardiner and Stamm (1993))

these objectives. Furthermore, although disagreement over these type of actions was a consistent pattern, there was no consistency in which actions were favoured by which function. Rather, the results were firm-specific. Having said that, and with the present research in mind, the one area where marketing and manufacturing managers consistently disagreed in the same way from firm to firm was over the elimination of low-profit product variants; furthermore, in the part of the analysis that attempted to relate level of disagreement with firms' use of formal strategic planning, this was by far the area of disagreement most mitigated by strategic planning. These are interesting findings but, of course, despite unusually thorough testing of validity and high response-rates for such a questionnaire-based study, the data collected were only expressions of intention and attitude: no evidence as to actions was collected. Thus, although espousing a Mintzbergian view of strategy as pattern in a stream of decisions, this is not what St John eventually addresses. (And anyway, Mintzberg and Waters (1985) adjust their definition to 'pattern in a stream of *actions*', distancing themselves further from the study of mere *expressed* intentions and plans.)

Studying the supposed gulf between *sales* (rather than marketing) and manufacturing in another single-industry study, Clare and Sandford (1984) found that the two functions tended to blame each other for communications breakdowns, but also found that, whereas respondents from both functions reported much the same personal values of themselves, they 'create artificial distances' between themselves and their opposite numbers by a process of functional stereotyping.

Hill (1981), like St John, attributes the problem not so much to inevitably diametrically opposed priorities of the two functions, but to the precedence given to marketing in development of strategy, and the lack of debate between the functions. This in turn he attributes to the traditionally reactive role of manufacturing management, the lack of language, as compared to the marketing and finance fields, and the typically late involvement of manufacturing management in the formal strategy process. So whereas Shapiro and Crittenden et al identify the symptoms at operational level, Hill attempts to diagnose the cause which, as he sees it, lies in manufacturing's role in the strategy process, a view partly confirmed by Swamidass and Newell (1987). A recent article (Berry, Hill and Klompmaker, 1995) indicates that Hill still perceives that the same problems exist, although in the successive editions of his textbook (at least those available in the UK) his target has shifted from marketing to corporate strategy (Hill, 1985: 32-58; 1993: 25-58; 1995: 23-59).

Crittenden et al (1993) are disappointing in prescription. They identify four mechanisms by which interfunctional conflict generally can be reduced: organisational design, communication, evaluation systems and models. Rather too abruptly, these are dismissed in favour of group decision support systems which apparently 'hold much promise'. Notable is the emphasis on coping with the mismatch in objectives and aspirations of the two functions, rather than bringing them closer in line. St John (1991) is more optimistic, arguing based on her results that agreement can be influenced by formal strategic processes. She acknowledges, however, agreement implies nothing about firm performance. Clare and Sandford (1984) propose training and communication enhancement initiatives, rather than any fundamental strategic alignment.

Shapiro (1977) suggests a number of improvements, strongly related to the manufacturing strategy ideas of Skinner (1969, 1974). He divides these into ways of 'managing the conflict' and of 'strengthening the functions'. The short-term conflict-management approaches include making explicit the trade-offs that exist between marketing and manufacturing requirements (i.e. not eliminating the trade-off but making it explicit in the way that Hill's 'debate' is intended to); making the functions' performance measurements more consistent; and using organisational development approaches such as mixed career paths to develop all-rounders that have experience of both functions' perspectives. Shapiro's point about performance measures is a recurrent theme in his work, in particular his emphasis on pursuing profitable business (Shapiro, 1979, 1988) rather than *any* business. Hill (1985: 36-37) adopts this.

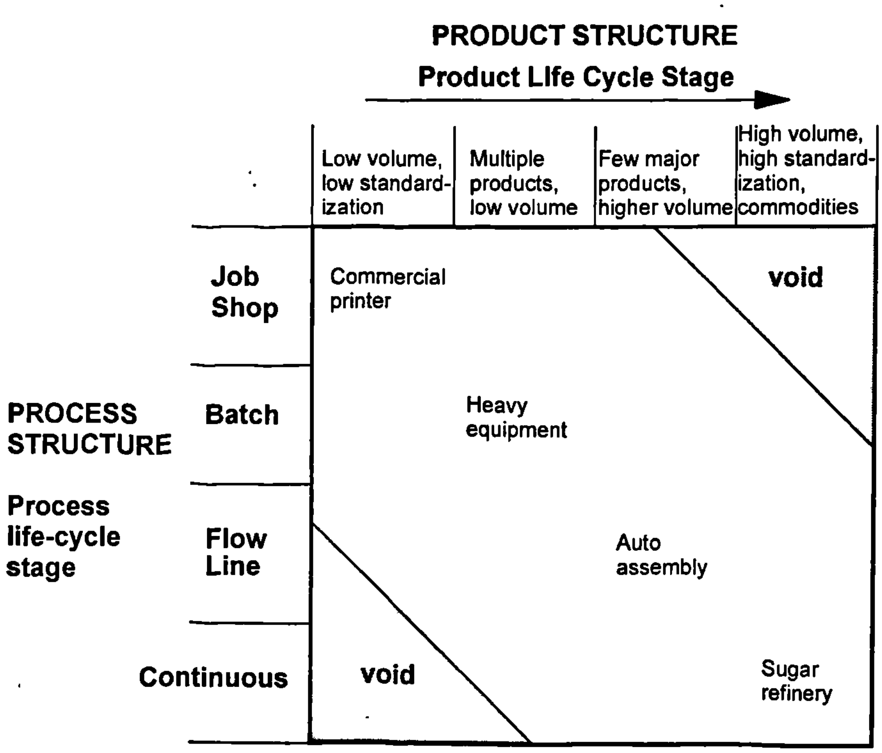
Shapiro's longer-term approaches are also of interest:

> 'Marketers should build their programs around the operational strengths of their manufacturing unit...[and] divide the market into segments and select for penetration those segments whose needs [they] can fill. Finally, [they] must develop a product policy that builds on the manufacturing unit's ability to service customers in those chosen segments' (Shapiro, 1977: 113)

To this he adds a call for the adoption of an explicit manufacturing task in exactly the way that Skinner (1969) proposed and, finally, cites modular design as a method that 'supplies the consumer with apparent variety even though the production output is based on the concepts of mass production'.

2.4.2 Strategic Reconciliation

The work reviewed in 2.4.1 has been largely concerned with describing the conflicts between marketing and manufacturing and, to a lesser extent, suggesting means by which the conflict can be managed and mitigated. In that all these writers consider the interface as a problem area, it is implicit that the promise of top-down planning, in which functional strategies and action plans are all derived from the same business strategy and therefore, presumably, mutually consistent, has not been fulfilled. The typologies of conflict do not paint a picture of two functions where the only issues remaining to be resolved are the detailed translation of orders and forecasts into production schedules, but of fundamental mismatch. The review will now turn to a number of frameworks that have been proposed by which the conflict can be addressed more fundamentally, that is by attempting to align the strategies of the two functions more directly. These are presented in Figures 2.7 - 2.10 and discussed below.



Source: Hayes and Wheelwright, 1979a

Figure 2.7 Hayes and Wheelwright's Product-Process Matrix (1979a)

Hayes and Wheelwright link marketing and manufacturing via the product-process life-cycle concept. They do not, apart from this, make a case for any special linkage between marketing and manufacturing strategy - the two functional strategies are, along with other functional strategies, subordinate to the competitive strategy. (Having said that, nowhere in their 1984 book do they devote such attention to other functional strategies in the way that they do to marketing.) The key issue here is the linking of the competitive criterion, to be inferred from the Product Life-Cycle Stage, with the process type. Hill's framework (Hill, 1980, 1985), shown in Figure 2.8, relates the same variables to one another but is different in that:

- whereas Hayes and Wheelwright's matrix is seen as a supporting tool in the development of manufacturing strategy, Hill's is seen as the basic framework and, as such, the marketing-manufacturing interface is of more fundamental importance for Hill;

- it does not purport to represent the product life-cycle in the way that Hayes and Wheelwright's framework is supposed to.

Furthermore, as discussed elsewhere, Hill's order-winners are different to the competitive criteria in that they are more marketing-oriented (but they were not included in the 1981 version). It is doubtful that Hayes and Wheelwright intended the product life cycle as anything but a 'shorthand' for volume and variety issues. In the examples they give there is no reason to suspect that, for example, the products made by a commercial printer are any younger than those made by an automotive manufacturer: the real point is that a commercial printer makes many different products in low volumes and a car plant makes fewer products in higher volumes.

Figure 2.8 Hill's Manufacturing Strategy Framework (Hill, 1985: 41)

1	2	3	4	5
Corporate Objectives	**Marketing Strategy**	**Order-winning Criteria**	**Manufacturing Strategy**	
			Process Choice	**Infrastructure**
Growth Profit ROI Other financial measures	Product markets and segments Range Mix Volumes Standardisation v customisation Level of innovation Leader v follower	Price Quality Delivery speed Delivery reliability Colour range Product range Design leadership	Choice of process Trade-offs embodied in the process choice Role of inventory	Function support Manufacturing systems Controls and procedures Work structuring Organisational structure

Shapiro links the volume/variety dimensions to product customisation holding that 'The two variables, [production] run length and degree of customization, loom large because the marketer plays the 'bridge role' in relating customer needs and company manufacturing capability' and 'Indeed, the degree of customization in a product line or line of services marketed is beginning to appear to be the most important product policy variable for industrial goods producers and many other types of companies' (Shapiro, 1979). Based on this, the framework of four marketing-manufacturing alignments is proposed. Whilst the prescription is, by Shapiro's admission, 'quite incomplete', the major contribution made by this is the linking of the volume-variety dimension, which underlies much of the classic manufacturing strategy theory, with customisation. Nowhere other than in Shapiro's work (and in that of Blois, below), until the recent 'discovery' of mass customisation, has customisation been treated as anything other than a marginal issue e.g. as just one of many aspects of 'flexibility' (see above).

Figure 2. 9 Shapiro (1979) "Analyzing What Things Must Be Done Well"

	Low customisation	High customisation
Long production runs	**Manufacturing-oriented marketing** Strong cost-effective production capability Tendency toward automated equipment and fixed costs	**Account-oriented marketing** Strong applications engineering function Strong direct sales force
Short production runs	**Order-based marketing** Strong distribution system Large inventories in field and factory Careful product-line management Justified fear of product-proliferation	**Flexible marketing** High gross margin High manufacturing capability Small operating units Integrated sales and manufacturing organisations

These basic issues are further combined by Blois (1980a) into the so-called Policy Interaction Grid. The context of Blois' concerns is the role large customers play in influencing the areas of activity in which manufacturers become involved. He thus combines the same basic analysis as Shapiro's with a more explicit focus on the degree of emphasis on building relationships with large customers. This represents an early sortie into the territory subsequently explored in depth by the IMP researchers (indeed, Blois cites a 1975 article by Håkansson). Blois warns against trying to occupy too many 'boxes' on the grid.

Figure 2.10 Blois' Policy Interaction Grid (Blois, 1980a)

Product Policy	Manufacturing Policy	Marketing Policy	
		Custom Marketing	Mass Marketing
Special Order Products	Small Batch Manufacturing	1	2
	Volume Manufacturing	3	4
Standard Products	Small Batch Manufacturing	5	6
	Volume Manufacturing	7	8

In various formats then, these frameworks seek to link together the following dimensions:

- volume/variety
- product customisation
- competitive criteria or order-winners
- customer account size

and, with their own particular emphases, they all advocate concentration on a limited combination of these or, at the very least, an acknowledgement of the dangers of attempting to operate across a range of dimensions. Shapiro's and Blois' analyses extend the prescription beyond the plant, effectively into 'focused' applications engineering and sales organisations.

Blois (1980b) suggests that distinctive competence, until then perceived as an attribute of one function or another (e.g Snow and Hrebniak, 1980), may be better considered as obtaining from the very link between the two functions. In this sense, Blois' work predicts some aspects of both the core competence (e.g. De Leo, 1994) and network (Biemans, 1995) literatures, as well as being in similar vein to Shapiro (1988).

Blois also identifies some reasons for conflict between the functions, the most interesting of which is 'disagreement as to whether marketing or manufacturing activity is the most cost-effective method of producing value'. This is an original and powerful insight. Blois holds that manufacturing is the 'process of restricting use': each stage in the process makes the possible uses of its output fewer than those of its input. Marketing have the role of identifying the value that customers place on the satisfaction of needs; more specifically they have to understand the extent to which the customer is willing to pay to have the specific benefit of a more specialised product, rather than performing the function for itself. A further role of marketing is to identify new applications for existing products. Whilst this is a fairly standard re-statement of Ansoff (1965), Blois adds that, insofar as this creates an additional value-adding opportunity, it is the same as an additional manufacturing process stage and hence marketing and manufacturing activities are to some extent interchangeable.

The frameworks discussed above are essentially statements of immutable trade-offs. They provide more sophisticated ways of articulating and conveying the trade-offs, but accept them nonetheless. Blois' insight, albeit an under-developed one, seems to offer some promise of moving beyond this: of, to some extent, breaking the stalemate between marketing and manufacturing.

Blois concludes by identifying information requirements that assist the development of this manufacturing/marketing orientation, including 'cost estimates of supplying products outside the normal range', which he identifies as likely to happen when producers attempt to be responsive to large customers, despite loss of focus. The dominance of marketing and its associated information systems may, he suggests, be one reason why it is too often the manufacturing value-addition option that is chosen.

A small number of writers have attempted to link together marketing and manufacturing through a particular juxtaposition of design and manufacturing activities. Jouffroy and Tarondeau (1992) state that what they call an 'industrial strategy' should:

> 'concern value-adding activities... characteristic of the two main industry cycles: design cycle and manufacturing cycle' (Jouffroy and Tarondeau, 1992: 167-168)

These two cycles are illustrated as intersecting, orthogonal processes as shown here in Figure 2.11.

The same concepts were used by Harrington (1973: 12-23) in the section of his book on Computer Integrated Manufacturing (CIM) devoted to setting out the basic manufacturing activities to which he wished to apply computer technology. According to Harrington's distinction:

'The design cycle refers to the events occurring in the development of a specific product design, while the material cycle refers to the events occurring in the production of an individual piece of material taken from raw stock through to finished article.' (Harrington,1973: 12)

This calls to mind the distinction made by Håkansson (1982), with reference to the activities undertaken by a firm with respect to its customers, between problem-solving and transfer abilities (Håkansson, 1982: 382). Although the context is broader, concentrating on the buyer-supplier relationship rather than simply the activities occurring in the plant, there are strong conceptual parallels. These suggested conceptual parallels are indicated in Table 2.8.

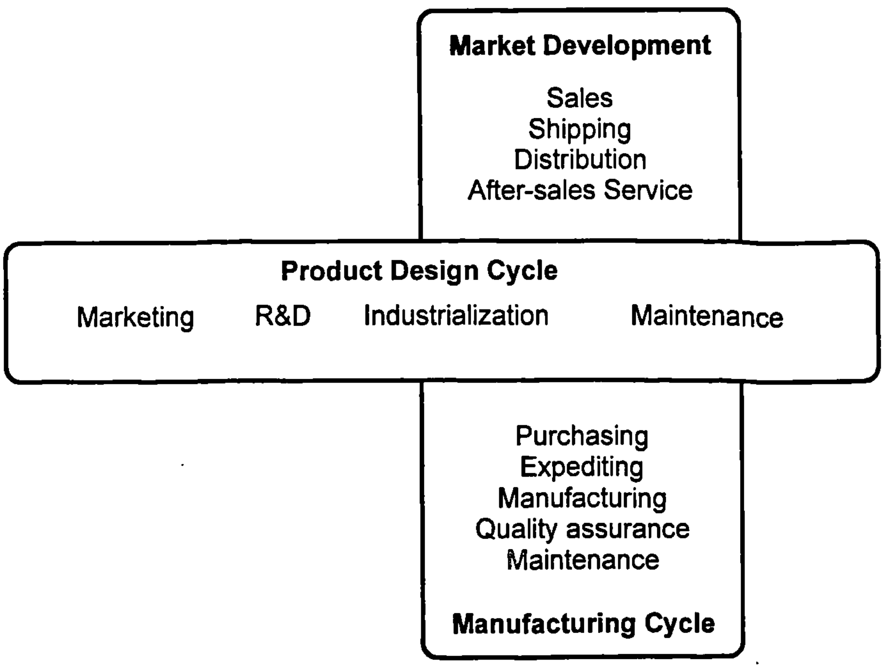


Figure 2.11 Design Cycle and Manufacturing Cycle as Orthogonal Processes (based on Jouffroy and Tarondeau, 1992)

Table 2.8 Design and Material Cycles: Parallel Concepts

Harrington (1973)	Design cycle	Material cycle
Jouffroy and Tarondeau (1992)	Design cycle	Manufacturing cycle
Håkansson (1982)	Problem solving	Transfer

Håkansson develops the idea further, associating with each type of ability a general aspect and an adaptive aspect. For example, the general aspect of the problem-solving part of a relationship describes how 'difficult, complex or advanced' (Håkansson, 1982: 383) it is; the adaptive aspect describes the extent to which the problem is specific to one customer (see Figure 2.12). In this sense there are further parallels with the frameworks discussed above relating to customisation, notably Blois' Policy Interaction Grid and Shapiro's framework.

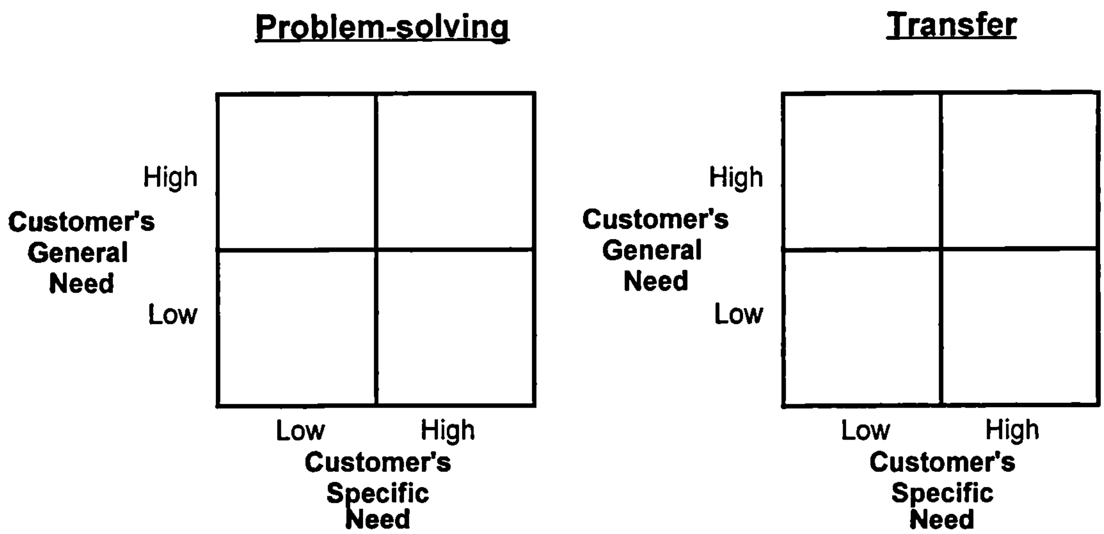


Figure 2.12 Problem-Solving and Transfer Abilities: General and Adaptive

Håkansson's primary concern is to relate these abilities to the degree of mutual dependence and trust in the relationship. Broadly speaking, where the adaptive aspect is high, then mutual dependence is high and the relationship between customer and supplier is very close. Håkansson also uses this analysis of the relationships to determine the most appropriate emphasis in the supplier's resources and activities. He comments:

> 'The connection between, for example, technical resources and the selling firm's general abilities is well known and widely discussed. Perhaps less established is the connection between the ability to design individual solutions and the technical and organisational resources required by the seller.' (Håkansson, 1982: 389)

Finally, it is possible to make a tentative connection between these two abilities and the manufacturing strategy competitive criteria as shown in Figure 2.13.

Problem-solving	**Transfer**
Quality - performance Service Cost?	Quality - conformance Delivery - speed and reliability Cost?

Figure 2.13 Problem-Solving, Transfer and Competitive Criteria

(This is a small set of criteria - the view adopted here is that, for example, flexibilities of various sorts are only means to the ends of achieving the primary objectives.)

The emphasis in much manufacturing strategy literature is on a variety-volume continuum e.g. Hayes and Wheelwright (1979a), Hill (1985: 66), Slack (1991: 101-104). These frameworks often conflate low-volume production with 'specials' and job-shop processes, and high-volume production with 'standards' and line processes (Hayes and Wheelwright, 1984: 209; Hill, 1985: 70-71). Shapiro's and Blois' analyses indicate that this is over-simplistic: for example, high-volume production using a line process may well be used to produce customised products. Finally, the distinction between design cycle and material cycle offers a way of clarifying the situation: it is material cycle factors that influence process choice. As such, it is suggested that the relationship implied in Hill's framework (Hill, 1985: 41) between standardisation/customisation as part of marketing strategy and process choice as the basic issue in manufacturing strategy is a spurious connection. Blois (1980a) tentatively introduces the supplier-customer relationship into the picture and Håkansson takes this further (with a stronger marketing emphasis). This progression takes us from a view which sees customised products as a low-volume abberation in a world dominated by mass-production as the only desirable state of affairs (the implication of the Hayes and Wheelwright product-process life cycle is that manufacturing plants should progress inexorably toward low-variety line production as the product matures) to a very different view which sees close, mutually-dependent relationships founded on the supply of customised products as a significant component of trade, particularly in industrial or business-to-business markets. This points to a need to revisit manufacturing strategy theory and integrate the customisation and relationship issues into established approaches.

2.4.3 Other Research

Hutt and Speh (1984) confirm that the interdisciplinary role of marketing, with manufacturing and with other functions, is increasingly important in the strategy formulation and strategy implementation processes. They identify an explicit role for marketers in influencing the design of logistics and manufacturing systems. Using a mathematical modelling approach, Kim, Ritzman, Benton and Snyder (1992) show that linkages between marketing and manufacturing, in this case taking the form of integrated product-line and process design decisions, improve performance. Although the modelling approach adopted is highly idealised in its assumptions, this piece of work is interesting in that it chooses these characteristics to represent the two functions, as well as being rare in attempting to model product-line rather than individual product management decisions.

Lim and Reid (1992) offer a largely derivative framework that appears to do nothing more than suggest that other functions' strategies should be formulated with marketing strategies in mind so that 'potential synergy effects' can be identified and exploited. No basis for identifying these is proposed. Konijnendijk (1993) carried out a more discriminating study, attempting to identify co-ordination problems and approaches in firms distinguished by logistics structure. The hypothesis he examined was that the type of coordination problems most prevalent would depend on whether the firm operated in a make-to-stock, make-to-order or engineer-to-order context. A notable finding of his was that 'specials' were a recurrent source of coordinating problems in firms with a make-to-stock logistics structure.

In their discussion of the relationship between manufacturing strategy and marketing objectives, Gupta, Lonial and Mangold (1991) stress the marketing pursuit of market share and note that this is often achieved through expansion of the product line. Their research instrument adopted the three-dimension characterisation of manufacturing strategy developed by Kotha and Orne (1989) (see 2.3.9) and sought to identify relationships between these three dimensions - product line complexity, process structure complexity and organisational scope - and the firm's marketing objective distilled down to one of three attitudes to market share. The data were collected by questionnaire and the results indicate that, as we move from 'minor competitor' to 'dominant market share' (via 'major competitor'), firms have increasing process structure complexity and organisational scope. Product line complexity does not vary significantly. These results are of somewhat dubious merit anyway as the dimensions were assessed using Likert scales on a postal questionnaire and there is no evidence of any assessment of construct validity. Thus, the purely quantitative assessment of product line complexity is of doubtful validity; also, both the fact of describing 'marketing objectives' purely in terms of some individual's professed attitude to market share and the risks involved in defining what the market is anyway render the independent variable next to meaningless. Finally, it is doubtful that any one person would be in a position to answer all the questions accurately anyway, despite the fact that Gupta et al tell us that 37.2% of respondents had Masters degrees and 7.6% had doctorates. The insights here are of dubious merit then, although the lack of variation in the product line complexity may indicate that product variety is a problem to the same extent in many types of firm. Once again though, we have no idea of whether a product line complexity of 10.643 (yes, three decimal places) is high or low in absolute terms.

In their special issue of the Journal Of Operations Management, Berry, Hill, Klompmaker and McLaughlin (1991) note the early stage of development of the marketing-operations literature, and the eclectic and inconsistent literature base used by the authors writing in that edition. Gupta et al's 1991 article demonstrates a similarly desperate throwing-together of under-developed constructs in an attempt to generate some quantitative data, with little apparent interest in *understanding* anything. As discussed elsewhere here, Berry et al call for much more plant-based case-study research. (It is also interesting to note that the pre-eminent US Operations Management journal only attracted 29 submissions for the edition.)

Draaijer (1992) adopts much of Hill's framework. His study, however, attempts to link improvement programmes in manufacturing to their effect on marketing, expressed in terms of the order-winning criteria (Hill, 1995: 42-43). In this way, the study goes beyond Hill's work, by making connections with programmes and projects. Draaijer's key findings rather support those of Blois in that he finds that the manufacturing functions have information systems that do not relate to the order-winning criteria, but concentrate on costs. As such, the impact of improvement programmes is not easily assessed. Incidentally, Draaijer's study also found that in two out of his three groups of firms, customisation was cited as a key order-winning criterion but, disappointingly, offered no specific insights as to how the improvement programmes adopted addressed this requirement.

In summary then, there is considerable agreement that conflict exists between marketing and manufacturing and that it relates to a number of issues of concern to both functions. St.John's work in particular elaborates on this, providing some evidence that, while functions articulate similar aims and objectives, they diverge in particular over the concrete actions and decisions necessary to bring about those aims (St John, 1991). Konijnendijk (1993) brings a contingency approach into the picture, finding that the areas of disagreement vary with the logistics structure of the operation. Prescriptions for improvement range from accepting the inevitability of conflict and trying to mitigate its effects by training initiatives (e.g. Clare and Sandford, 1984), through making the trade-offs more explicit (Shapiro, 1977; Hill, 1980), to re-aligning the manufacturing and marketing strategies to identify which segments the firm can profitably compete in (Shapiro, 1979) and designing the manufacturing system accordingly (Shapiro, 1977; Hill, 1985; Hayes and Wheelwright, 1979a, 1979b). It is notable that the trade-off still informs much of this work. Blois' theoretical analysis is rare in questioning the rigidity of the trade-off, and his suggestion that to some extent marketing and manufacturing are interchangeable as ways of adding value appears potentially useful (Blois, 1980a). Finally, it is particularly noteworthy that the product, product customisation and product variety are central to many of these assessments of the marketing-manufacturing interface.

2.4.4 The Product and Related Issues

As we have seen, Hayes and Wheelwright's (1979a, 1979b) principal linking mechanism between marketing and manufacturing is the product-process matrix. They acknowledge Shapiro's interfunctional problem areas (Shapiro, 1977) but suggest that:

> '[d]ealing one-by-one with the problem areas in [Shapiro' paper] is not by itself likely to lead to a substantial increase in harmony between marketing and manufacturing. Instead, one needs to understand, in managerial terms, why that interface can so easily become a fault line in the firm......One approach to developing that kind of understanding is based on an analysis of how product and process life cycles interact.' (Hayes and Wheelwright, 1984: 199, 201)

Hill's approach (Hill, 1995) links marketing and manufacturing by means of the criteria by which products win orders. Although less deterministic than the life-cycle approach of Hayes and Wheelwright, again it is the product that is the connection. Crittenden, Gardiner and Stamm (1993) have the product as the only common concern of the two functions, and New (1992) has 'Product' as the only 'P' common to both the marketing and the manufacturing mix in the Cranfield Competitive Edge Model. For this reason the discussion now turns to the product, product-range policy, the product life-cycle and product customisation.

2.4.4.1 The Product

The product is popularly conceived as part of the marketing mix - one of the Four Ps (McCarthy, 1960), along with price, promotion and place. Although it is understood that the Four Ps is not seriously adopted as a useful guiding framework, particularly as applied to business markets (IMP, 1990: 8), it still informs a good deal of work in the area. And whether the Four Ps mnemonic is used or not, the marketing mix is certainly central to basic marketing theory:

> '*Marketing strategy* is the marketing logic by which the business unit expects to achieve its marketing objectives. Marketing strategy consists of making decisions on the business's marketing expenditures, marketing mix, and marketing allocations in relation to expected environmental and competitive positions.' (Kotler, 1991)

According to Kotler, 'Marketing mix is one of the key concepts in modern marketing theory' (Kotler 1994: 98). In expanding the Ps, Kotler proceeds as follows:

Product:	Quality, features, options, style, brand name, packaging, sizes, services, warranties, returns.
Price:	List price, discounts, allowances, payment period, credit terms.
Place:	Channels, coverage, locations, inventory, transport.
Promotion:	Advertising, personal selling, sales promotion, publicity.

It is accepted that the product is a complex idea. Kotler's definition is:

> 'A *product* is anything that can be offered to a market for attention, acquisition, use, or consumption that might satisfy a want or need. It includes physical objects, services, persons, places, organisations, and ideas.' (Kotler, 1991)

As the marketing concept emphasises the satisfaction of consumer wants and needs, rather than simply the selling of products or services, the core benefit or service is placed at the centre of this model and (where appropriate) the physical product is only seen as a vehicle for the satisfaction of the customer's needs. This tangible product has 'as many as five characteristics: a quality level, features, styling, a brand name, and packaging.' (Kotler, 1991) At a third level, there is the augmented product, which includes further services and benefits: installation, delivery and credit, warranty and after-sales service.

2.4.4.2 Product Range

Cardozo (1979) offers a slightly different view of the marketing mix:

> 'In most cases, an organisation will offer a line of products or services, rather than just a single product or service. ..The product line is a more useful unit of analysis than the single product, because almost all individual products are managed as members of a product line.'
>
> 'A product line is itself a variable in the marketing mix, like price, promotion, or distribution, but is the most important.'

> 'The objective of a product policy is to establish an optimum portfolio for an organisation.' (Cardozo, 1979: 1-3)

It is useful at this stage to attempt to define terms. Kotler proposes the following definition for product-line:

> '..a group of products...that are closely related, because they function in a similar manner, are sold to the same customer groups, are marketed through the same types of outlets, or fall within given price-ranges' (Kotler, 1994: 434)

First, it is interesting to observe that some of these parameters by which 'relatedness' may be assessed are, we have been led to believe, non-product decisions: 'types of outlets' - place (or promotion?); 'price-ranges' - price. Secondly, relatedness is subjective. To the manufacturing department, our two identical *tangible* products with different credit arrangements are, indeed, identical. To the finance department they are not. To the customer, they are not. So, we have non-orthogonal variables in the marketing mix. As Kent (1986) puts it: 'To define product ranges as simply groups of related products, as is common in the literature, is not really adequate. Not only does what counts as a "product" vary, but "relatedness" may itself take many forms.' Here, Kent uses the term product-range rather than product-line and there is indeed some inconsistency in usage in the literature. In the US, the product-mix, is 'the set of all product lines and items that a particular seller offers for sale to buyers' (Kotler, 1994: 434) and has four parameters: width, length, depth and consistency, defined as follows (Kotler, 1994: 435):

Width	the number of different product-lines
Length	the total number of products offered
Depth	the number of variants in each product-line
Consistency	how closely-related the various product-lines are

Product-mix in UK operations management terms refers, for example in a scheduling context, to the number of different product being made in a relatively short period of time and their respective volumes. To keep the distinction clear here, the term product-range will be used to refer to all the products that a firm makes or offers (e.g. in a catalogue). Product-line will be used to refer to products explicitly related in some way (Kent's doubts being acknowledged). These definitional issues aside, it is contended that 'the fate of companies is determined largely by how they handle such large numbers of products in their range.' (Kent, 1986). This section will now examine some of the ways in which product-ranges and product-lines may be characterised.

As mentioned, Kotler (for example) gives three measures of the product-range which are all quantitative - they simply tell us how many lines there are, how many separate items there are, and so on. The fourth, consistency, attempts to express relatedness and is qualitative. Kent (1986) meanwhile, stresses the need to consider the *structure* of the product-range and identifies two key variables. Ranges can be considered hierarchical, where there is some notion of superiority/inferiority between products ('basic'/'de luxe'), or they may be parallel, where products are not better or worse than one another, just different (orange juice, tomato juice). The other dimension is that of concentration versus diversification, which again attempts to capture how far apart products are from one another. These are shown in Figure 2.14. Whilst this may be possible for hierarchical ranges, it is difficult to see how this would apply to parallel ranges where, by definition, there is no dimension by which to measure similarity i.e. how similar is orange juice to tomato juice?

	Hierarchical	**Parallel**
Concentrated		
Diversified		

Figure 2.14 Kent's Types of Product-Range (from Kent, 1986)

Shapiro (1987) develops two dimensions that are similar to those of Kent, although Shapiro does not attempt to fit them into an orthogonal model. First, there are universal benefits, which are basic performance benefits that all customers buying a particular class of product want to some degree: e.g. size, power, insulation. This is close to Kent's hierarchical variable. The other type of benefit is what Shapiro terms 'diverse specifications': these are features that are either present or absent and, whereas universal benefits are such that customers all want as much as they can have of the benefit, in the case of diverse specifications, customers may actively prefer not to have them. Shapiro models consumers as making trade-offs (a) between universal benefits (e.g. power and fuel efficiency) as well as between universal benefits and diverse specifications (e.g. left-hand drive). We will return to the implications of this identified by Shapiro.

Fisher, Jain and MacDuffie (1994), in discussing the automotive industry, hold that product variety in the industry is 'often' classified as fundamental variety or peripheral variety. Fundamental variety refers to 'platforms', models and body styles, whereas peripheral variety refers to options. They note that Japanese manufacturers have 'typically' competed on fundamental variety, whereas US producers have had less fundamental variety and more peripheral variety (although this seems somewhat at odds with their gleeful observation that Mazda produce their 323 model in *four shades of black* at their Hiroshima plant).

Although less concerned with identifying the structure of product-lines or product-ranges, Cardozo (1979: 31) identifies seven 'distinct attributes of a product-line' which may be altered 'individually or jointly':

1. Position
2. Physical characteristics
3. Package
4. Brand
5. Amount and nature of value added
6. Expansion or reduction of the product line
7. Composition of the product line

If, indeed, these can be altered independently, then they ought to offer an exceedingly powerful way of defining and structuring product-ranges. However, without dwelling on the details of the text for too long, it soon becomes apparent that they are distinct neither in the sense of being clear, nor in the sense of being separate and unconnected with one another. For example, we are told that changing the position of a line may involve altering the physical characteristics (one of the other 'distinct' attributes), or by raising the price (one of the other 'Ps'); and that one way of changing the composition of the line is to offer optional features (features are part of the physical characteristics), which appears to be a shift toward customisation. Perhaps our only conclusion here is that many of the terms used are ill-defined and that the Four Ps, long since considered inviolable tenets of marketing theory, are not independent levers that can be pulled at will, but highly interrelated and multi-faceted.

2.4.4.3 Product-Range Breadth

The previous section has concentrated on approaches to dimensioning and structuring product-ranges. A related but distinct issue is the determination of the most appropriate breadth of product-range. As with the typologies of marketing-manufacturing conflict, a number of writers have identified reasons for and against product variety, and this section of the review begins by drawing these together. Some writers go further and propose ways of evaluating product-line additions. One article reviewed (Kekre and Srinivasan, 1990) assesses whether firms with broad product lines have proved successful. The factors militating for and against a broad product line are summarised in Table 2.9.

Table 2.9 Factors Influencing Product-range Breadth

Shapiro (1977)	Kekre and Srinivasan (1990)	Guiltinan (1993)	*Quelch and Kenny (1994)
<u>For:</u>	Hypothesised relationships:	<u>Sales benefits from variety</u> depends on:	<u>The Lure of Line Extensions</u>
Loss of competitive position as full-line supplier	A broad product line results in higher market share	Buyers' need for variety Use of substitute categories Price-performance gaps Importance of differentiation from pioneer Category differentiability	Satisfying customer segments Potential for premium pricing Entry barrier Retailer pressure for customised offerings
Loss of position as supplier in particular market area or segment	A broader product line leads to higher relative prices		
Loss of distributor/sales force support Loss of economies of scale	Direct costs increase with line breadth due to lower volume/higher variety of bought-in parts but, if market share increases, costs may reduce through increased buying power	<u>Fixed Cost impact</u> depends on: Economies of scope FMS Economies of scale	<u>The Pitfalls of Proliferation</u> Confused role of each item Weakening of brand loyalty Underexploited ideas Cannibalization in stagnant total market Retailer dissatisfaction Increased costs
<u>Against:</u>	Inventory increases, both WIP and FGI, but can be mitigated by parts commonality	<u>Cannibalization loss</u>: depends on	
Added inventory costs in materials, WIP, finished goods	Costs increase due to increased changeover, materials handling and quality control activity; market share increase may mitigate this.	Relative price/performance Brand name leveraging Attribute similarity Usage context similarity	*Note: Quelch and Kenny's concern is specifically with extensions to existing lines rather than with product-range breadth more generally; it is also specific to consumer goods.
Changeover costs - downtime, setup, scrap, 'stress and strain on equipment and employees'	Higher market share increases profitability; higher costs may reduce profitability	<u>Sales loss through *inaction*</u> depends on	
Order-processing and transportation		Loyalty/switching costs Rate of diffusion of new offerings Competitors' resources Development risk	
Sales-force, distributor, customer confusion and displeasure	Broader product-line may adversely affect profitability (combining above effects)		
		<u>Complementary product sales</u> depend on	
		Opportunity to enhance satisfaction with other products High potential search cost savings Significance of image complementarity	

The schemes all tackle the problem in different ways and have slightly varying emphases. Quelch and Kenny are primarily concerned with the implications of line extensions on retailer and consumer. The other work is more general.

Shapiro observes that:

> '...the costs of the [overly] narrow product-line and all of the *measurable* (as distinct from actual) costs are in the marketing area. For the broader than optimum line the situation is reversed - all of the measurable costs and almost all of the actual costs are in the manufacturing area.' (Shapiro, 1977)

This marketing-manufacturing interface perspective is particularly relevant to the present research and will be pursued here. Rather than attempting to consolidate all these into one comprehensive model of the effects of product-line breadth, there is a more important observation to make, in addition to that of Shapiro's. The effects of product-line breadth on marketing are a mixture of qualitative and quantitative; the effects on manufacturing are almost exclusively quantitative. Table 2.10 shows this, based on the four articles reviewed. Whilst there is no pretence at exhaustive analysis of the factors, there is sufficient evidence to indicate that almost all the effects on manufacturing identified are a result of there being, simply, *more* products. More products means smaller batches, more set-ups, more inventory, parts purchased in smaller lots, more administration and more materials handling - more cost. The marketing implications include quantitative issues - market share and profit, for example. But they also include many qualitative issues: whether the products fit particular customer needs, how much and in what way they differ from other products, how clear a role their particular features and attributes play in satisfying customers. A number of equivalent manufacturing issues could just as easily be identified. For instance, does it not matter to manufacturing whether Product A is similar to or entirely different from Product B? Does it not matter whether Product A is required in batches of 20, and Product B is required in batches of 10 000? Does it not matter to manufacturing that Product A is positioned as a premium, high-specification product, and Product B is positioned as a basic low-specification, low-price model? Does it not matter that Product B falls right in the middle of the size-range that can be accommodated by the production machine, but Product A is at the limit of the machine, recently extended by judicious modification to the machine's tooling? Very little is reflected in the schemes discussed here other than that the changeover from Product A to Product B will involve stopping the machine and changing it over (incurring cost), build-ups of WIP and other inventory due to the stop-start process (incurring cost), administration of the changeover and materials handling (incurring cost). These issues fall naturally within the ambit of the classical applied operations research approach to Operations and Production Management, but do not present a comprehensive picture; indeed they may present a misleading one if they encourage all products to be treated in the same way.

The other perspectives from which this issue will be reviewed is the extent to which the treatment given here is systemic, in that it considers not only whether the addition of one new product variant is desirable, but also what the effect of the whole range is and, related to that, to what extent an interaction view can be accommodated. Both of these need further explanation.

Table 2.10 Quantitative and Qualitative Effects of Product Variety on Marketing And Manufacturing

Marketing		Manufacturing	
Qualitative	Refs	Qualitative	Ref
Full-line supplier	1	Common parts may mitigate variety problems	2
Supplier of particular need	1, 4		
Differentiation	3		
Image complementarity	3	Quantitative	
Attribute similarity	3	Set-up/changeover costs	1-4
Confusion of positioning	4	Inventory costs	1,2
		Quality control costs	2
Quantitative		Purchasing power lost	2
Market share	2	Economies of scale/scope	3
Profit	2		
Refs: (1) Shapiro (1977); (2) Kekre and Srinivasan (1990); (3) Guiltinan (1993); (4) Quelch and Kenny (1994)			

Notable as systemic issues are the notion of being able to operate as a 'full-line' supplier (Shapiro) and that of erecting entry barriers (Quelch and Kenney). These contrast with the more localised issues of whether a manufacturer offers a particular model or variant that exactly satisfies a customer's particular, immediate needs. Especially as many industrial purchasers seek to reduce their supplier-base, it is increasingly an issue that the supplier be able to offer a 'full' range *per se*. This makes it (a) more likely that a buyer will enter into a long-term relationship with the supplier and (b) (which is Quelch and Kenney's point) less likely that a competitor will easily be able to supplant the supplier in that relationship once it is established.

The connected point about relationships/interaction has already crept into the discussion above. In the context of the single, isolated purchase decision, the main point is that the supplier have a product model that offers the benefits that the buyer seeks. Being a 'full-line' supplier, on the other hand doesn't, of itself, win any one isolated order. But it may affect the *relationship* with actual or potential customers. This is an observation that calls to mind the earlier comments about flexibility acting more at the level of relationship than at the level of the individual order or delivery. Just as flexibility is 'a measure of potential behaviour' (Slack, 1983), so, it is suggested, is being a 'full-line' supplier. Hill's framework (1985: 41) includes 'product range' as an order-winner in its own right although, based on the foregoing discussion, this appears logically inconsistent.

Kekre and Srinivasan (1990) proceed, despite the reservations set out above, to test their hypotheses using PIMS data. They conclude that US manufacturers seem to be able to produce broad product-ranges 'while managing costs' and:

> 'The main conclusion from our model is that a broader product-line leads to a higher market share as well as to increased profitability'

The results, though, are fundamentally weakened in that the PIMS database assessment of product-line breadth is (a) entirely quantitative (see critique above), (b) subjective and self-reported via questionnaire. How respondents define 'product', much less 'product-line breadth' is very dubious.

2.4.4.4 Product Customisation

As discussed above, Shapiro (1979) gives an unusual prominence to customisation as an issue in marketing strategy. Crittenden et al (1993), Skinner (1969), and Hill

(1985) are among those who include it as one of a number of trade-off or conflict areas; Konijnendijk (1993) found 'exceptions/specials' to be the biggest problem among firms operating in a make-to-stock logistic environment.

Shapiro (1977b: 17-21) identifies three types of industrial product lines:

Proprietary or catalogue products

Custom-build products

Custom-designed products

Shapiro sees the customisation-standardisation variable as one of three that dominate industrial product policy. The other two are the extent of branding and the conformance to or deviation from industry standard specifications. It is notable that 'number of products' does not appear in the list.

Konijnendijk (1993) used the categories make-to-stock, make-to-order and engineer-to-order, which combines material-cycle and design-cycle issues. Sharma (1987) suggests the following categories:

Standardised products:
- with no options
- with customer-specified options
- modified to customer specification

Customised product produced to customer specification

In their automotive industry work, Fisher, Jain and MacDuffie (1994) discuss peripheral variety in terms of 'package options' (e.g. all the parts needed to provide air conditioning) and 'standalone options'. These are subdivisions of the 'custom-build' class of Shapiro. Surprisingly, Mintzberg (1988) also offers a classification of customisation approaches: pure, where the product is designed from scratch; tailored, where a basic product is modified to the customer's specification; and standardised, which is again custom-build in Shapiro's terms.

A number of writers have, then, attempted to categorise customisation approaches. Shapiro (1979), in linking customisation *per se* with some aspects manufacturing strategy, has identified his four-part typology of marketing tasks (in similar vein, perhaps, to Skinnerian manufacturing tasks). However, there is little consideration given elsewhere to the management of customisation.

Again, returning to Shapiro's work, he has elaborated somewhat on the role of customisation in the evolution of industrial products (Shapiro, 1987). Re-configuring earlier concerns, he identifies two 'generic approaches to product policy': variety and value. These are related to the universal benefits and diverse specifications discussed above. A variety-oriented line can be achieved by custom-designed items or special-purpose products. The latter appear to be similar to custom-build items (Shapiro, 1977b), but '[i]n some situations, the special purpose units are not custom-built. Instead, the manufacturer has a broad product-line, designed to meet the needs of many customers or purchase or usage situations'. Shapiro goes on to describe the typical pattern of interaction between standardisation and customisation as products evolve over time. He terms this the Product Evolution Trajectory (PET). Products start as customised units which are experimental attempts to 'mate a technology and a need'. The suggestion is that this variety approach shifts from custom-designed to special purpose (i.e. custom-built or standard). The next stage involves the arrival of a dominant design, offering great universal benefits. This may stabilise on a few models offering clear price-performance trade-off positions (Kent's hierarchical dimension). The next stage involves differentiation, as customers learn to be more discriminating, and competitors seek profitable niches.

Shapiro relates this PET to the 'way companies must operate to succeed' at each stage. This is reminiscent of the Hayes and Wheelwright product-process life-cycle, and of the more general PLC theory discussed below. The Phases and accompanying prescription are:

Phase 1	Few custom-designed	Selection of profitable market opportunities; pricing high enough to make money.
Phase 2	Special-purpose units	Sales and Technical support; relationships essential.
Phase 3	Dominant design	Radical changes; performance-to-price; cost-sensitive product- and process engineering, rapid growth, specialisation
Phase 4	Fragmentation	Search for new profits in saturating markets via return to Phase 1

and so on. The importance of identifying transition points is emphasised. During the customisation phases:

> '...because each order is a different item, functional integration among sales, marketing, manufacturing, engineering and applications engineering is an absolute necessity. In custom producers, *the profits are made at the interfaces of the functions, not in any single function.*' (Shapiro, 1987: 17, emphasis added)

2.4.4.5 Mass Customisation and Product Family Management

It is only in the last few years that customisation has become a topic of debate of any note, via the 'mass customisation' literature, popularised by Pine (1993). Kotha (1995) recently saw fit to describe Mass Customisation as 'the emerging paradigm for competitive advantage' and his article begins:

> 'The nature of competition in many industries .. is being transformed....'

and continues:

> 'Mass customization is generally described as a process by which firms apply technology and management methods to provide product variety and customization through flexibility...'

Early in Starr's 1965 Harvard Business Review article:

> '..now change is occurring once again. Many enterprise managers are aware that something new is creeping into the production sphere...'

and then:

> 'The change that we are talking about can briefly be described as the consumer's demand for *maximum productive variety* (or maximum choice). To achieve this variety, what I call "modular" or "combinatorial" productive capacities - that is, capacities to design and manufacture parts which can be combined in numerous ways - are required, as well as compatible management abilities.' (Starr, 1965)

According to Starr, '...a new form of effort which will cut across many functional organizational areas is required'.

The phrase 'mass customisation' has particular rhetorical power due to its oxymoronic quality, but the 'paradigm' appears, in fact, to differ very little from the 'New Concept' that Starr described thirty years earlier. The most significant development has been the emergence of relatively inexpensive and commonplace microprocessor-controlled production equipment, which has made Starr's vision of 'adaptive automation' a real possibility (although one that is not always exploited to the full (Jaikumar, 1986)).

Elsewhere, Kotha is more equivocal about mass customisation, noting that much of what has been articulated in its name (e.g. Pine, 1993) is nothing new, and that it is dangerous to assume that all firms must aspire to it: 'mass customization taken to an extreme can position the firm as trying to *be all things to all people*' (Kotha, 1994 -

emphasis in original). Even in his own description of a mass-customising firm, Kotha notes that a mass-production plant and a mass-customisation plant operated in parallel, satisfying separate markets (and that the mass customisation plant only produced a small proportion of the firm's volume). The empirical evidence is limited, but the few applications that have been documented involve information systems allowing customers to specify products' configurations from a range of options. The dominant type of customisation is, then, custom-building based on modular designs. The only element of custom-designing is the relatively simple translation of customer dimensions - usually anthropometric dimensions - into parametric variations in the product e.g. bicycle frame size (Kotha, 1995) or the dimensions of jeans (Pine, 1993). Most examples are in consumer durables.

A recently-emerging literature contributes to this development and begins to address some of the concerns of Kent (1986) discussed earlier. The management of product-*families* as opposed to individual products is just beginning to attract the attention of technology management writers. Sanderson and Uzumeri (1995) and Uzumeri and Sanderson (1995) describe examples from consumer durables industries of different patterns of model-succession and inter-model competition, and how attention to different levels in the product hierarchy are particularly important in markets with rapidly-changing technologies. Ulrich (1995) addresses the concept of product architecture, which is 'the scheme by which the function of a product is allocated to physical components'. The architecture of a product design determines the extent to which a variety of products can be made from common components (by the use of modules) and how readily products may be up-dated as aspects of their technology advance. At this stage in its development however, the literature is struggling to move far beyond Starr's thirty-year-old prescriptions about the benefits of modular design.

2.4.4.6 The Product Life-Cycle

This is no place for a comprehensive review of the product life cycle (PLC) literature. However, as it has informed some of the manufacturing strategy literature and is a relatively well-entrenched part of business strategy thinking, it is important to outline the concept, assess some of the evidence for its validity, review some of its criticisms and limitations, and identify ways in which it can inform the present research.

The product life cycle 'portrays distinct stages in the sales history of a product' and these are usually known as introduction, growth, maturity and decline (Kotler, 1994: 335). These are illustrated in Figure 2.15

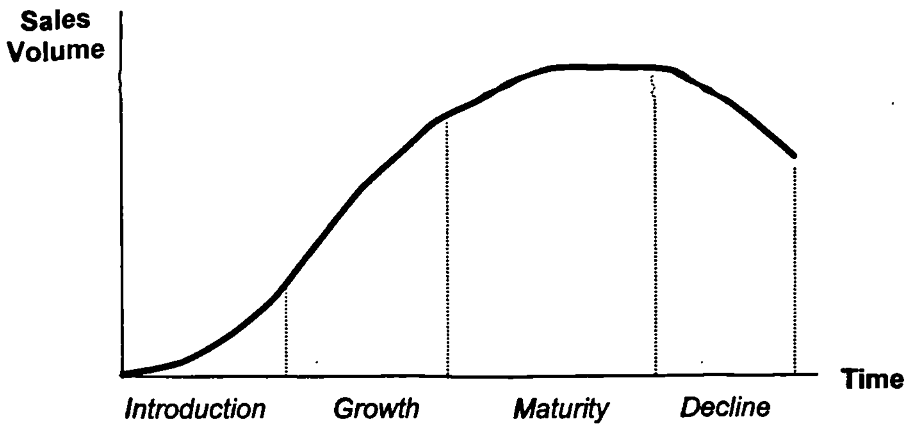


Figure 2.15 The Product Life Cycle

Hofer (1975) claims that:

> 'The most fundamental variable in determining an appropriate business strategy is the stage of the product life cycle'

Thorelli and Burnett's (1981) conclusions based on their study of over a thousand industrial goods manufacturers are less categorical. They comment that : '[a] question that still remains is whether the findings have any practical significance for strategic planning' and 'PLC forces are at work, but they do not appear to be the ultimate independent variable for strategic decision-making in such [industrial] businesses'. However, they also acknowledge a number of shortcomings of the research method used, notably its inability to take into account differences in PLC length (a) with the passage of time or (b) between different types of product.

Day (1981) comments that PLCs 'summarize the effects of many concurrent changes' and hence that there is a need 'to incorporate the underlying factors and processes within the particular market situation into the life cycle model'. Evidently the PLC concept is a useful 'shorthand' for a range of causal factors, but it is important to look beyond the summary and identify these causal factors individually for strategic decision-making purposes. Day (1981) also identifies the problems associated with what constitutes a 'product' in PLC analysis: as Weitz and Wensley (1988: 157) comment:

> 'A problem confronted by all strategy analysis is determining the appropriate level of aggregation'

The unit of analysis in PLC theory appears to influence the strength of the evidence for the PLC *per se* . Should it be the brand, the product form, the product class, the market segment or the industry? (Weitz and Wensley, 1988). Dhalla and Yuspeh (1976) advise us to 'forget the product life cycle concept' because their analysis at the *brand* level and the product class level provides no evidence to support the existence of the PLC; Neidel (1988) accepts the PLC concept based on analysis at the product form level. Abell (1980: 205-210) again looks beneath the PLC shorthand and suggests that a new PLC starts when one of his three dimensions for defining the business - product technology, customer function , or customer group - changes. The underlying causes are the adoption and diffusion processes in the extension to new customer groups, 'systematization' in the extension of customer functions, and technological substitution in the case of product technology. Abell argues that these must be understood in a disaggregated way rather than being summarised in their effects via PLC theory which is then itself adopted as an independent variable rather than as a useful but limited way of summarising the outcomes of a number of complex and interrelated causal mechanisms. It is instructive to note that Abell's more discriminating understanding of the relationships - or more convincing commitment to working at that level and in that qualitative way rather than at the level of purely quantitative relationships between aggregate variables - resulted from research of an in-depth case-study nature.

Anderson and Zeithaml (1984) carried out a study to determine (a) how a wide range of strategic variables changed with PLC stage and (b) what correlations existed between these variables and company performance, measured in terms of ROI and market share. Of particular note is that the study was exclusively of industrial product firms, making its relevance to the present research rather more than might have been the case if the data had been collected from consumer goods firms or firms in a mixture of industries. Also, compared to Thorelli and Burnett's work, the collection of rather more specific data than is possible by reliance on the PIMS database adds to the validity of the results. They concluded that, in general, the PLC stage is indeed one contingency variable that informs strategy formulation, but not the predominant one, as claimed by Hofer. More specifically, they found that product line breadth grew in maturity and contracted in decline; ROI was better for firms with low customisation in the growth and, to a lesser extent, the mature stage; market share was lower for firms with greater customisation in the decline stage; and market share was strongly enhanced by greater product line breadth in both growth and maturity stages. Other relationships were not significant.

Another issue connected with the PLC is organisation structure. This is implicit in the work of Hayes and Wheelwright in that they include it as one of their infrastructural variables and link it by implication to the PLC via the process life cycle; Hill makes this more explicit (Hill, 1985: 70-71) and, to a large extent these ideas were present in the work of Burns and Stalker (1961) (particularly in relation to new products) and Woodward (1965) (particularly in relation to process choice). This contingency theory approach was explicitly related to the PLC by Donaldson (1985), who drew together various studies into a framework that specifies the structure most appropriate to different combinations of circumstances associated with the PLC. Interestingly, the Donaldson framework attempts to prescribe for situations where multiple products at different stages in the life-cycle are being produced, and acknowledges a 'trade-off' between the bias toward innovation on one hand and toward productivity on the other. However, the prescription is at such a macroscopic level, hinging on whether products are 'mainly mature' or 'mainly early', and specified in terms of a choice between functional, product division, matrix or project structures, that it can only be a very general guide. What is perhaps most notable is that a version of the trade-off is articulated in this rather different context.

The PLC then, has been adopted as an important informing construct in manufacturing strategy theory. Examination of some relevant literature in marketing and other areas indicate that, whilst the PLC is a useful shorthand, it is advisable to understand the underlying factors that give rise to the phenomenon and to take great care in defining the unit of analysis. This latter point is particularly relevant where an attempt is being made to link product strategies to decisions on manufacturing system design. There are strong parallels between this problem of the level of aggregation to adopt and the level of aggregation appropriate in manufacturing strategy (see 2.3.7). One study in particular (Anderson and Zeithaml, 1984) has some findings relevant to the concern of the present research with product variety and customisation: namely that profitability appears to be better for firms not customising products in the earlier stages of the PLC and, perhaps not surprisingly, that firms offering product variety gain market share (but not profitability) early in the PLC. However, the research design did not enable identification of whether the manufacturing system in each case was appropriate to the amount of customisation.

2.5 Implications for the Present Research

The literature review has been wide-ranging, as befits the inter-disciplinary nature of the research question. This section will draw together the ideas from the three main sections of the review and set out the key issues for the empirical work to address.

2.5.1 Major Issues From The Literature

2.5.1.1 Scope

Scope was identified in section 2.2.1 as very much the concern of corporate strategy. However, a great deal of the sections devoted to manufacturing strategy and the marketing-manufacturing interface indicate that these functions have a not inconsiderable part to play in determining the scope of their business unit's activities. Some important dimensions of scope which appear to be very much part of functional strategies, particularly those of the marketing and manufacturing functions, are:

- degree of vertical integration
- process type i.e. volume/variety positioning
- exact positioning i.e. product-range policy
- customisation - extent and nature
- problem-solving/transfer abilities

These are additional to the dimensions proposed in Section 2.2.1 by which we might 'define the business' or, indeed, assess the 'Yes, we can do that ...' claim. Certainly, there is more to functional strategy than 'the maximisation of resource productivity' (Hofer and Schendel, 1978: 29); Hayes and Wheelwright (1984: 396-403), with their concept of the 'Stage 4' manufacturing organisation, suggest that the functional strategies of successful firms *must* go beyond this.

2.5.1.2 The Product and the Product-Range

The Product is central to marketing strategy. The breadth and structure of the product-range are less well theorised by marketers but, it appears, determine to a large extent the most appropriate manufacturing strategy. For example, the need for various categories of flexibility or the ability to 'focus' manufacturing derive directly from the product-range policy. And yet, despite the observations of a few writers that the product is the concrete link between marketing and manufacturing (e.g. Crittenden *et al*, 1993: 'manufacturing and marketing converge on product decisions'), manufacturing strategy theory does not give prominence to product or product-range policy.

The costs and benefits of making product-lines broader has been analysed by a number of writers but, whilst the marketing implications are identified in both their qualitative and quantitative aspects, the manufacturing implications are almost exclusively seen in quantitative terms. That is, it is the fact of adding another product

- any product - that incurs costs in manufacturing, and there is little concern for how, and to what extent, the additional products may vary from the rest of the range.

2.5.1.3 Strategy Process

Much of the manufacturing strategy process literature attempts to develop strategy formulation techniques that are rather like the business strategy process approaches of the 1960's and 1970's. There has been no development in the manufacturing strategy process field, parallel to the work of business strategy process researchers such as Mintzberg and Pettigrew, in taking a longitudinal and emergent view of the manufacturing strategy process.

Furthermore, it is notable that many of these strategy formulation processes involve hiatuses between strategy formation and action programmes: in Mintzberg's terms, '..where does the strategy stop and the project begin?' (Mintzberg, 1994: 77). Following from the comments in the previous sub-section, it is contended that The Product or Product-Range is an important concrete vehicle for the formation of strategy in manufacturing as well as marketing.

2.5.1.4 Marketing and Manufacturing

Most research into the marketing-manufacturing interface has either identified domains of conflict, attempted to measure this conflict in some way, and/or made suggestions as to how to achieve strategic reconciliation between functions. Despite the acknowledgement of conflict between these functions, there appears to be no documented research of a more intensive nature into the details of conflicts, in day-to-day activities, between the functions. If, as Shapiro (amongst others) notes, success in manufacturing customised products in particular is achieved at the interfaces between functions rather than in any one function, then a rich understanding of this most important interface seems essential.

2.5.1.5 A Theory of Manufacturing Strategy for Industrial Markets?

Those authors who have attempted to set out more detailed procedures for formulating manufacturing strategy have often advocated taking data from aggregated sales of products or product families from which to determine competitive criteria (e.g. Hill, 1985). This type of procedure implicitly abstracts individual purchases from the manufacturer-customer relationships in which they take place, a step that has been demonstrated to be inappropriate to many industrial marketing situations. Industrial buyer-supplier relationships are characterised by stability and close involvement over long periods, rather than fleeting, atomistic transactions in perfect markets.

Among those authors reviewed, Shapiro (1979) and Blois (1980a) have made tentative connections between basic manufacturing strategy concepts and the issues of customer relationships and product customisation. Based on these efforts, there is a need to develop a theory of manufacturing strategy that takes account of relationships of the type found in industrial markets, as well as of simplistic ideas of products being sold in markets.

2.5.1.6 Product Customisation

Product customisation is neglected in much of the manufacturing strategy literature. Two authors in industrial marketing (Shapiro and Blois) have proposed that it is a more fundamental issue than has hitherto been recognised. Despite this, much of the coverage of customisation has consisted of rather facile exhortations to develop modular designs. This tendency has been increased by the publicity given recently to 'mass customization', a concept which, when subjected to close examination, appears to have limited novelty or applicability.

Product customisation has the potential to define fundamentally the nature of the link between the design cycle and the material cycle or, to place it in the context of the buyer-supplier relationship, problem-solving and transfer activities. Understanding the nature of this link is essential to developing consistent manufacturing and marketing strategies.

2.5.2 Research Questions

The primary research question for this work is:

> **How can manufacturing strategy theory be extended and modified to accommodate product customisation as a central, rather than peripheral, issue?**

Included in this question are such subsidiary questions as:

- how do deliberate and emergent strategy formation processes involving manufacturing and other functions, notably marketing, determine firms' success in producing customised products?

- in this context, what are useful dimensions by which to define, and against which to change, the business?

- to what extent and in what ways are problems of customisation associated with the conflicting requirements of marketing and manufacturing and, if these are significant, how might they be addressed?

A supplementary question, which results from an emphasis on industrial markets in much of the literature that *does* address customisation is:

- does manufacturing strategy theory take account of the distinctive characteristics of industrial markets? If not, how could it be modified to do so?

Chapter 3

Research Design

3.1 Introduction

This chapter sets out the rationale for the design of the research. First, intensive and extensive approaches and criteria for the assessment of research quality are discussed in general terms. The two approaches are then assessed as to their suitability for the specific research question in hand. Having identified the case-study approach as suitable, the more specific issues of case-selection, data-collection and data-analysis are discussed.

3.2 Extensive and Intensive Approaches

Research approaches can be described as being either extensive or intensive (Sayer, 1992: 242). Extensive approaches take a relatively superficial look at a large number of instances of some phenomenon. Intensive approaches involve the in-depth examination of a small number of instances - sometimes only one. This can be characterised as taking a 'thin, deep slice' and is also called an 'idiographic' or 'concrete' approach (Tsoukas 1989).

Extensive approaches are designed to make possible statistically-based generalisations. They involve the assumption that the sample of the population investigated is in some clearly-defined way, and to a quantifiable degree, representative of the whole population in which one is interested. Typical extensive approaches include large-scale surveys, experiments, questionnaires and various combinations of these.

The most widely-used intensive approaches are case-studies, historical studies and archival research (Yin, 1989: 17). The means of generalising from intensive approaches is theoretical rather than statistical. A small number of case-studies does not represent a small 'sample'. Indeed, the alternative term 'idiographic' means precisely that the instance is unique. Cases, or the bounds of archival studies, are chosen for explicit theoretical reasons, rather than randomly.

There has been a major debate over the relative strengths and weaknesses of these approaches. This has often taken the form of a debate between qualitative and quantitative 'methodology' and has 'generated rather more heat than light' (Crompton and Jones 1988: 72). These authors go on to state that in organisational research it is 'not a mutually exclusive decision' between the two methodologies and, indeed, that it is 'very difficult to study organisations without using both...'

One of the problems in such discussions is the conflation of extensive research with quantitative data and of intensive research with qualitative data, as shown in Figure 3.1. Tsoukas (1989) points out that 'qualitative' and 'quantitative' are simply *types of evidence*. Miles and Huberman (1984) make the similarly simple distinction that quantitative data are in the form of numbers and qualitative data are in the form of words and images. Whilst it is likely that qualitative data will feature more strongly in intensive research approaches, many intensive studies also require a good deal of quantitative data. Indeed, Jick (1979) calls for the creative use of both in intensive studies.

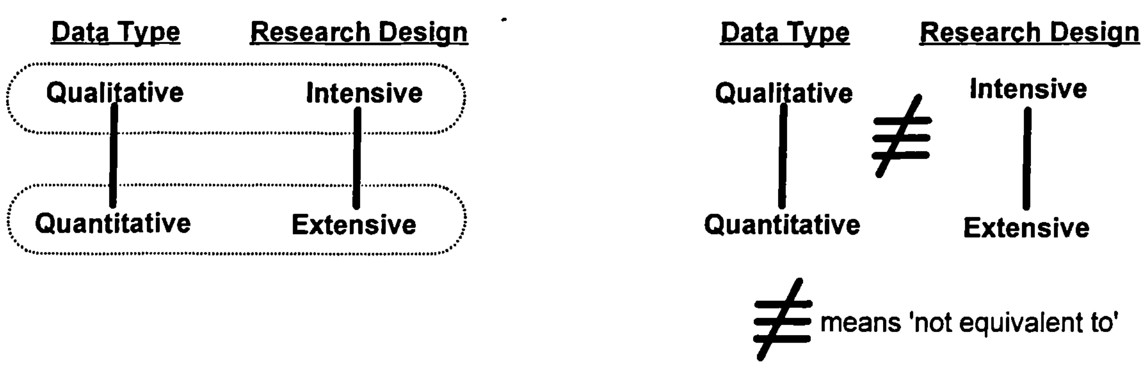


Figure 3.1 Data Types and Research Designs

The debate is about something much more important than simply the form of data used. Research design depends on an assessment of what constitute valid, generalisable or reliable results. This is strongly influenced by the nature of the research question in relation to the extant knowledge in the discipline concerned, as well as the philosophical predisposition of the researcher. Criteria for the assessment of research quality are needed, and these are discussed next.

3.3 Assessment of Research Quality

The literature on methodology is inconsistent in its interpretations of parameters relating to research quality. Terms involving various combinations of 'reliability', 'validity' and 'generalisability' are used, and used inconsistently. For example Easterby-Smith, Thorpe and Low (1991: 41) use validity, reliability and generalisability as their measures of research quality; Yin (1989: 41) uses construct validity, internal validity, external validity and reliability.

Inconsistencies in terminology notwithstanding, some yardsticks for judging the quality of research design are necessary. The terms used here are more or less those adopted by Yin (1989: 40-45) as these seem to cover the main concerns as precisely and comprehensively as any.

Construct validity is a measure of how well the chosen data-sources describe or measure particular phenomena. This may involve assessment of *a priori* constructs or, in theory-building, constructs that are established during data collection. For example, one may be interested in assessing product variety: there are a number of ways this might be measured, including the total number of products made, the number of product-lines, or by some relevant assessment of the differences between products, say the range of sizes. Each one of these could be posited as a construct for measuring 'variety'.

A related consideration, especially in theory-building research, is **testability**. Yin (1989) does not use this term but Eisenhardt (1989) sees it as important that constructs that are developed and 'sharpened' during the research should be defined in such a way as to be readily tested. To be useful, they will also need to be transferable to other circumstances. **Triangulation**, by the use of multiple sources of evidence, is an important way of improving construct validity (Yin, 1989; Eisenhardt, 1989).

Internal validity relates to causality. It is a measure of how compellingly and convincingly data can be related to one another in terms of one event <u>causing</u> another. This is discussed at some length later in this chapter.

External validity requires some discussion even at this stage. Tsoukas (1989) discusses the way intensive approaches are viewed by positivistically-inclined social science and in so doing uses 'external validity' to mean '...generalisability of findings beyond the cases researched'. Critics of case-study and similar approaches hold that such approaches can only ever investigate <u>local</u> causality: the problem is thus one of <u>breadth</u> of generalisability or of low external validity.

Miles and Huberman (1984) see 'external validity' as a measure of 'authenticity and meaning' and suggest that traditional positivistic methods have low external validity. Advocates of intensive methods point out that many of the 'laws' produced from the 'rigour' of extensive methods are so facile, so abstract and so far-removed from reality as to be practically useless: even people *who were sampled* in a survey may not recognise the 'general' results of the survey as relating to them or having any relevance to their lives. This is the sense in which Miles and Huberman use the term and, relating as it does to depth or relevance of generalisability, it is different to the sense of Tsoukas' usage.

Both of these interpretations relate to the way in which generalisation may be made from the results of a piece of research to instances outside the sample, case, or other bounded data-source studied. One aspect is the breadth of reasonable generalisation: to how many other instances can the results be applied? The other aspect is the relevance and utility of generalisation to a given other instance, which might be characterised as the '"So what?" factor', since this may well be the result when facile, abstract, 'general' results are reported.

Reliability is less contentious than some of the foregoing. It is an assessment of the likelihood that, were the research to be carried out by another investigator, the same result would be achieved. Reliability is largely a matter of defining and implementing procedures during data-collection and analysis.

3.4 Discussion of Generic Approaches

Advocates of extensive research methods criticise intensive methods on the grounds of lack of 'generalisability' (the aspect of external validity relating to breadth of application of results) (Tsoukas, 1989).

First of all, it has to be said that most 'extensive' studies just aren't very extensive. A thirty per cent response-rate to a questionnaire would be greeted with considerable delight by the average (!) extensive researcher. This means that in most such studies, the majority of the sample are never 'measured'.

Furthermore, how much notice is it reasonable to take of those replies that are received? Organisations receive many survey questionnaires from students and from other organisations. In many, the response is to throw the form away. In others they may be referred to the personnel department or to the office junior, neither of whom are likely to be well-placed to give competent responses on operations issues, even assuming that they take the time and effort to try to give accurate responses and have the data available in appropriate form. This is a particular problem when concepts are ill-defined or subject to significant variations in interpretation. In these circumstances at least then, extensive approaches lack construct validity, because the data collected are not a good representation of the phenomena in which the researcher is interested.

Whilst the criteria discussed here are valuable for structuring any assessment of research quality, there is also a need to consider what the objective of the work is. Leaving aside the subject-specific content for the time being, it is useful to clarify what kind of knowledge the work is to result in i.e. whether the aim is to describe, to explain to predict or to test theory (Yin, 1989: 16-17).

The state of knowledge in the field to some extent determines what type of objective is feasible. In completely unexplored research areas for example, it is unlikely that precise predictive results can be achieved. But, given the current state of knowledge in any field, there are still choices to be made about the objectives of research in it.

The aim of this research is not simply to determine what happens and how often in a sample and hence to 'predict' what will happen and how often somewhere else in the population. It is to understand how and why something happens: to understand the mechanisms and contingent factors (Tsoukas 1989) of the situations studied. Based on this understanding of, rather than simple measurement of, what happens inside the scope of the study, the researcher can think more informedly about what is likely to happen outside the study. Where relevant generative mechanisms and contingent factors exist outside the study, then similar phenomena are likely to be observable. This concern with causative processes involved in particular cases is closely linked with internal validity. Adequate understanding of structures and mechanisms implies internal validity, i.e. that the causal processes are convincingly identified, based on empirical data.

Yin states that internal validity only applies to 'explanatory' studies (he is referring particularly to case-studies). To him, it is simply not relevant to studies (usually intensive studies) whose sole objective is to *generate* theory. This seems a limited view. Even where the main reason for a case-study is to generate theory, rather than to test it, surely there must be a concern with generating *good* theory? And, using the concept of internal validity, good theory will be more valid than bad, will better withstand the line of questioning Yin (1989: 43) proposes for explanatory studies, viz:

- Is the inference correct?
- Have all the rival explanations and possibilities been considered?
- Is the evidence convergent?
- Does it appear to be airtight?

What 'airtight' means is debatable, but there are some pointers here for improving internal validity. Eisenhardt (1989) suggests that theory generated from case-studies 'is likely to be empirically valid' because of the intimate relation between theory-development and the evidence, previously noted. In well-executed theory-building research, 'investigators answer to the data from the beginning of the research'. This is another way of applying the idea of internal validity to theory-*building* research.

Following on from the previous comments, Eisenhardt also notes that the theory developed from case-study work may be 'narrow and idiosyncratic'. In other words, this is an assessment of external validity. Thus the theory may be relevant only to a limited field, but it is likely to be very relevant in that field. The implicit contrast with the results of extensive research is that they will be widely applicable, as far as they go, but not mirror reality very closely.

The external validity of any approach, it is argued, depends first of all on internal validity: if no internally valid conclusions about structures and generative mechanisms are drawn, then there is nothing *to* generalise external to the cases studied. Given internal validity, the external validity depends upon other supportive theory and research design, particularly case selection.

3.5 The Method for This Research

So far, aspects of validity and reliability have been discussed in relation to intensive and extensive research approaches in general. It is now time to turn to the specific research question in hand and to determine an appropriate design and methods, such that the criteria of validity and reliability may be satisfied.

The primary research question for this work is:

> **How can manufacturing strategy theory be extended and modified to accommodate product customisation as a central, rather than peripheral, issue?**

Also included were the subsidiary questions shown in Figure 3.2.

How can manufacturing strategy theory be extended and modified to accommodate product customisation as a central, rather than peripheral, issue?

> How do deliberate and emergent strategy formation processes involving manufacturing and other functions, notably marketing, determine firms' success in producing customised products?
>
> In this context, what are useful dimensions by which to define, and against which to change, the business?
>
> To what extent and in what ways are problems of customisation associated with the conflicting requirements of marketing and manufacturing and, if these are significant, how might they be addressed?
>
> Does manufacturing strategy theory take account of the distinctive characteristics of industrial markets? If not, how could it be modified to do so?

Figure 3.2 The Research Questions

Given this research question and the state of knowledge set out in the literature review, the chapter will go on to assess extensive and intensive methods in turn.

Extensive, sampling-based approaches have their limitations in the best of circumstances. Many aspects of the research question are not consistently interpreted, even by practitioners and academics working directly in the fields concerned. For example, 'flexibility' has many different meanings; 'product-range', 'product-mix' and 'product-line' are used in various ways and depend for their meaning on the subjective idea of relatedness of products (and even 'product' is difficult to define); various types of customisation have been identified. Chapter 2 discusses a number of other terms whose usage varies considerably.

As has already been noted, a questionnaire about operations issues is as likely to be answered by the personnel manager as by anyone directly involved with operations. For both these reasons it seems unlikely therefore, that data collected in this way would relate very closely to the phenomena being investigated: i.e. extensive approaches would lack construct validity. Careful design of a questionnaire can mitigate these effects to some extent e.g. by clear definition of terminology. However, this is not an option where the reason for the research is precisely that theory and definitions do not exist. This is particularly true in the specific concerns of this work with customised products. Lacking construct validity, questionnaire-based studies cannot have internal or external validity. If there is no consistent way of measuring or describing the phenomena under investigation, then there is no prospect of convincingly establishing causality between them. And, to complete the argument, without internal validity, there can be no external validity.

Single, in-depth interviews might be considered appropriate. These would allow some discussion about the constructs being used and hence would improve the validity to a limited extent. This approach though, would founder when addressing the less-well-defined issues: because of the intrinsic cross-functional nature of the work and its concentration on the operational level, a single interview in each firm would not capture the different perspectives that form part of the very object of the research. Finally, interviews alone, from however many sources, would not provide adequate triangulation of the data - alternative sources e.g. written documents, production records are needed to substantiate opinions.

If construct validity is a prerequisite for internal validity, questionnaire surveys and in-depth interviews are not satisfactory. One might assume that a few interviews in each firm would be adequate, regardless of the suggested deficiency in triangulation. This approach would, however, be almost entirely lacking in internal validity as there would be little opportunity to establish causality in anything but the most trivial matters. To develop good new theory - 'good', as suggested previously, in that it has internal validity - some understanding of the processes of causality must be achieved. It has already been suggested that this requires a lot of data from multiple sources. The present research question requires that, more than in better-defined areas, time be spent teasing out interpretations and opinions to set against documented organisational transactions. This will necessarily be an iterative, and hence an involved, process. Finally, it is difficult to imagine how a compelling understanding of causality in an organisation could be achieved without spending a significant amount of time in it so as to build a picture of power relationships, and different groups' priorities. The only means of addressing this particular research question in a satisfactory manner then, is by a case-study approach.

As extensive approaches have been dismissed for the purposes of this work, it must be established whether the only remaining contender, the case-study approach, has external validity. Alternatively, more modest objectives for the research may need to be set. External validity is dependent on internal validity and on other research design factors, especially case-selection. The objective of this work being a combination of theory-testing and theory-building, there is also a need for careful consideration of the process by which this is done.

Table 3.1 Some Possible Research Methods Assessed

	Construct validity	Internal validity	External validity	Reliability
Extensive				
Questionnaire survey	(a) Poor due to lack of definitions in the area	Not without construct validity	Not without construct and internal validity	Strong if designed carefully and piloted
	(b) Reinforce by imposed definition of terms	Poor in identifying causality	Yes: wide but likely to be superficial and weak on causality	
Individual interviews	Quite good. Can clarify definition/ understanding of terms	Moderate - single view of causality	Some, but founders on poor internal validity	Quite good with well-prepared interview schedule.
Intensive				
Case studies	Good. Can clarify and revisit definitions and understanding of terms.	Good. Multiple respondents and data sources - interviews, documents, observation - allow exploration of causality.	Powerful but possibly limited in range of applicability. Depends on theoretical logic in case selection.	Quite good, but open-ended nature might result in different researchers following different 'leads', depending on prior understanding.

What follows is a consideration of these research design issues in two dimensions: cross-sectional, bearing on case-selection; and longitudinal, dealing both with the way the cases are conceived to exist in time and with the progress of the design, fieldwork, analysis and theory-building as the study proceeds. In this extended discussion it is argued that the proposed approach does have adequate external validity. This discussion of the suitability of various research methods is summarised in Table 3.1.

3.5.1 External Validity: Cross-sectional Considerations

The original formulation of the research question was, in effect, based on a personal multiple case study by participant observation. Of course, this wasn't clear at the time, the 'studies' were far from rigorous and there was a lot more participation than observation! Nonetheless, the process of describing multiple instances from personal experience was the way in which some apparently more widespread concerns began to emerge. Observation of these phenomena in *several firms* greatly strengthened the suspicion that they may be widespread.

This experience led to a feeling that a multiple-site design was best suited to this project. By studying several firms making different products, the potential for new insights is much greater than it would be in a study of one firm. Although the 'variables' cannot be explicitly defined, a number of issues were felt to be relevant at the outset. For example, one such issue might be organisational structure. By carrying out studies in several firms, it is possible to develop understanding of the ways in which firms with similar and dissimilar organisation structures make product-range decisions involving customised products.

Looking at the cross-sectional aspect of research design less intuitively, it clearly depends on some initial, if implicit, theorising because cases are selected, as we have seen, for theoretical reasons. One might select cases to replicate previous studies, to fill theoretical categories or to provide examples of 'polar types'. The latter are cases presenting extremes of one or more contextual factors and Pettigrew (1990), noting that one can usually only study a few cases, advocates the selection of extremes where possible. Tsoukas (1989) sees this in terms of the contextual levels and identifies three in organisational studies: contingent characteristics such as technology and economy; sectoral domains i.e. areas in which the organisation has been operating; and national/cultural features.

3.5.1.2 Case Selection

Choosing the case-study sites was a combination of the kind of pre-understanding embodied in the 'participant observation' studies just mentioned; of theory in manufacturing strategy, marketing and more general organisational studies; and of a large helping of opportunism and practical concerns. The theoretical propositions more or less explicit in the choice of cases were as follows.

Company size. Previous experience pointed to a significant organisational and communications element to the research question. Thus initial contacts were limited to companies with over 100 employees as it was felt that companies much smaller than this may not be sufficiently large to have separate manufacturing and marketing departments.

Activity. Initial contacts were also limited to manufacturing companies involved in significant value-adding activities. Thus firms who were involved simply in taking in goods manufactured elsewhere and either repackaging them, 'badging' them or undertaking trivial modifications were not considered.

Technology. Efforts were made to include a variety of basic technologies in the cases studied. This amounted to an explicit proposition that the type of product and/or process technology, with concomitant supposed product life cycles, rates of change, capital equipment requirements and potential for profitability, could be significant. Thus electronics firms were included in the cases as well as, for example, more traditional engineering manufacturers.

Geography. Again, previous experience had engendered a notion that international or multi-plant companies were one of Pettigrew's (1990) 'polar types' in respect of the organisational and functional separation issues. Hence every effort was made to include such companies in the study. As it turned out, a number of international companies responded positively and this was achieved easily. Conversely, single-site firms were also included in the initial contacts and one was included.

Nature of Production Task. As the concern of the research is with the tension between more and less customised products, it was necessary to establish whether firms were indeed in this position. Although it was usually possible to determine this from a telephone conversation, in a few cases it was not until an initial visit that unsuitability for this reason became apparent.

Markets. Perhaps it is an indication that customised-product manufacture is a phenomenon more associated with industrial or 'business' markets, but very few companies expressing an interest in the work were involved in supplying the retail market. It was hoped that more of a balance between the two might be achieved but, in the event, nearly all the cases are based in manufacturers supplying industrial markets.

The theoretical rationale for case selection is closely linked to the number of cases to be studied. The view that there is a 'correct' number of cases to be used in comparative studies generally[1] is rejected. The number of cases depends on the extent to which variables or issues have been specified in advance, and the number of these variables, although there is no direct relationship between these factors. Where a number of factors are tentatively suggested as having a bearing on the research question, then case-selection should attempt to include cases with clear differences in terms of these factors.

The number of cases is also determined by the research resource available in comparison to the desired 'depth' of investigation. A finite number of researcher-

[1]The reference for this assertion has unfortunately been lost.

hours can be spread thinly between many cases, perhaps where the 'factors' are relatively well-established and the objective is to refine and replicate them as constructs across as wide a range of circumstances as possible. Alternatively, perhaps where the factors are only tentatively suggested, the resource is more usefully employed in fewer, more-deeply investigated cases. Whilst these will be selected in an attempt to capture 'polar types' (Pettigrew, 1990), as Eisenhardt (1989) comments '[n]o construct is guaranteed a place in resultant theory'. There is then, little point in meticulously selecting cases to cover all the possible combinations of factors when the factors are only tentatively suggested and, a week into the field-work, it may turn out that other factors are more important and the original selection rationale is more or less irrelevant.

3.5.1.3 Case Definition

An important consideration of case-study research design is deciding what 'a case' is a case of (Yin: 1989: 31). The theoretical rationale for the work suggests at least four possible units - a product, a contract (for a particular individual customised product between the firm and a customer), a production plant or a firm. Others might include the relationship between a focal firm and one of its customers (implicitly encompassing product(s), contract(s) and at least one production plant. In the end, the choice is a matter of where the emphasis of the research question lies, and at what level of aggregation we wish to describe or test and develop theory. Yin stresses the need for clarity about the 'unit of analysis', but also comments that case-study research is suited to situations where 'the boundaries between phenomenon and context are not clearly evident' (Yin, 1989: 23).

The individual contract was initially considered as a very strong contender as the unit of analysis. But it was easy to foresee an early need to move beyond the contract and examine aspects of the relationship with the customer, the manufacturing process, the plant, the industry and, in the end, the context would overshadow the case (Figure 3.3a). It was also not clear at the outset what quality of access to detailed data on contracts would be possible and, as such, this would be a risky as well as theoretically-dubious choice of unit of analysis.

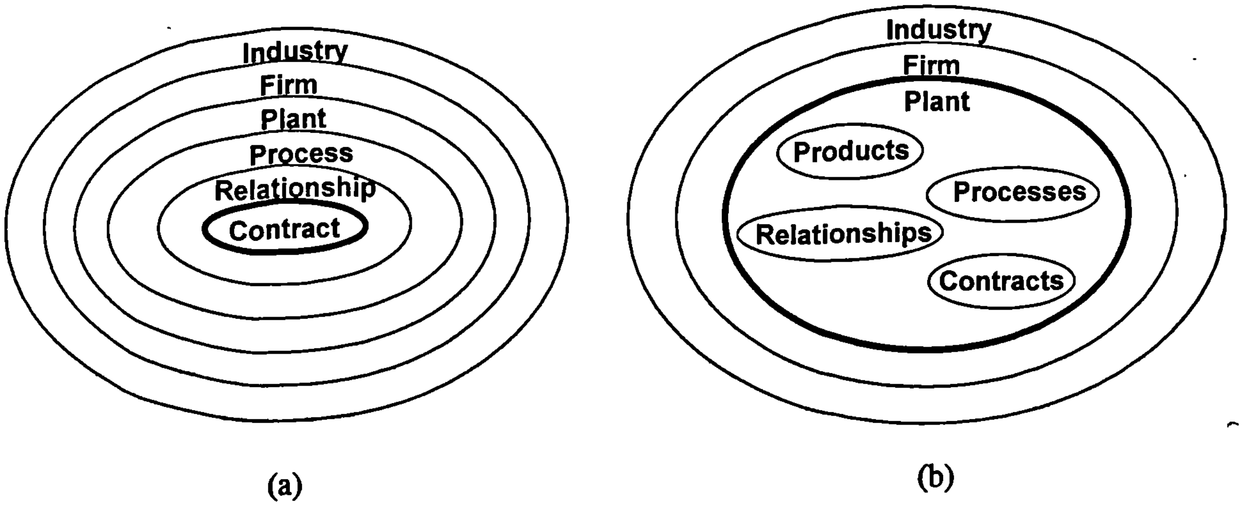


Figure 3.3 Context and Case: (a) the Contract and (b) the Plant as Unit of Analysis

Subsequently, the plant was adopted as the basic unit. Most of the manufacturing strategy theory refers to the plant level (e.g. New, 1992) and, as the primary objective is to contribute to that theory, the plant as unit of analysis is consistent with that objective. 'Contracts' could still be used as part of the (plant) case-study, as could products, processes etc (Figure 3.3b). Although it is possible to find arguments in favour of studying at the firm level, it was felt that this would have resulted in dissipation of the limited research resources. So, for reasons both of theory and of practice, each firm was studied essentially at one site - the production plant.

3.5.1.4 Practicalities

All this talk of selecting cases, of course, pre-supposes that one is in a position to 'select'. The scope for selection in practice is constrained to some extent by whether companies are willing to participate, particularly when a significant commitment of time is involved, as it is in intensive studies. Thus the firms involved were always likely to be the sort of firms who:

- have a sympathetic attitude toward working with people from universities;

- have an awareness, latent or otherwise, that they might benefit from someone looking at the way they manage the manufacture of customised products.

This is another way in which there is no attempt made to suggest that the firms studied are selected on the basis of some kind of 'sampling logic', to 'represent' manufacturing industry in toto. They are not.

At the outset, it was essential to take into account that any empirical research approach requires that access to firms be achieved. The main questions to be answered were:

- Would *any* firms grant access?
- How ready would they be to divulge commercially-sensitive data?
- In what form, and when, would they allow such data to be published?
- How much of their employees' time would be made available?

Early communication with potential collaborators revealed that there was interest in the subject in some firms and that, where this interest was present, there was a general willingness to devote time to the work. Based on the previously-expressed preference for an in-depth approach, an estimate of four weeks' contact time with each company was suggested and none of the firms expressing interest at the outset were put off by the prospect of this level of commitment. Confidentiality was a concern, but once fairly general guarantees were made, not an insurmountable obstacle.

So, the practical concerns discussed here influence the choice of approach. In short, there was a preference for in-depth case-studies and the apparent willingness of some firms to participate in such studies indicated that this was a viable approach. The resource constraints, principally of time and geography, meant that only a small number of studies could be carried out. (A total of six to eight firms was used for planning purposes before detailed research design was carried out.) This was not seen as an impediment to adopting the preferred approach and, as discussed in the accounts of the fieldwork, proved to be less and less one as the work proceeded.

3.5.1.5 Cases Selected

The actual cases selected are described in greater detail elsewhere. It is nonetheless useful at this stage to briefly outline the firms involved and their particular reasons for interest in the work. The firms are summarised in Table 3.2, described in terms of the factors previously used for case-selection. Two other firms were involved. One, a manufacturer of consumable parts for textile machines, acted as a pilot for early attempts at collecting and analysing data, particularly the quantitative data on product volumes and variety. The second was investigated in some depth as a fifth full case-study, but withdrew from the research following a major restructuring resulting from a company takeover.

Table 3.2 The Case-Study Firms

	Hyster-Yale	Honeywell	Philips BCS	Letts
Company size (at plant)	450	300	400	250
Activity	Finished product from steel raw materials	Components assembled plus some upstream production	Circuit-board build and product assembly	Complete diary manufacturing
Product Technology	Steel fabrication design, hydraulics	Electro-mechanical	Microprocessor -based circuit board assemblies	Paper, glues, inks
Process Technology	Machining, fabrication, painting, hand tools	Small tools and treatment equipment	Automated circuit-board assembly; testing systems	Desk-top-publishing, Printing and binding
Geography	One of three European sites of US Parent	One of many European sites of US parent	Largely autonomous UK site of European parent	Only production plant, distant Marketing group
Nature of Production	Custom-designed products mixed with custom-built	Widely varying volumes and degrees of customisation in plant	Varying products in one plant; rapid variant proliferation	Separate markets for standard and bespoke; all made in one plant
Markets	End-user, business	OEM, business	Large and small business end-user	Retailers and business end-users

3.5.1.6 Summary of Cross-Sectional Issues

This consideration has shown that decisions about the cross-sectional aspects of research design have been made for sound theoretical reasons. It also shown that, despite significant practical constraints, there has been sufficient scope within case-selection to provide important elements for comparative study. For these reasons, it is argued, the potential external validity of the work is enhanced (so far as it can be, given the impossibility of knowing exactly what theory will emerge from the work).

The cross-sectional aspects are largely determined at the outset. Complementary to them in enhancing internal and external validity are what have been called here longitudinal aspects. The following is a consideration of the research design and execution in these terms.

3.5.2 External Validity: Longitudinal Considerations

In this kind of work, time can be treated as having past values i.e. a historical approach, can be treated as constant (synchronic study) or as having real-time values (diachronic study) (Tsoukas 1989). In the latter approach, often termed a longitudinal study, the fact that time has elapsed between the collection of two data is a major part of the comparison. One is looking to identify change, just as one watches motion pictures for the motion as much as for the picture. A synchronic study does not set out to explicitly observe change over time: it is a snapshot rather than a motion picture.

The research question is based in the present - how <u>is</u> it that companies make decisions about customised products? The case-study approach involves intensive work with firms <u>now</u>. There is some element of archival analysis e.g. of past sales records, but these are treated as recent, other 'nows' taking place in much the same context as currently exists.

The reality of course, is that data-collection takes a finite amount of time. Filling in a questionnaire may take ten minutes. Participation in a case-study may take weeks or months. In this research, the assumption is made that the duration of the data-collection is insignificant compared to the time taken for significant contextual changes in the situation under study. At the risk of labouring the analogy, the shutter-speed is occasionally rather slow, but the snapshot is still not too blurred to be of use.

This section looks at how the inevitable longitudinal aspect of the work is exploited both in terms of the learning that takes place during the whole research process and in terms of the creative interaction that can occur between one case and another, between case and theory and between data-collection and data analysis.

3.5.2.1 Learning New Skills, Learning New Theory

At the start of the data-collection, the pre-understanding and extant theory is embodied in the data-collection instrument, which is discussed later in the Chapter. For the sake of clarity and simplicity, a couple of terms to be used throughout this section are now defined. Yin (1989) uses 'protocol' to mean the document that gives the case background and defines to the investigator the fieldwork procedures, the topics to be addressed during data-collection, the analysis plan and the format of reporting. The part defining the topics to be addressed is called 'data-collection instrument'.

The investigator goes into the field with the data-collection instrument and whatever interpersonal and organisational skills he or she may already have and begins collecting data. As the fieldwork progresses, there is inevitably development of these skills. This is one of the types of learning which take place during fieldwork and is to do with the efficiency and effectiveness with which data can be obtained, once the type of data required is established.

This is to be separated from another type of learning that takes place within and between cases: that relating to what data to collect. This is the more-or-less explicit process of theory-building. The research is founded in established theory in the field of manufacturing strategy and marketing. It has been demonstrated that this theory is rather weak in taking account of product customisation and the product-range. Thus the main objective of this work is to *build* new theory in this more specific area.

In a situation where practically no theory exists, it is legitimate to start with an unstructured approach to case design, very few prior notions about theories and very widely-flung data-collection nets. The ideal in theory-building case-study work is 'no theory under consideration and no hypotheses to test' (Eisenhardt 1989) because bias and limitation in the findings are thus eliminated. However, this ideal is clearly compromised as soon as the researcher decides to research a particular subject, however broad. Thus it is accepted that the researcher should

- formulate a research problem
- possibly specify some potentially important variables
- make some reference to the extant literature

(Eisenhardt 1989).

In the current research, the problem has already been formulated (see section 2.5.2). It is also possible to specify some potentially-important variables. These can be derived from relevant aspects of the literature and from the kind of personal pre-understanding that led to the formulation of the research question in the first place.

Reference to the literature occurs at two levels. First, the existing literature has, in varying degrees, defined terms and identified relationships between some of them. In other words, there is a body of literature with a degree of construct validity and some internal validity. As indicated in the literature review, the ground here is far from solid, but it does provide some footing for the development of new, related theory. Second, relevant terms and constructs are tentatively extracted from the literature to provide initial direction to the theory-building in the more specific territory of the present research. By using the established constructs as far as possible, the new theory developed can be related to the extant literature.

3.5.2.2 Data Collection and Data Analysis

This brings us on to considerations of process. Yin (1989) separates the single-case data-collection and analysis from cross-case analysis. Furthermore, within the single-case part of the process, he separates 'conducting' the case-study (apparently used to mean 'collecting the data') and analysing. This is very much based on a positivistic, natural-science-based view that one:

- designs the research, THEN
- collects all the data, THEN
- analyses them, THEN
- draws conclusions.

The view held here is that, far from being 'fraught with danger' (Yin, 1989), analysing-as-you-go-along gives the researcher a 'head-start' in analysis and enables the exploitation of flexible data-collection (Eisenhardt, 1989). If, as here, theory-building is an overt objective, the new theories will raise new questions and so the data-collection has to be flexible. Indeed, this is one of the ways in which the internal validity of intensive research can be enhanced, because as theory develops it is immediately put to the test by the next iteration of data-collection and analysis, be that in the same case or in others.

The logistics of the fieldwork influence the nature of this iterative process. For various reasons, the data collection phases of the case-studies took place in parallel to some extent. This means that, as well as reaction to findings within cases, research on one case feeds from that in other cases that are going on concurrently. There is also learning and adaptation as a result of work on cases that have gone before. In this way then, both the cross-sectional and the longitudinal dimensions are involved and interrelated. (This is more so in situations where one researcher does all the field-work, as in this instance.)

The way in which data-collection and analysis are related in execution is a slightly different issue to the way in which the two are related in their design. Even Yin (1989) notes the need to think about the analysis even at the design stage and suggests that the protocol should include a section on analysis and that considerations of analysis should be reflected in what data the data-collection instrument specifies to be collected. Further consideration of the general strategy of how the data are to be related to the research question makes it clear that this cannot be left until after the data-collection 'phase'. Yin suggests that the goals are to:

- treat evidence fairly
- produce compelling analytical conclusions
- rule out alternative interpretations

As the fieldwork progresses, the research question should inform and constrain how far the investigator diverges from the initial guide, based on pre-understanding, extant theory and whatever other theory has been built during earlier parts of the fieldwork.

Yin suggests that the ideal way of analysing the data is to structure the analysis (and hence, presumably, collection) using the original theoretical propositions, if there were any. The 'second best' alternative, if there are no theoretical propositions, is to develop case descriptions. Within either of these approaches, Yin suggests three 'dominant modes' of analysis. First, pattern-matching involves either showing literal or theoretical replication by patterns of several 'dependent variables' or by trying different theories against the data of one or more cases. Second, explanation-building is an iterative process where the analysis of data from one case influences the theory to be used as the basis for the next case. Finally, time-series analysis is, in essence, either drawing graphs of constructs over time, or creating chronologies. It is not just a matter of observing trends but also of constantly addressing the how? and why? questions. The notion of 'dependent variables' seems to be a misappropriation from positivistic methodologies. If the idea of the work is to understand 'how?' and 'why?' - in other words there is a concern with causation - there needs to be more than a demonstration of the patterns of 'conjunction of atomistic events' as Tsoukas (1989) has it. The idea of patterns does have some use though, but it is with patterns of causative mechanisms that we should be concerned rather than with 'independent' and 'dependent' variables.

The reality of the iterative process is messier than Yin's conception of 'explanation-building'. Case-execution may well be in parallel to some extent. The view presented here also seems to preclude the possibility of the investigator *having ideas during* a particular case study.

Eisenhardt (1989) identifies two key features of analysis. First, there is within-case analysis - typically 'writeups for each site'- where the 'overall idea is to become intimately familiar with each site as a standalone entity'. Second, there is a cross-case 'search for patterns'. The key to this second aspect is, she suggests, 'looking at the data in many divergent ways'. Some different approaches are suggested, including categorisation of cases based on theory or the research question, some form of paired comparison between cases, identifying similarities and differences, and separation of data by source - interview, shopfloor transaction data etc.

Although Eisenhardt mentions the writing process as a way of becoming 'intuitively familiar with each case as a standalone entity', her description of the cross-case analysis is of a search for patterns across the cases. This emphasises the synchronic - analysis - over the chronological - narrative (Sayer, 1989). This emphasis on writing prose as a way of documenting and becoming familiar with single cases and on analysis - by tabulation, extraction of key dimensions and separation of data by source - as the way to understand multiple cases underplays the value of writing *per se* as a way of developing understanding (Sayer, 1989). As Sayer notes, the process of structuring a narrative and of accommodating non-sequentially experienced phenomena into a (necessarily) sequential form - i.e. prose - is itself a powerful technique for building understanding. In the end, prescription is also narrative ('If you plan now, you will be more competitive later'), so this approach to analysis is reflective of the intended outcome of a good deal of research. There are problems with narrative though. Most notably, narrative can 'gloss over the difference between mere temporal succession and causality' (Sayer, 1989). This risk is enhanced by the (inevitable) rhetorical content of prose.

The approach adopted here is intended to exploit the strengths and hopefully militate against the risks of these approaches by using a variety of methods. The cases involved triangulation in that multiple respondents were asked about the same things and, where possible, corroborating documentary and quantitative data were sought (Jick, 1979). These data are presented in prose, diagrams, graphs and tables. Particularly in the cross-case analysis chapter (Chapter 8), tabulation serves the dual purpose of analysis and summary (i.e. the act of creating the table is not merely a means to the end of communicating to the reader, but often constitutes analysis in itself). Only narrative though, can move us forward from existing to new theory.

This can finally be related to research design. A relatively recent exchange (Eisenhardt, 1989; Dyer and Wilkins, 1991; Eisenhardt, 1991) has examined the relative merits of 'better stories' (from single cases) and 'better constructs' (from multiple, comparative case-studies). For the purposes of the present research, the extra value of multiple cases is considered to far outweigh the single, very intensive case and the process of documenting and analysing the data reflects a combination of 'stories' and comparisons.

3.5.3 The Data-Collection Instrument

The data-collection instrument is included in Appendix 1. In the spirit of Yin, the 'questions' it contains are not actual forms of words to be used in interviews but are questions posed *to the researcher*. The methods of answering the questions will be many and varied. "The main purpose of these questions is to keep the investigator on track as data-collection proceeds" (Yin, 1989). The purpose here is to briefly explain the purpose of the sections of the data-collection instrument.

Section 1 requires that basic descriptive data about the plant and the company be collected. This is to facilitate subsequent comparison between companies at a broad level. The intention is *not* to carry out a complete manufacturing audit but to collect (a) the relatively mundane quantitative data describing the parameters of activity at each site and (b) more detailed and complex data relating to the particular concerns of the research and in which the case takes place.

Although there has not been complete freedom in choosing sites or cases, each collaboration that *has* been undertaken has some characteristic felt to be of theoretical importance. As such, it is necessary to include in the contextual data *for all the firms* data on these substantive characteristics and Section 1 is intended to do this.

Sections 2 and 3 deal respectively with the 'Design cycle' and the 'Material cycle'. This distinction, taken from Harrington (1973), is not intended as the definitive way to consider a manufacturing operation but is a pragmatic way of breaking down activities for data-collection.

Section 4 covers more specific issues relating to customisation and individual contract chronologies, where these are appropriate.

Whilst the data-collection instrument progresses more or less from the general to the specific, it is unlikely that the practical data-collection will do the same to such a degree. The distinction between the case and the background against which it is being studied is not clear-cut and there is a need to pursue lines of enquiry when the opportunity presents itself, rather than rigidly following the sequence of the instrument.

The questions have mostly been written as such i.e. complete sentences and have been supplemented in some cases by prompts as to likely sources of data as suggested by Yin (1989). This has enabled a uniform style even though the questions have come in various forms from various sources.

Chapter 4

Hyster-Yale Materials Handling

4.1 Introduction

4.1.1 Company Background and History

Hyster-Yale is a US-based manufacturer of Fork-lift trucks (FLTS). The project described here was undertaken between October 1992 and April 1993 and centred on the Scottish plant, located in Irvine, Ayrshire. It is one of three plants within Hyster-Yale Europe, the others being located in Holland and N.Ireland. The markets served directly from Hyster-Yale Europe are Europe, the Middle East and Africa. Products are also supplied to other Hyster-Yale divisions.

The Irvine site, as well as being the location of one manufacturing facility and its support functions, is the chosen location for a number of European divisional activities. These include divisional procurement, some design engineering and Sales Support and Administration (including application engineering).

Ownership of the firm has changed in recent years, with the current Hyster-Yale having been formed by the merger of two firms in the FLT business. At the time of the study, the process of combining and rationalising the resources, activities and products of the two firms continued. The brands of the two firms retained separate identities, although they had come to be manufactured in the same plants and often engineered by the same engineers.

Sales of the FLTs are nearly all carried out through dealers, although a few large customers are served directly through key account sales representatives. The dealers for the two brands remain separate and in some cases (e.g. the main UK dealer) FLTs are just one of many materials handling and related products sold. Dealerships in other countries vary according to local circumstances.

4.1.2 Irvine Manufacturing Facility

The Irvine plant manufactures small and medium-sized FLTs incorporating a number of product-lines and power-sources. At the time of commencing the study, the current year's turnover was £60m. The site, first established in 1960, occupies 300 000 sq ft and 450 people were employed, of which 380 were Irvine plant personnel and 70 were Hyster-Yale Europe staff. Shop-floor employees numbered 240. The site had been extensively refitted in the early 1980s for the production of a then-new range of products and, at the time of the study, these same products constituted the bulk of the production from the plant. In years immediately prior to the study, production volumes had fluctuated between 3500 and 4000 trucks per year.

In outline, the manufacturing processes consist of machining, various forms of fabrication, painting and assembly. The major refit involved the introduction of CNC lathes and machining centres, fabrication robots, Automatic Guided Vehicles (AGVs), a paint system and a reorganisation of assembly lines. As a result, all operations except assembly are organised on a functional basis e.g. machining for all trucks is carried out by the same operators on the same machines. Assembly is carried out on flowlines specific to a particular range of models, usually according to size.

4.1.3 Context of the Study

A meeting with the Plant Manager quickly revealed that product customisation and product variety was a current concern of Hyster-Yale. Recent years had seen the proportion of trucks designed to customer's own specifications growing. From what had been an occasional requirement to add customised features, the problem was quantified at the initial meeting: customised assembly work on special trucks had been responsible for 11% of the standard hours worked in the plant. Furthermore, this work was expensive, requiring skilled fitters, and the volume unpredictable, requiring a large amount of overtime to be worked.

The brief then was a wide one: to look at the process for special products from order intake to product despatch and to comment critically on it. These custom-designed trucks were referred to as SPED (Special Products Engineering Department) and 'What to do about SPED' was characterised as the subject, along with company car policy, that generated most discussion at Hyster-Yale.

4.1.4 Research Process

Access to Hyster-Yale was, on the whole, excellent. Following the initial interview with the Plant Manager, a one-day introductory visit was made, during which meetings with the following personnel took place: Plant Manager, Sales/Administration Manager, SPED Design Supervisor, Materials Manager, Cost Accountant, Factory Manager. Following these initial meetings, contact was made directly with individual personnel and meetings were arranged as necessary. Access was granted to the SPED files and personal-computer-based order information system and, especially in the later stages of the study, a good deal of time was spent reading the documentary evidence and extracting relevant data from the information system. Access to the Shop floor was also good.

4.2 Strategy Statements

4.2.1 Hyster-Yale Europe Mission

The H-Y Europe Mission Statement is made available to all employees. A large excerpt from it is presented in Figure 4.1.

> We are in the lift truck and warehouse equipment business (including the aftermarket) and supply products to the market through the separate Hyster and Yale marketing and distribution organisations.
>
> The markets for our products are Europe ,the Middle East, Africa and affiliate demand (USA, Australia, Japan, Asia, Latin America).
>
> Our vision is to be the best supplier of materials handling equipment in our chosen markets.
>
> To achieve this we must:
>
> - Be aware of the needs of our internal and external customers, and regularly measure our performance against those needs.
> - Meet the required delivery requirements of all our customers at the lowest cost.
> - Continuously improve our performance by applying the Total Quality Process to all aspects of our business, and utilise a team approach throughout our organisation.
> - Develop and train our people to their fullest potential.
> - Provide a modern, competitive product-range to the market which delivers the lowest cost of ownership to the user.
> - Develop and maintain world class distribution networks.
> - Maximise business opportunities in the aftermarket.
> - Ensure the full participation of our employees, dealers, suppliers, and affiliates in meeting customer expectations.

Figure 4.1 Hyster-Yale Europe Mission Statement

4.2.2 Worldwide Assembly Strategy

The internal management document called the Worldwide Assembly Strategy is the closest Hyster Yale come to an explicit manufacturing strategy. It is reproduced in Figure 4.2.

Objective:

To provide cost effective product on a timely basis to our worldwide distribution network

Strategies to deliver the objective:

1 Assign product to factories that capitalizes on commonality and optimizes part number complexity to achieve product focus and maximize operating efficiencies.

2. Assign product to factories that complements the existing infrastructure of our facilities to minimize investment and maximize asset utilization.

3. Assign product to factories with a bias toward assembly in market of sale to promote customer responsiveness, minimize trade issues, and optimize transport cost and investment.

Lean production measurements to address strategy effectiveness:

total part numbers in data base
total factory effectivity
projected asset/facility utilization
average order cycle time

Economic Requirements to guide strategy selection

total factory conversion cost
one-time facility and equipment investment
one-time transfer and start-up investment
in-stock and in stock inventory investment

Note: Only identify those investments and expenses which would be incremental to the previously accepted strategy requirements for assets and new product tooling.

Worldwide Assembly Strategy Development Methodology

Define existing measurements and economics

Define measurements and economics of previously accepted worldwide assembly strategy

Develop alternatives and assess risk, economic and responsiveness implications: market focus, facility utilization, lowest product cost

Optimize alternatives

Present recommendation

Implement

Figure 4.2 Hyster-Yale Worldwide Assembly Strategy

4.2.3 Marketing Communications

Whilst this is no place to carry out a detailed content analysis of the company's marketing communications, it is useful to give an indication of the themes that predominate in such documents as sales brochures, dealer newsletters and advertisements. In summary, these indicate that Hyster (and most of the literature was about Hyster rather than Hyster-Yale):

- are dedicated to the Fork-lift-truck business and have been in it for a long time
- offer quality, performance, reliability and value-for-money
- provide an extensive support network and spares service
- have a comprehensive product range (the quick guide to products is called 'The Total Range')
- are a technology-based firm.

4.2.4 Development of Irvine Plant Role

The brief plant history provided in interview with the Plant Manager (summarised in 4.1.2) was supplemented by an internal document that has been prepared for new employees and visitors to the plant. This is reproduced in Figure 4.3.

Hyster opened its second European manufacturing facility in Scotland at Hillington near Glasgow in 1957 and subsequently moved to its current location in Irvine, Ayrshire in 1960.

During this period, the Irvine facility has seen sustained growth and investment, running parallel with increasing market share penetration in the FLT industry. Today, the Irvine facility is one of the most advanced FLT manufacturing entities in the world, embracing the latest manufacturing philosophies and technologies in this highly competitive industry.

From 1960 to 1972, production in Irvine focused solely on the manufacture of internal combustion product with a lifting capacity range from 1.25 tons to 12.5 tons, aimed at the UK European and Middle East/Africa Markets.

A new era for the plant started in 1972 with the introduction of electric product with a lifting capacity range from 1.25 to 5 tons.

Approaching the end of the 1970s, business continued to grow unabated, resulting in high employment levels. At this time though, some ominous clouds appeared on the horizon. Initially, Japanese manufacturers in particular had started penetrating new high volume market for high quality, low cost product with limited option features. On top of this, the world economy went into severe recession in the early 80s with a subsequent dramatic downturn in demand for capital goods in general and FLTs in particular. Consequently, the Irvine plant was downsized in line with market demand.

In order to counteract the significant threat emanating from Far Eastern FLT producers, Hyster company formulated a strategy aimed at competing directly in these volume markets - developing the first of a new generation of low cost, high quality product - the XL series.

Having constructed a purpose-built facility in Craigavon, Northern Ireland, to manufacture this product range, the unparalleled success of adopting this stratgey helped the company decide that this philosophy should be expanded across all product ranges and across all locations.

In February 1983, Hyster Company announced a major investment programme in the Irvine facility - approximately $40m over a three-year period - that would culminate in Irvine being the most advanced facility of its kind anywhere in the world.

After completing the physical changes to the plant - CNC machining centers installed, welding robots introduced in the fabrication process, automated guided vehicles to move components through the manufacturing process and a total re-layout of assembly lines and stores - the new XL product came on stream through 1986-1987, replacing all product lines previously manufactured. Again, the XL product was a major success and considerably helped the company's increased market share thrust at this time.

In 1989, NACCO Industries acquired the former Hyster Company and merged this with their existing materials handling division - Yale.

A new corporation resulted - Hyster-Yale Materials Handling Inc. - and in the intervening era, the company has forged ahead with maximising the opportunities afforded by becoming a true global player on the world stage. From an Irvine perspective, the plant has successfully integrated Yale product manufacture across the complete electric 3-wheel and 4-wheel range, using this incremental volume to further absorb fixed costs.

Strategically, Irvine is now ideally fixed to manufacture volume in line with the market share growth plans of both Hyster and Yale and looks forward to the challenges that competing on a true global business level will bring.

Figure 4.3 Irvine Plant History

4.3 Hyster Operations at Irvine

4.3.1 Organisation

The Irvine site accommodates both the Irvine plant operations and some H-Y European functions. A summary of the Irvine plant operations organisation is given in Figure 4.4. The Plant Manager, reporting to the VP Manufacturing Europe, was the primary contact for and sponsor of this research. With the recent integration of Hyster and Yale, all these functions are carried out for both Hyster and Yale products. The organisation of the other departments particularly important to this research is less straightforward. These still maintain some divisions between Hyster and Yale and mostly operate at European rather than domestic level.

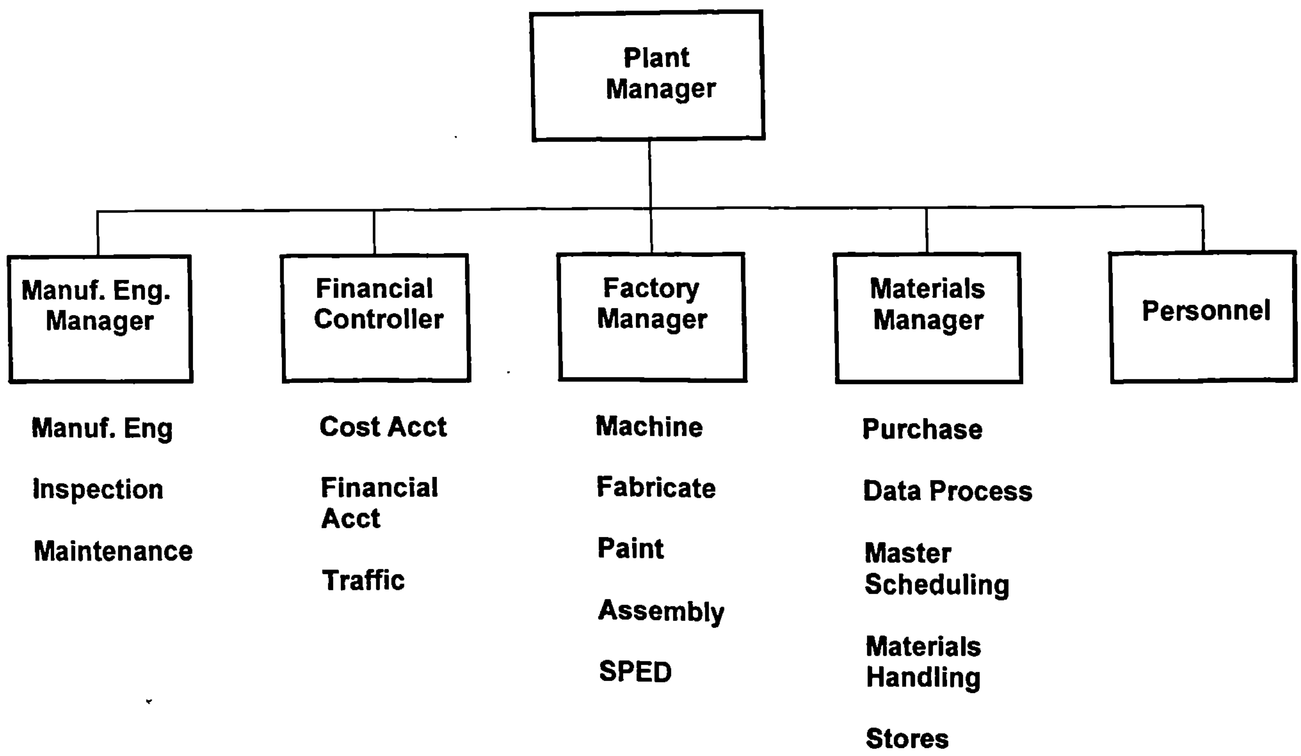


Figure 4.4 Irvine Plant Organisation

As most of the sales are through dealers, Hyster does not operate an extensive sales activity of its own, but provides from Irvine administration and technical support to the dealers. These remain largely divided along Hyster/Yale lines, in the same way as the dealer networks remain separate. The same person, who reports to H-Y European management, manages the Administration (for Hyster and Yale) and Sales Support (for Hyster only). These functions are detailed on Figures 4.5 and 4.6.

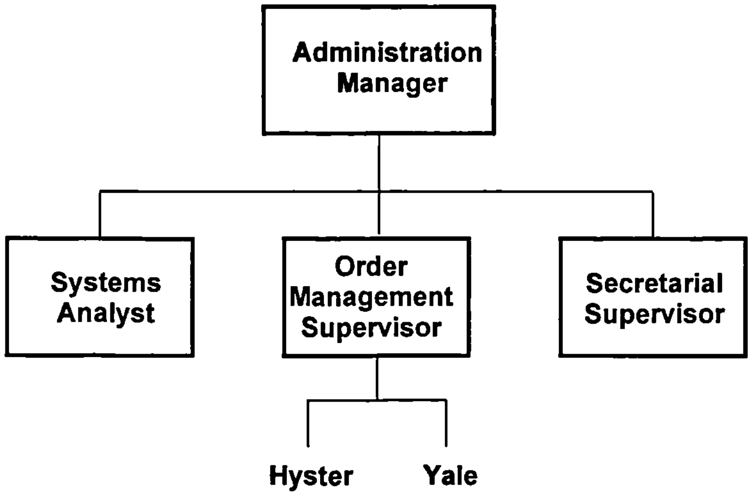


Figure 4.5 Hyster-Yale Central Administration Organisation

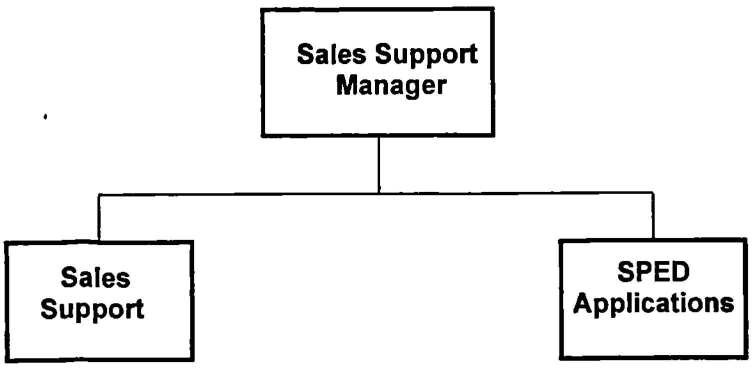


Figure 4.6 Hyster Europe Sales Support Organisation

Within the Hyster Europe Sales Support Centre, there are two groups. The Sales Support Supervisors offer a wide range of support - everything but the strictly technical - to their respective dealers. Organised along geographical lines, these Supervisors are often linguists. The other group are SPED Applications Engineering, who are responsible for specifying custom-designed products. As such, they will figure very prominently in this research.

The Hyster-Yale Engineering group is also a hybrid in that there are a mixture of Europe-wide and plant-specific responsibilities (Figure 4.7). Furthermore, the European Technical director reports to both European and US-parent senior managers. This structure results from a need to combine corporate-wide standards and economies in the design of basic products with country-, plant- and product-line-specific local specialism. Two large components of the Engineering Department are the Special Products Engineering groups, one in the UK (for Craigavon and Irvine) and one in Nijmegen. These functions will also come under scrutiny in this research.

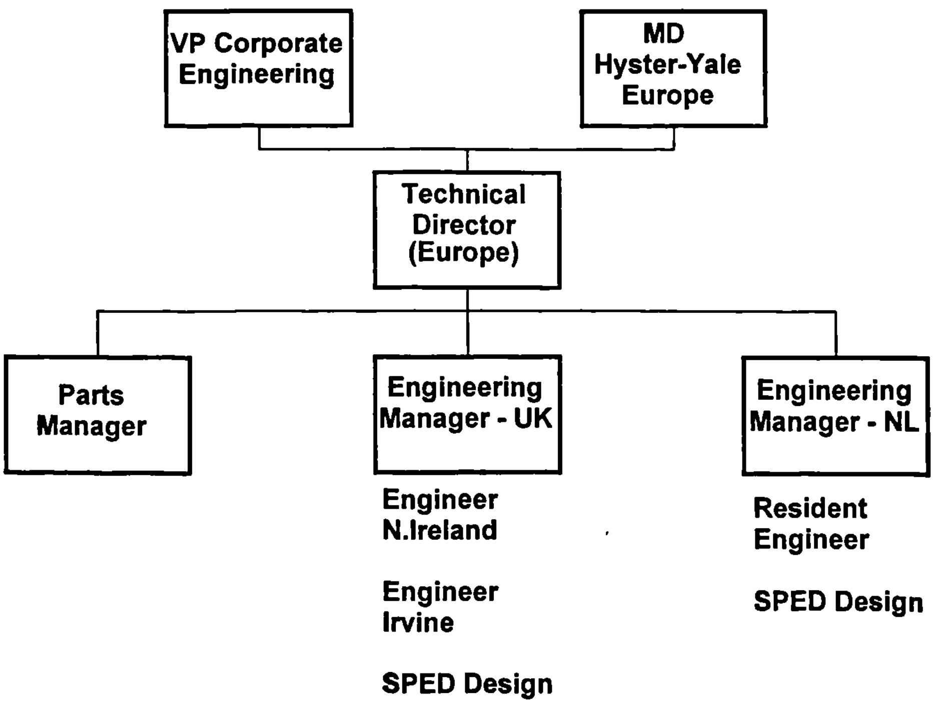


Figure 4.7 Hyster-Yale Engineering Organisation

4.3.2 Products

There are many variables by which FLTs may be categorised. Hyster and Yale products are grouped into series according principally to power source and carrying capacity. The Hyster range is summarised in Figure 4.8. The Challenger Range is driven by diesel- or LPG-fuelled engine, as are the Spacesaver trucks. The Electric range is electrically-powered. All three basic Ranges cover a range of lifting capacities, with the Challenger Range extending to 48 tonne capacity.

The Irvine plant, as well as manufacturing trucks from scratch, also takes in trucks manufactured elsewhere - e.g. in US plants - and either modifies them to suit particular requirements or completes them by adding certain attachments or features. The volumes of these 'recleared' trucks are small - a few percent in terms of units and even less in terms of labour hours. These 'recleared' trucks aside then, the main task of the Irvine plant is the production of the smaller electric trucks - 1.00 - 3.00 tonnes - and of medium-sized engine-powered trucks (3.50 - 7.00 tonnes). Craigavon produce a limited range of small trucks; Nijmegen produce the larger engine-powered trucks.

Characterising and quantifying the number of models is not so simple as the diagram might suggest. Within these broad categorisations, series are identified - e.g. E1.25-E1.75 and E2.00-E3.00 are treated as two distinct series. Within these series, models are identified at regular intervals of carrying capacity - e.g. E1.25, E1.50, E1.75. In terms of the series and model database, Irvine handles 16 Hyster metric series, of which six are recleared. These break down into 79 models, of which 20 are recleared.

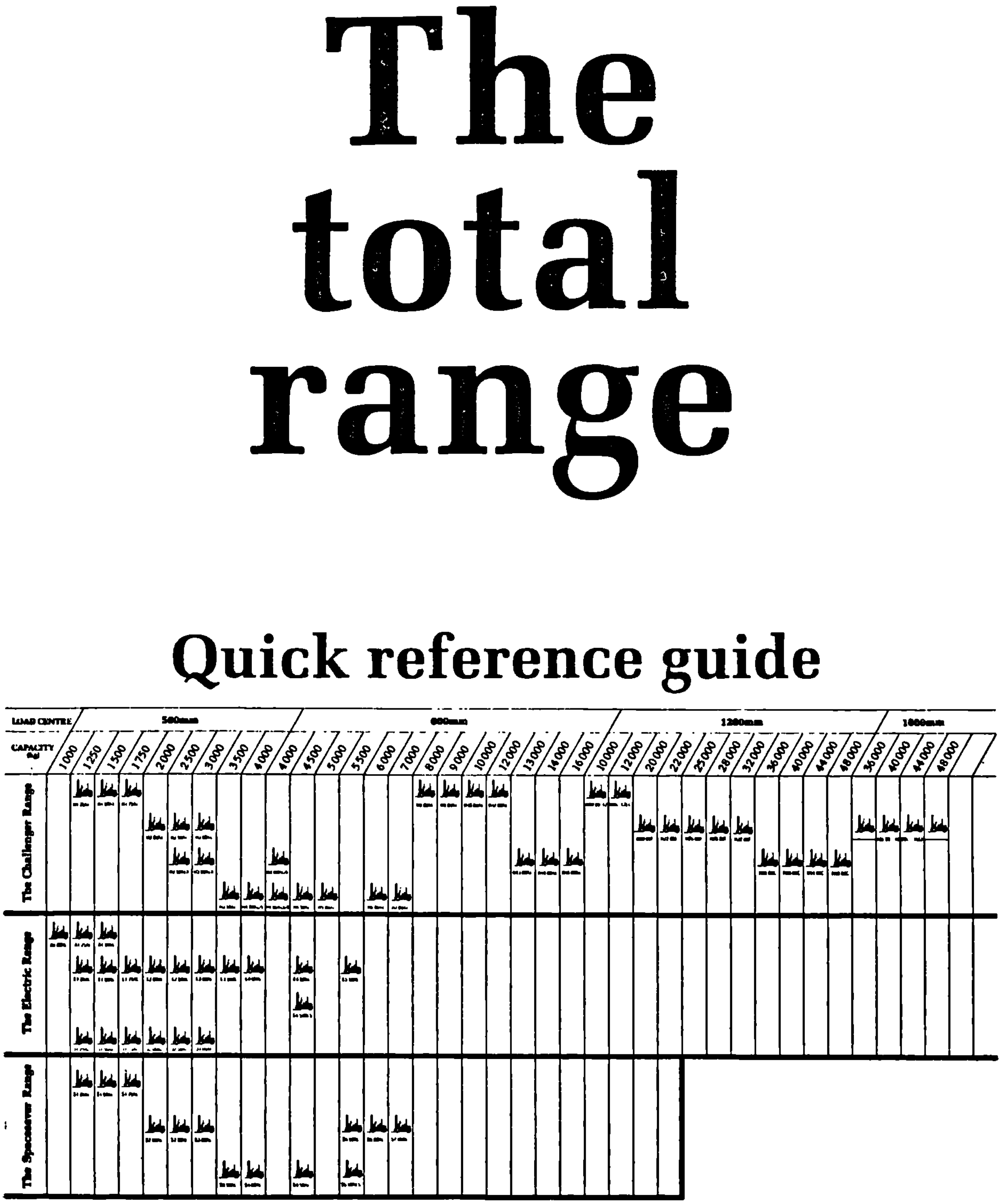


Figure 4.8 The Hyster Product Range - 'The Total Range'

Any 'model' as discussed above only constitutes a platform on which the final truck is configured. All trucks are extensively custom-built from a large but finite range of options; some (SPED) also have custom-designed options from a theoretically infinite range of possibilities. Custom-built options range from the fairly fundamental - selection of diesel or LPG-fuelled engine for example, or specification of lift height - to the relatively detailed. The estimated number of permutations that are feasible is 20 000. The processes by which custom-built and custom -designed features are specified, planned and manufactured is discussed at some length later in the case.

4.3.3 Manufacturing Facilities and Processes

The Irvine plant manufacturing facilities are contained in two buildings. The main works houses the machining, fabrication, paint and assembly operations. The SPED workshop contains the general purpose machines and parts storage necessary for the manufacture and/or fitting of practically all the custom-designed features required on 'SPED' trucks. The general layout of the two shops is shown in the diagram Figure 4.9.

In terms of the structural and many drive-train aspects of the product, Hyster are largely self-sufficient. Basic steel section and plate materials are fabricated - cut and welded - to produce the chassis, frames and uprights of the trucks. Welding of most components is carried out using dedicated robots, and AGVs are used to carry uprights through the process. Frames are built on fixtures dedicated to series; the

AGVs in conjunction with the upright welding robots are termed a flexible manufacturing system and can indeed accommodate a range of uprights for various truck series. (There are some limitations in terms of sequencing flexibility; it is also very difficult to use the FMS outside the range of sizes or at increments other than those that are considered standard upright heights.)

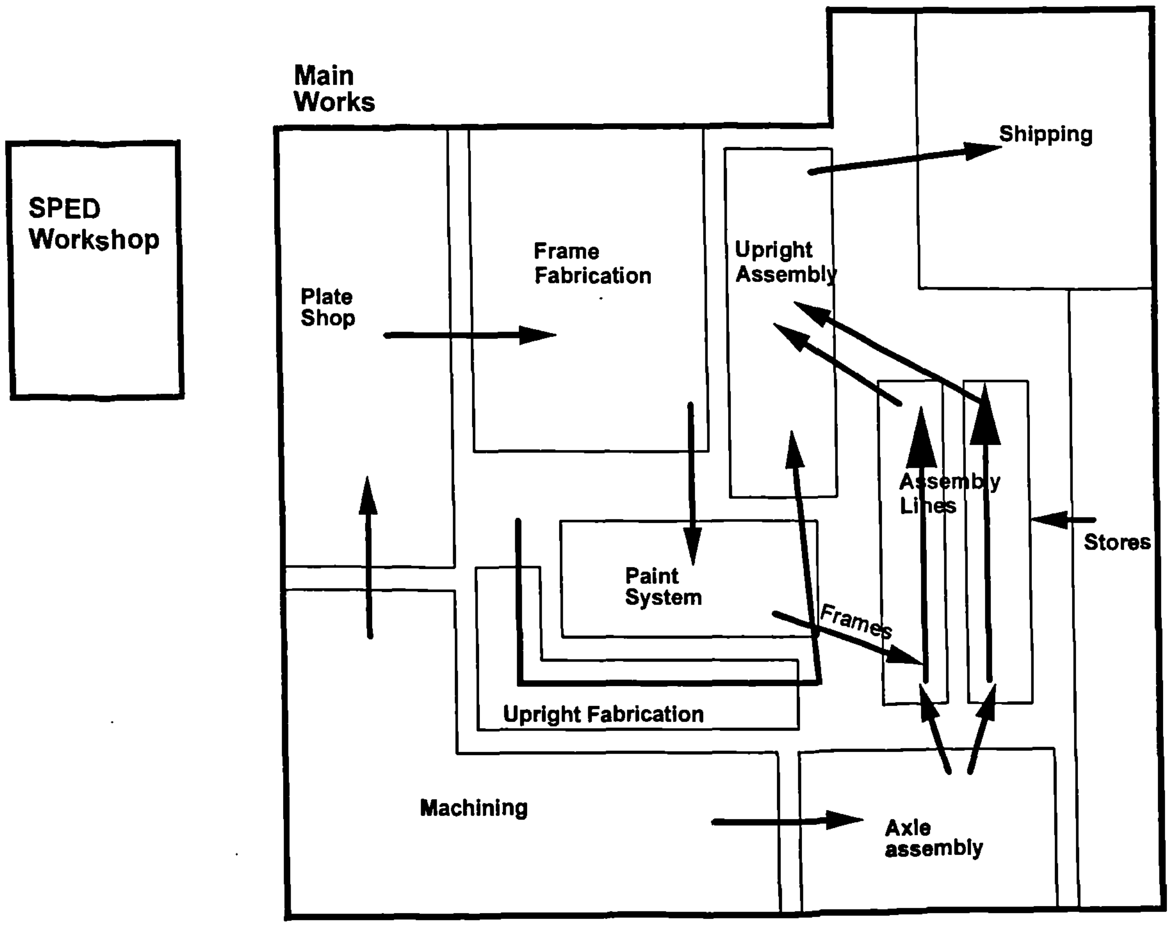


Figure 4.9 Irvine Plant Layout - Main Works and SPED Workshop

Axle, frame and upright components are also machined from bar and similar stock on the range of CNC lathes and machining centres. Whereas most other aspects of the process are planned and controlled by a Materials Requirements Planning (MRP) system, machining of these components, which are common to many series and largely unaffected by customer-specified options, is carried out on a Just-in-Time (JIT) basis, using a kanban system.

Other components are bought in with more value added. These include engines, axle castings, wheels and tyres, mechanical, electrical and hydraulic components and seats. Many of these are brought to the assembly line where they are fitted as required. A separate area of the main works is devoted to axle assembly, which involves bringing together bought-in castings, wheels, bearings and other components machined in the Machining section. Axle sub-assemblies are then available for installation on the trucks.

The frame, chassis and upright fabrications are painted and dried in the purpose-built paint system, being carried through the successive stages on overhead mechanical handling devices. Frames then proceed to the relevant assembly lines and the customer-specified options are built on. The upright is fitted as the last major step, with trucks from all series being worked on in the same area.

4.3.4 Ordering, Specification and Planning - Standard Procedure

The large majority of trucks are ordered through dealers. For Hyster, a Europe-wide computer network enables dealers to sit at a terminal and specify individual trucks from the large range of options. Typically this will proceed according to the following hierarchy:

Series - frame / power source

Model - carrying capacity

Options by 'option group' e.g. engine details; tread/tyre/wheel etc

As the specification proceeds, the system configuration only permits technically-feasible combinations to be chosen e.g. choice of i.c. engine power source will preclude all control system features relating to electric or LPG sources. For custom-built trucks then, the dealer can completely specify and order a truck without intervention from Hyster personnel.

At the time of ordering, each truck is given a sales order number. This is allocated regardless of specification and does not in any way indicate the type of truck. If a dealer orders more than one truck of the same specification at the same time, it is likely that they will be allocated consecutive numbers. However, from that point on for planning, scheduling and cost accounting purposes, they will be treated as separate orders, just as though they were different trucks for different end customers. No Hyster information system available to production staff presents a multi-truck order as one order - the only way this may be evident is if the trucks share particular features and have the same delivery date. Rarely is the customer identified because, so far as the plant is concerned, the customer is the Hyster dealer network.

For initial capacity planning purposes, trucks are disaggregated down to the level of option groups e.g. uprights or axle/wheel/tyre combination. Options are then re-aggregated for option planning by pulling together requirements for, say, uprights, from all truck orders so as to determine, for a particular planning period, what the demands on upright manufacturing will be. At this point, some iteration and discussion may be necessary if capacity does not permit fulfilment of all dealers' requested delivery dates. Through this process, an acceptable plan at option level is established.

Detailed materials and labour requirements are then planned using MAAPICS MRP. This is run once a week, over the weekend, and plans produced relate to trucks to be shipped four weeks later, with assembly line work to begin between 12 and 18 days (elapsed time) after the MRP run, and availability for shipment to be three weeks after the run, as shown in Figure 4.10

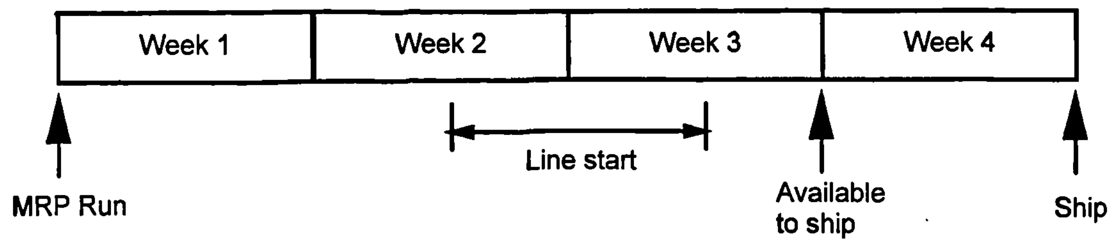


Figure 4.10 Plan - Build - Ship Timing

The MRP run then drives procurement of materials and the 'front end' manufacturing processes of fabrication and axle assembly. As machining is done on a JIT basis, detailed workplans for this are not derived from the MRP system. This results in eight or so working days for assembly and ten for parts manufacture and assembly.

Those components and materials for custom-built (as opposed to custom-designed) options that are bought in are sourced from suppliers identified by the European purchasing group. The purchasing of these materials is, then, largely a matter of vendor scheduling at a local (i.e. plant) level, within some kind of blanket supply arrangement negotiated by European purchasing staff.

4.3.5 Ordering, Specification and Planning - SPED

The process for specifying, ordering and planning SPED trucks is different to that for custom-built trucks. At the heart of this is the need for engineering involvement in specifying and designing SPED options. Within the (large) range of dealer-specifiable options, the structure of the ordering system is able to avoid the combination of options that are technically incompatible or downright unsafe. SPED options, on the other hand, have to be treated on an individual case-to-case basis so that a safe and appropriate overall specification results. SPED options may be incompatible with the dealer-specified options chosen (all trucks will have some dealer-specified aspects) and/or, where more than one custom-designed or SPED option is required, with one another. Thus, although some SPED options may appear relatively trivial and may be requested quite often, the specification of every truck requiring SPED options will need the involvement of Applications Engineers and possibly SPED design engineers.

The Special Products Applications group, working for the Marketing function ('Sales Support'), have two basic roles. They advise on the specification of trucks requiring SPED options and then administer order entry and parts requirements planning for the SPED options. This is carried out on a Local Area Network entirely separate from the MRP system used for production planning and 'standard' Bills of Material (BOMs).

The SPED Applications group are engineers, doing mostly engineering analysis and design work. They will provide whatever technical support is necessary to the dealer and customer to arrive at a specification. The extent of this involvement will vary enormously depending on the extent of customisation required. It could amount to rubber-stamping a requirement for, say, a non-standard light, or it could involve a number of site visits and extensive collaborative design work with the SPED Design group.

Where the SPED Applications group identify a need for a SPED option that hasn't been used before (some SPED options are requested by many customers), they will request SPED Design (part of the Engineering function) to carry out the detailed design work, establish materials requirements and, where necessary, identify suitable vendors for parts and materials.

So far as the dealer is concerned, when an order is placed for a truck involving SPED options, they simply bracket each SPED option by means of an option number. Their order will not attempt to describe or specify the SPED option in anything more than an indicative way and it will be the option part number that links the line on the order (and hence, via the MRP system, to the BOM) to the detailed design established by SPED Design. This option number could refer to anything from a different light bulb to a complex custom-designed lifting attachment.

The buying-in of components or materials for SPED options cannot be dealt with by a simple vendor-scheduling approach, as for the custom-built options. SPED Design engineers will identify suitable local vendors for anything they need and will negotiate price and delivery themselves. Very often, fast delivery is very important and price considerations less so. This may, in some instances, necessitate ordering components before a firm truck order is placed, in order that overall leadtime is not excessive. Commercial matters related to such an order are dealt with by the vendor scheduler but, in view of the involvement of the SPED Designer, the vendor scheduler is presented with a *fait accompli* in most respects and will be able to do little more than hold the vendor to their delivery promise and, in some cases, press for small price discounts.

As well as materials and parts, SPED options require labour. Most of the SPED work is carried out in the SPED Workshop and labour requirements are estimated by the SPED Applications engineers. In some cases, where it is within the capability of the SPED workshop, machined parts are made on the general purpose machine tools they have at their disposal. Most of the SPED work though, is fitting.

Perhaps more than materials requirements, it is SPED labour requirements that cause great difficulty for the Plant Manager. Although this will be examined in further detail soon, it is at a macroscopic level that problems become evident. In part, this is related to the way in which medium-term plans are made. Whilst dealers place firm orders for the specific trucks they require in the way described above, they are also required to commit further in advance to selling certain volumes by series. This enables forecasting of materials and labour requirements for basic trucks and common options. However, dealers are not committed to taking custom-built vs custom-designed (i.e. SPED) trucks and, whilst most forecast requirements will be for custom-built trucks, a large but unpredictable proportion of these will 'turn into' SPED orders once they are confirmed. Furthermore, orders placed as custom-built may be modified into SPED. Section 4.6.1 discusses the effect of late specification on delivery performance.

Thus a capacity plan is very difficult to establish, as the forecasts on which anything but the next month to six weeks is based will underestimate the SPED requirement to an unpredictable degree overall and in an unpredictable way in respect of which types of SPED labour will be needed on which series. Thus it is very difficult to determine the manning level for the SPED workshop. SPED fitters are skilled and relatively highly-paid: overmanning just in case would be very expensive; undermanning necessitates high levels of expensive overtime working and the training and occasional redeployment of fitters from the main works, with all the implications that has for quality of fitting in SPED and disruption of the main works assembly.

Although inter-series differences will be discussed more later, SPED labour content in terms of SPED labour hours as a proportion of standard labour hours for a custom-built truck ranges from 10 to 50 %. These are not trivial fluctuations, but very significant ones. The delay between orders being placed and SPED options being added is often between two and three months which , with typical requested leadtimes being about 100 days, makes last-minute significant changes in SPED labour requirements commonplace.

Assembly of all trucks is planned and controlled with the assistance of a document termed the final assembly schedule (FAS) which gives, for a week at a time, a truck-by-truck breakdown of the assemblies scheduled to start that week, indicated planned start and finish dates. For those trucks with SPED work content, an extra week is allowed as a matter of course (two weeks in exceptional instances) and SPED start and finish dates are also scheduled on the FAS.

Production Planning negotiate with all parties concerned to try to spread out the SPED orders - principally in assembly - so that as consistent a mixture of standard and SPED trucks as possible is maintained. With the proportion of SPED trucks increasing, this becomes an increasingly difficult task, especially when relatively large orders of SPED trucks with tight deadlines are required (e.g. a specific order at the time of the research which was required for the end of the financial year). In a more general sense, 'acute' problems with such orders demand extra attention of management and other staff with a consequent distraction from the important 'chronic' concerns of standard production.

4.3.6 The Shop Floor Reality

An output target or day rate for each assembly line is calculated based on a forecast aggregated at series level. This is expressed in trucks per day e.g. for the line assembling H3.50-5.00 XL and H 6.00-7.00 XL it varies between 6.0 and 7.6 during 1993, as seen from November 1992. Thus, each assembly line supervisor has an output target in the very tangible form of a number of FLTs.

The reality of SPED is that, depending on the exact nature of the special work required and when in the sequence of operations it is best carried out, trucks are at some point pulled off the Main Works assembly line and taken to the SPED workshop ready for the SPED work to be carried out. (The plant employs 25 'movemen' whose duties include this.) Thus a line supervisor may come into a shift and see, say, eight truck chassis/frame assemblies waiting for final assembly and look forward to achieving the day rate, only to find that four of them are SPED trucks and will disappear from the main works without contributing to the 'score for the day'. They will return sometime in the next week for further fitting and for the completion of upright assembly, but when that happens is largely a matter of chance, as SPED assembly operations, being by definition one-off or very infrequent, are rather unpredictable in duration. Not only does the removal of SPED trucks make detailed scheduling and loading very difficult for the non-SPED main works assembly then, but it also leads to a lack of task ownership on anyone's part for the completion of SPED trucks. Co-ordinating when exactly in the sequence the SPED work should be carried out also makes demands on SPED and Main Works supervision.

Further complicating the picture in some instances is the need to send some trucks to SPED (or to subcontractors) more than once, coupled with the fact that some SPED work inevitably damages standard work previously carried out (paintwork is the most common) and this necessitates additional rework. Some trucks may also have SPED options that are best dealt with prior to assembly e.g. overhead guard modifications. Thus a truck becomes the subject of significant 'orchestration' of activities between main works, SPED and, in some cases, subcontractors.

More generally, a number of criticisms of engineering were made by manufacturing supervision. Notable amongst these was the concern that, because of the demands of simply keeping up with new SPED designs, the SPED Design group rarely finds time to do more proactive work such as value-engineering the more commonly-produced SPED options. At the time of the study, the *Manufacturing Manager* indicated that he was carrying out such an exercise, at his own initiative, on a SPED part that was causing particular problems. There was also the feeling that, because of the often long delay between the design of an option and its manufacture, engineers 'lose interest' and are reluctant to become involved if any assistance is required when a new option is eventually being manufactured.

4.4 Quantifying the SPED Problem

So far, the description has concentrated on outlining the processes, both business and manufacturing, by which customer requirements are translated into finished goods. The evolution of the SPED problem has been briefly mentioned and quantified very broadly. Here, some further detail will be added to help define the SPED issue more precisely.

4.4.1 Overall Measures

The following summary measures indicate the scale of the SPED issue:

- SPED, in the year to November 1992 accounted for 11% of standard hours worked at the Irvine plant and capacity was often exceeded: in August 1992, estimated custom assembly demand was 2400 hours, capacity without overtime was 1300; in September, the requirement was 3500 and capacity 2000.

- The SPED workshop occupies 13% of the plant floor area.

- One fifth of all purchased part numbers are SPED parts.

- About one third of the vendors used supply nothing but SPED parts.

- Revenue from SPED trucks up to October 1992 was £3.5 m: annualised this represents about 7% of the annual £60m turnover of the plant.

Clearly this is no minor sideline and in various ways plays a very significant part in the Irvine plant's activities.

4.4.2 Trends

The three years prior to the time of the study showed two clear trends:

The total volume of trucks shipped from Irvine fell 20% between 1990 and 1992 (see Figure 4.11)

The proportion of trucks having some SPED content rose by about 10% over the same 2 year period and by nearly 15% over the 89-92 period (see Figure 4.11)

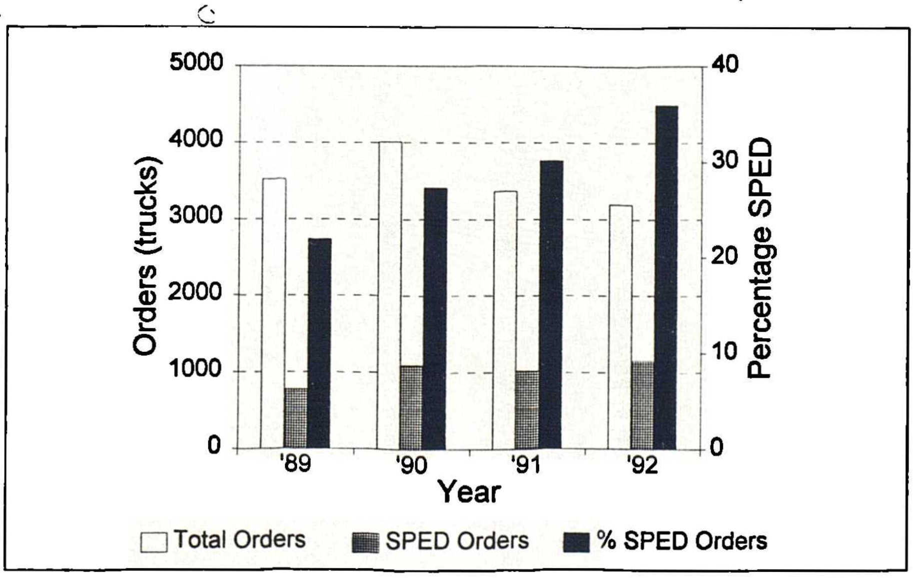


Figure 4.11 Total Volumes and SPED Volume 1989-1992

These results do not consider the SPED work content, categorising trucks as being either with SPED or without. The content of SPED work is now summarised for the year 1991 (the last for which data were available at the time). Figure 4.12 indicates the number of SPED options overall. Out of about a thousand SPED trucks in 1991, over 400 had only one SPED option. The labour content for individual jobs is summarised in Figure 4.13. Assembly hours predominate here and most jobs overall are of ten hours or less. Having said that, about half of the *assembly* jobs take over ten hours. Bearing in mind that the standard hours allowed per truck for capacity planning are as follows:

H 3.50-5.00 XL	45
H 6.00-7.00 XL	58
A 1.00-1.50 XL	33
E/J 1.25-1.75 XL	30
E 2.00-3.00 XL	37
J 2.00-3.00 XL	36

it is clear that SPED work adds very significantly to the work content of some trucks.

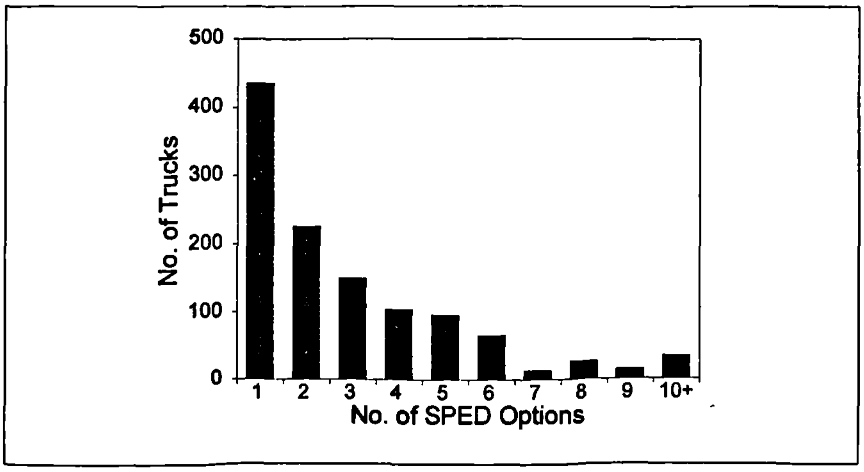


Figure 4.12 SPED Options Per Truck: 1991 Orders

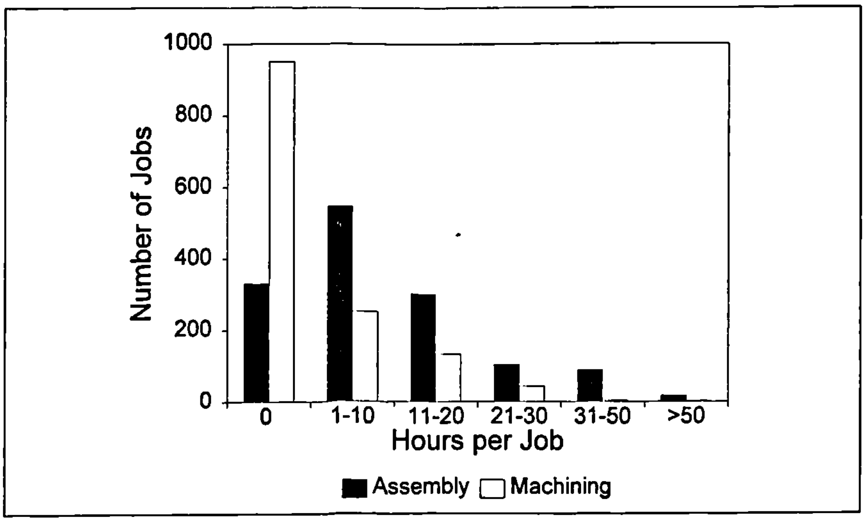


Figure 4.13 Estimated Labour Hours Per SPED Option

4.4.3 Series-to-Series Variation

These are overall indications in terms of trucks and do not take account of variations between series. For the purposes of this analysis, the top five series in volume shipped are used to indicate series-to-series differences. Figures 4.12 and 4.13 indicate the relative volumes and SPED proportion over four years. From these, further trends are apparent:

- attrition of total volume has been broadly shared between the "top five" Irvine series, except for the H3.50-5.00 XL, which has declined more, despite remaining the most popular series;

- the proportion of SPED trucks varies significantly from series to series, with the lowest being around 10% and the highest being around 60%;

- the proportion of SPED trucks is rising in each series, although the increase is greater in some series than in others.

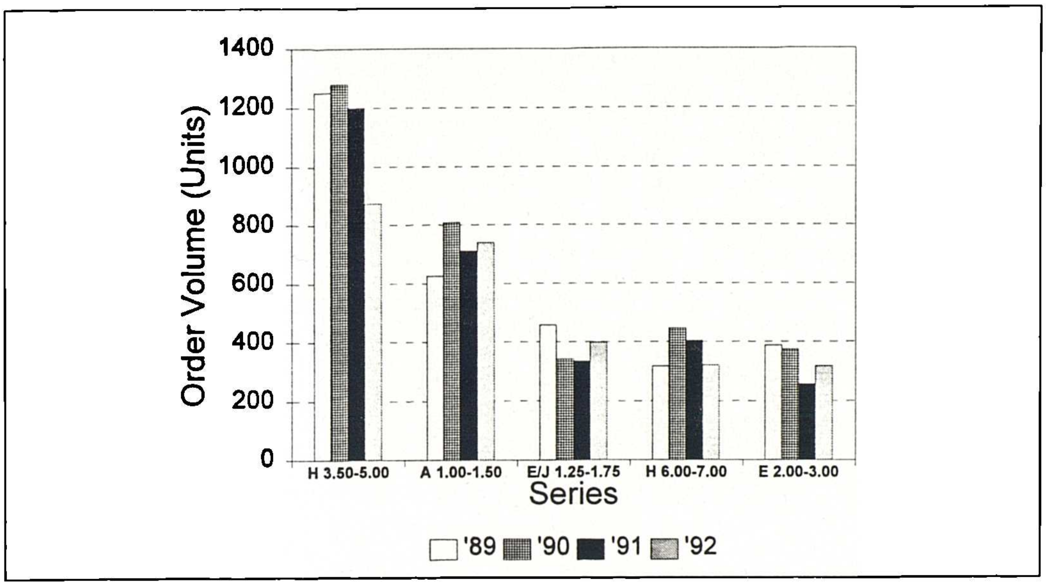


Figure 4.14 Volume Trends by Series - 1989-1992

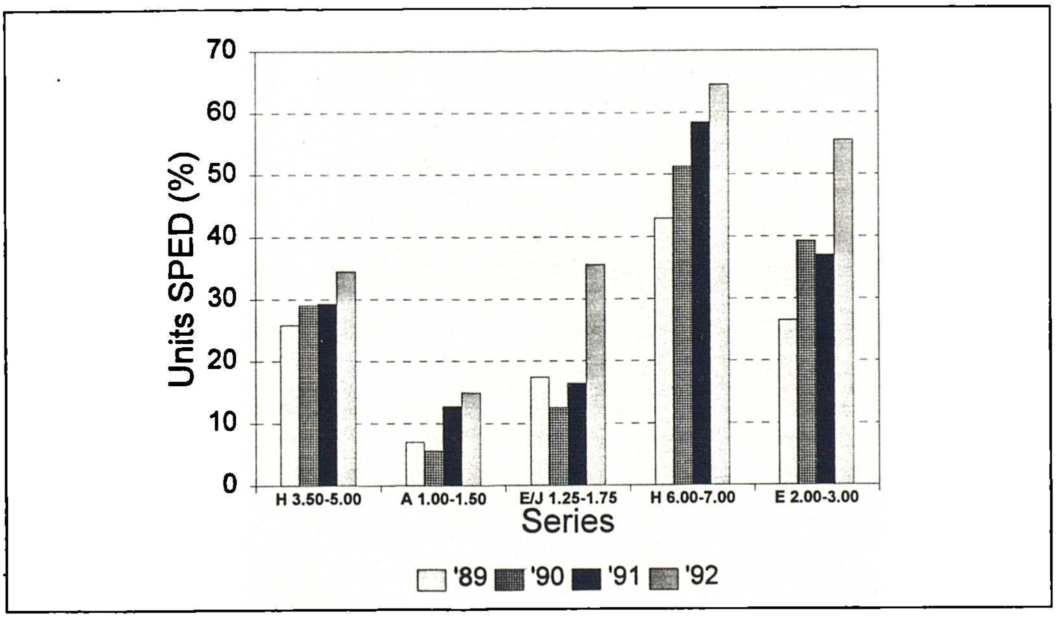
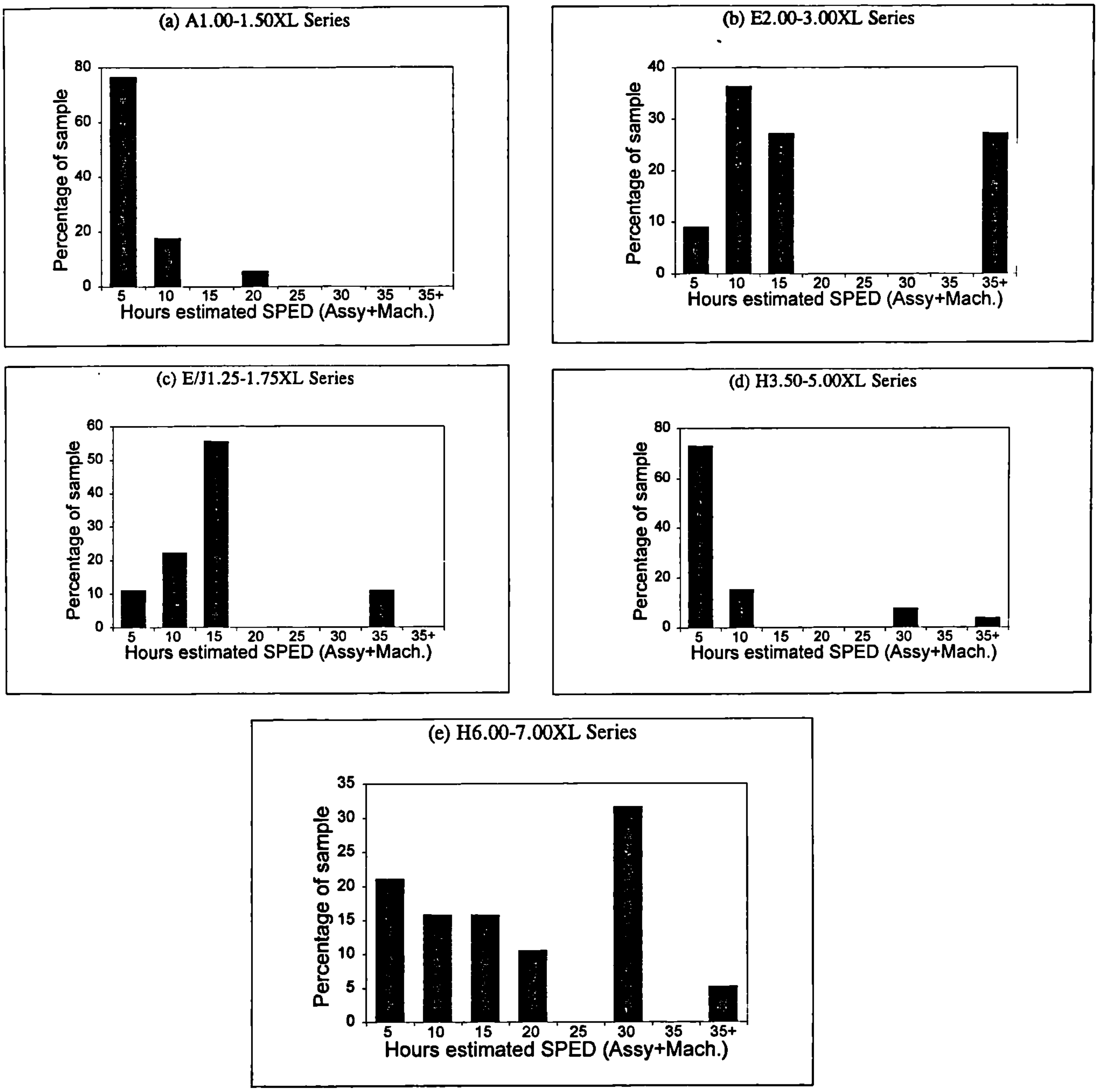


Figure 4.15 SPED Proportion Trends by Series - 1989-1992

Samples were taken over a four-month period in order to determine the SPED content, in terms of labour hours, for each series. The results of this study are summarised in Figures 4.16 a-e



Figures 4.16 a-e SPED Labour Content for Top Five Irvine Series

From these it is evident that there is a similar pattern in series-to-series differences in SPED content as there is in the proportion of SPED trucks (Figure 4.15). Two series involve very little SPED:H 3.50-5.00 XL and A 1.00-1.50 XL. In all series but the H6.00-7.00 XL, there is a clear bimodal tendency: there is either a day's SPED or a week's SPED and very little in between; the H6.00-7.00 XL series trucks are more evenly spread over the range.

4.5 Competitive Position

The competitive positioning of Hyster is important in determining how the production policies have evolved. This study has not incorporated a full industry structural analysis but has concentrated on how staff within the firm perceive and articulate the firm's competitive strategy. Whilst the data collection process has centred on understanding the processes by which customer requirements are translated into finished goods, an important secondary aspect of this study, like the others, has been to assess what the important competitive issues are as seen from within the firm, and how these influence the decisions made.

4.5.1 The Challenger Range

The account of the introduction of the XL series in section 4.2.4 was corroborated and expanded on by the Sales and Administration Manager. In particular, he commented that the introduction of this range (slightly less than ten years prior to the study) was the first time Hyster had attempted to produce a standardised product, albeit still a custom-built product from a standard range of options. Before that, all products had been made to customer specifications.

A new product range, incorporating many more features as standard than did the Challenger, was currently being designed in the USA. The SPED Applications and SPED Design supervisors compared what they knew of the new product and commented that 'the old Challenger was *very* basic'. This is somewhat ironic: the Challenger had been introduced to counter the Japanese ingression into the 'new high volume market niche for high quality, low cost product with limited option features' (see Figure 4.3) and now the new product was being designed with many previously exotic features as standard, directly influenced by the Japanese automotive industry.

The market was described as still 'very competitive' at the time of the study. This was reflected in the Sales and Administration Manager's attitude to taking possibly difficult custom-designed work: 'No-one's walking away from business [i.e. sales force or dealers]'; hence SPED jobs are sometimes accepted without full quotations having been done; 'We have to fit it in and maybe the rest of the business suffers'. This kind of approach was evident from another discussion, this time with the Order Management Supervisor. For a particular order the records showed that the order had been promised despite clear indications from manufacturing that the promised delivery would not be met. The explanation was 'I suppose salesmen have to tell porkies sometimes'. In a recession like the current one, he further explained, Hyster would 'do anything' and the priority was 'to give the customer what they want'.

The Sales and Administration Manager also discussed a current corporate drive to reduce delivery leadtimes. Typical quoted leadtime was 13 weeks: the aim was to reduce this to six weeks' delivery. There was some scepticism on his part about the need for this, especially in the context of the typical customer purchase process, which involves several weeks, if not months, of expenditure requests being debated and approved by relevant managers. Customers 'don't need trucks the next day'.

Also, bearing in mind that (sometimes considerable) extra time is required for SPED work, the Sales and Administration manager commented that the five week leadtime initiative 'will be no good if all the SPED is squeezed out' i.e. that, in moving toward a five-week delivery as standard, the company has to turn away anything but the most simple custom-design work or, alternatively, not be able to promise this for all products.

Many of the competitive pressures are felt by the Plant at one remove - for the most part there is the intermediary of the dealer obscuring the individual cases. Dealers hold inventory and carry out, to a greater or lesser extent, modifications on trucks in that inventory to suit individual customer needs. This serves to distort leadtimes and order-sizes because customer orders can often, wholly or in part, with or without modifications, be satisfied from dealer stocks. All that the plant Sales and Applications staff usually see are orders for individual trucks for particular branches of the dealer network.

4.5.2 Technical Lead and Custom Design

There is considerable support for the view that Hyster trucks compete on technical merit. Perhaps not surprisingly, this is the view of the Applications engineers and the design engineers. The SPED Applications supervisor commented that Hyster 'know we're not the cheapest' but that competition is first of all on the basis that 'it's a good product'; SPED trucks win business on performance and product and the views of the real end user - the driver - are seen as favouring Hyster: 'we have no worries about going on trial'. One example from recent work was for Coca-Cola, where competitors proposed 2.5 and 3 tonne trucks for an application and Hyster proposed a more expensive 3.5 tonne truck, despite protestations from the salespeople involved. The need for the larger, more expensive truck was proven and Hyster won the order.

The competitive role of SPED itself is important here. The SPED Design supervisor, in discussing the costing of his group's work, commented that SPED design hours are not charged to customers but are treated as a general overhead and that 'SPED is seen as supporting the business generally'. Again, according to the Plant Manager, the involvement of the dealer network makes it less straightforward to determine the extent to which and the ways, if any, in which the 'SPED sells our standard product' theory applies. One view is that customers who have been satisfied with SPED trucks will favour Hyster for orders of standard (custom-built) trucks: that is the implication of the cost accounting approach to SPED design costs, that somehow it is worth the standard business subsidising the SPED business.

In a lengthy discussion of this with the Plant Manager and the Sales and Administration Manager, the conclusion was that the process by which SPED influences demand for standard custom-built trucks is more diffuse and complex than the simple link postulated above. In some way, they suggest, there is a synergy between SPED and standard product that means that, in order to maintain a market presence of any sort in the industry, a 'full' product-range has to be offered, including custom design when necessary. 'The word gets around' amongst users and they want 'a Hyster' not 'a fork-lift-truck'. Via the trade press, dealer newsletters and personal contacts, the firm 'beats its chest' about technical successes i.e. custom designs for extreme applications. Linked to this is the suggestion from the Sales and Administration Manager that customers are tending to want more flexibility in their trucks. Whereas in the past firms might have bought two or three trucks, each with different custom-built options to deal with different tasks, they increasingly want one custom-designed truck with a combination of options that enables it to do everything.

4.5.3 Customer Service

The Sales and Administration manager refused to be held to a clear-cut order-winning issue. He sees the 'support' offered by the dealer network as being an important factor. The dealers are known for their efficiency, responsiveness to service call-out, spares availability and SPED capability. More generally, the willingness of Hyster to invest in production facilities, with all that that says about quality and technological prowess, is seen as an asset and exploited through the increasingly common vehicle of plant tours by customers. In an industry where safety is of paramount importance, Hyster's strict conformance to relevant legislation is also reckoned to be a selling-point.

4.5.4 Price

In the straitened economic circumstances prevailing at the time of the study, the usually relatively high initial purchase price of Hyster products may be an obstacle. There have been recent instances of 'dumping' from overseas competitors at 'crazy, crazy prices'. The measures seen as best combatting this purely price-based competition are customer visits to the plant and the improved dealer and sales support offered by such steps as recruitment of linguists in the sales support area. This move to customer service was described as 'the most significant change in attitudes over the 20-odd years I've worked here'. The Sales and Administration Manager commented that the typical purchase decision on SPED trucks was a complex one, amounting to 'what [i.e. degree of customisation] the customer can get for the money available, in the time available'.

4.5.5 Delivery

Delivery speed is not stressed by Hyster as an important factor to its customers, although in some instances it comes to the forefront e.g. at the time of the study, a particular large order was occupying many people's minds, primarily because it had to be completed and invoiced by the end of the customer's financial year, a not uncommon phenomenon when organisations realise they have underspent plant and equipment budgets and can remedy this by replacing a FLT. Such special cases aside, comments from the Master Production Scheduler tend to support this: if customers are notified of a delay well in advance, there is not usually a great deal of sensitivity; if, however, customers are only notified of a delay a day or two before the due date, then they do become upset, even if the delay is only a couple of days.

The Sales and Administration Manager commented that predicting demand had become more difficult 'since the mid 1980s' (notably, this roughly coincides with the start of production at the newly-refurbished Irvine plant) and so it was hard for the dealers to know what sort of inventory to hold. Products from the plant 'used to be supplied on a first come, first served basis' but now forward supply was guaranteed to the dealers i.e. dealers are asked to commit to taking certain trucks of certain series for stock and the plant commits to supplying them.

4.5.6 Dealers

Dealers hold inventory and carry out customisation themselves. When it suits them - for example if business is relatively slow and their complement of fitters has little routine service work to do - dealers will satisfy some customer orders for custom-designed trucks by buying spares and doing it themselves, using either a truck already in inventory or one ordered for the purpose but to a basic specification. When it doesn't suit them - when they don't have the particular skills required, when they are busy or when they know it will cost them too much - they will order a SPED truck from the plant.

The dealer involvement then, means that information on who buys what is rather limited because not only are most orders not identified as being for individual end users but, for the reasons just outlined, may not reach the end users in the same form as they leave the plant. In a similar way, it is difficult to determine the "real" demands for delivery speed or leadtime, as orders may be to replace inventory, or to provide a basis for further customisation by the dealer (with presumably, in the latter case, time allowed for the dealer customisation work and the plant delivery date brought forward accordingly).

Although much of these issues were only discussed in general terms during the course of the study, a company research exercise which only came to light during the last visit to the plant provides useful corroboration and quantification in a number of these areas. Some of the summary points from the study are presented here, first on customisation:

> *Changes to the configuration of 579 trucks shipped to customers during September and October 1992 [the period of the study in the plant] were reported by our dealers in France, Germany, Holland, Spain, UK and Belgium. This study showed the following: [excerpted]*
>
> *- Of the 579 trucks reported, 519 had some form of modification on them.*
>
> *- A mean of 4.1 modifications per truck were made, with a mean of 11 hours' work per truck;*
>
> *- 270 out of 579 shipped were from dealer inventory, with similar*

levels of modification to dealer inventory and plant-supplied trucks.

and secondly on leadtimes:

> *The...Study (June 1992) ... found that expectation of a quick delivery was typically 4 to 6 weeks from customer order;*
>
> *Information supplied by Hyster's Sales Managers indicate that, for trucks up to 3 tonnes capacity, the competition is meeting the expectation of the market place of typically 4 to 6 weeks delivery;*
>
> *The study of 579 trucks [above] found that only 32% of customer orders were delivered within 5 weeks of customer order. Of this 32%, 26% was from dealer inventory and 6 % from Hyster shipment. For Craigavon series, 5 week leadtime performance was 60% for H1.25-1.75 XL and 33% for the H2.00-3.00 XL. The results indicate that Hyster is failing to meet the customers' expectation using the current "supply from dealers' inventory" philosophy and may be at a competitive disadvantage.*

Perhaps it should not be surprising that 'information supplied by Hyster's Sales Managers', which presumably has in turn been reported by customers or dealers, all of whom have an interest in exhorting the factory to better performance, should indicate that the competition is doing better. Nonetheless, it seems that, regardless of how the competition are doing, Hyster is not doing well enough.

4.6 Performance Measurement

These data from the Europe-wide study complement plant-level data on delivery performance, which is available in some detail for individual trucks. The other key performance measure that is available is cost. This is not routinely produced in summary form for all trucks, but a number of individual cases are available. These will be discussed within the context of a broader description of the approach to costing and, in particular, the approach to identifying variances and dealing with SPED.

4.6.1 Delivery Performance

Delivery performance data were available from two separate sources, one which recorded the requested and achieved delivery for all trucks (held by Sales Administration), and another which related to SPED trucks only (held by SPED Applications). The database for all trucks did not distinguish between SPED and non-SPED trucks. The definitions used were as follows:

Requested Leadtime	=	Date requested - Date registered
Achieved Delivery	=	Ready to ship - Date registered

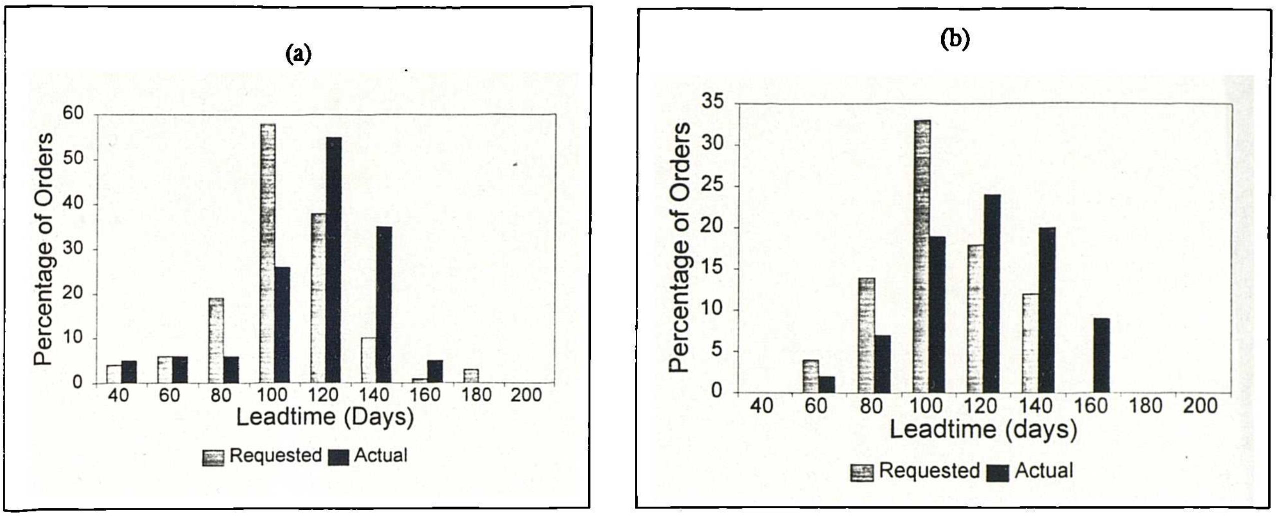


Figure 4.17 Requested and Actual Delivery Leadtime Distributions - (a) All Trucks (b) SPED Only

The first thing analysis of these data reveals is that many trucks are delivered late. Figure 4.17a shows the profile of delivery dates for all trucks; Figure 4.17b shows the same thing for a sample of approximately 100 SPED trucks, covering all the main series. Requested leadtimes in both cases are centred on 100 days; achieved leadtimes in each case are centred on 120 days. Statistical testing (t-test) of the data indicate that there is no significant difference between the two distributions i.e. SPED delivery request and performance is the same as for trucks custom-built from standard options.

These distributions do not indicate how many individual trucks were late to promised delivery. Figures 4.18a and 4.18b show the distribution of 'earliness/lateness' for all trucks and SPED trucks only, respectively. (Note that the units are trucks, and that the sample of SPED trucks was smaller than that of all trucks.) This clearly shows that many individual trucks are delivered late in both cases. The curious shape of Figure 4.18b cannot be explained by anything other than smallness of sample.

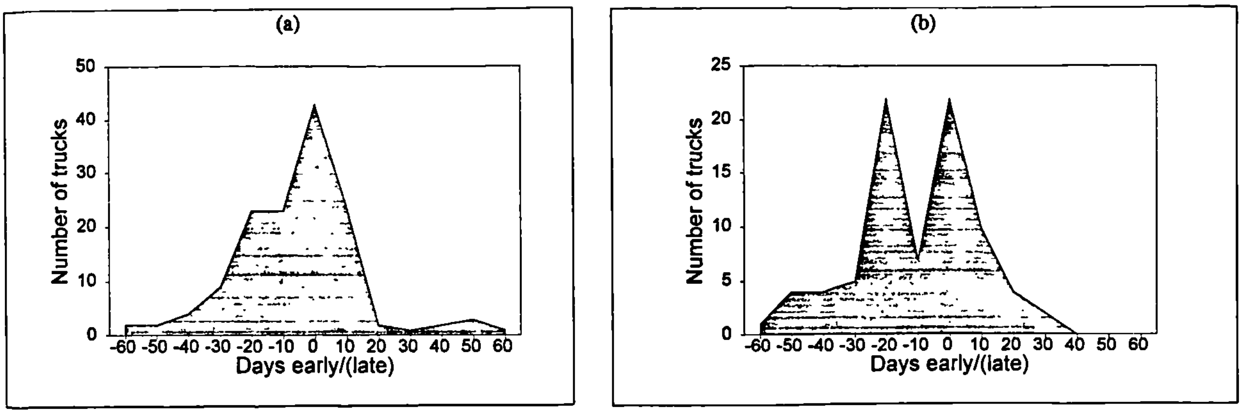


Figure 4.18 Earliness/Lateness of Individual Deliveries - (a) All trucks (b) SPED Only

This could be interpreted in various ways. The simplest interpretation is that different series and SPED don't make any difference to the demands on the plant. In view of what has already been discussed, this seems unlikely. Another interpretation is that, because Materials Management try to plan SPED in as even a manner as possible, everything is reduced to the lowest common denominator. In that there is no perception of different order-winning criteria in respect of delivery time between SPED orders and standard orders, this uniformity may not matter (except that it seems to be uniformity of failure). But it has serious implications for the expressed desire to reduce leadtimes generally. SPED trucks take more time, both in design and manufacture, and if leadtimes are to be improved, either the whole process has to be speeded up a great deal, or SPED trucks and standard trucks have to be treated in a more differentiated manner so that SPED doesn't drag everything down to its level.

4.6.2 Cost and Costing Systems

The principal contact for financial information was the plant Cost Accountant, who reported to the Financial Controller. Whereas order dates and delivery dates are collected as a matter of course in the process of logging and administering orders, information relating to costs is generated as a separate issue and as such, no neat summary table of the cost of each truck produced was available. Indeed, no systems were in place to collect actual costs.

Because the costing system is linked to the MRP and associated order management systems, it works, as these other systems do, at the level of option or "MLI" (Master Line Item). A standard cost exists for each option and, as the dealer builds up the options required for a truck, so the costs are built up. Costs are intended to reflect materials, labour and manufacturing (i.e. not general administrative) overheads. Manufacturing overheads are allocated in proportion to direct labour hours. Pricing, an area of policy outside the current study, then seeks to secure a contribution to general overheads as well as a profit.

SPED costing proceeds in a similar fashion. Every truck has some standard options and the costs associated with these are built up as they are specified. The SPED options are given MLI numbers - relating to each "SPED job" - and the costs associated with these are collected in much the same way. A cost summary for any SPED truck is thus a list of option codes and their associated standard costs, summed to give a total cost for the truck. This "Standard Cost Audit Trail" report, generated on an exception basis by cost accounting staff, does not distinguish in any way between SPED and standard options.

So far as standard options are concerned, there is a monthly process of 'rolling up' cost data so that the most recent cost estimate is available: for example, reflecting cost changes resulting from Engineering Change Notices. The costs used for any truck order are those in force at the time of manufacture rather than at the time of invoicing.

SPED option costs comprise two main elements - materials and labour. Material costs are simply the costs to Hyster of bought-in materials or components that were needed for a particular option. Labour costs are obtained by applying the relevant labour rate to the labour hours for the SPED option as estimated by the SPED Application Engineers. The Cost Accountant was under the impression that actual labour hours were reported by the SPED Workshop Superintendent and hence that there would be a check on inaccurate estimating by the engineers. In fact, shop floor observation and interviews indicate that no such cost reporting is carried out, nor was there any evidence of any systems existing by which this might take place. These same interviews indicate that SPED Supervision have grown to know the allowances they should make in respect of the estimates of SPED labour content, dependent upon which engineer was responsible for generating the estimate: some are accurate guides, others are very optimistic. This absence of any SPED labour cost reporting was confirmed by the SPED Design and Applications Engineers. The best information they had was that 'SPED overall is supposed to be paying its way'.

Where the SPED work involves a number of items which are separate for the purposes of design, but which are intimately inter-related for the purposes of machining and fitting, the way in which labour is allocated to individual MLIs may be misleading. The labour allocation has to be made MLI-by MLI, but in practice, several MLIs may constitute one large modification and hence one large and indivisible task for the fitter. So labour may be all allocated to one MLI, spread arbitrarily between them, or some attempt may be made to link labour content with designed option (i.e. individual MLI) insofar as that is possible or makes any sense. Thus whilst the total (estimated) labour cost will be reflected, the extent to which particular individual features requested by customers attract a labour cost will not be known.

As has already been indicated, although the SPED Design hours on each job are carefully logged, none of the design cost is charged to the individual customer. This is somewhat at odds with the description of the total cost appearing at the bottom of a Standard Cost Audit Trail report as 'cost of sales'. An accountant at the firm's Basingstoke central sales office carries out 'contract reviews' using the audit trail reports. The aim here is to compare actual and quoted costs, particularly where there are large variances. These are supposed, by the Irvine Cost Accountant, to include analyses of routings to determine whether the processes used and the labour hours involved were as estimated. As we have seen there is, in fact, no reporting of labour hours or process stages for SPED work carried out. It was not clear what the usage or dissemination of these reviews is: the Irvine Cost Accountant's view was that the firm does not 'learn from its mistakes and apply pressure to improve performance where costs indicate that this is necessary'. He also commented that, for SPED trucks, this approach clearly didn't reflect the reality of all the overhead associated specifically with SPED. Detailed examination of a major contract further that there were a number of differences between actual cost e.g. of bought-in items and audit trail costs.

A 'Statement of Income' for SPED trucks is issued to SPED and senior management once a month. For (a) the current month, (b) the year to date and (c) the prior month year-to-date, it gives a profit and loss statement for Irvine SPED operations. The headings under which data are reported are worth examining in more detail.

Net Sales

Cost of Sales
- Product cost at standard
- Manufacturing Variance
- Other manufacturing costs

- Total cost of sales

- Gross profit
- Percent of net sales

Operating expenses
- Engineering Irvine
- Engineering Yale

Marketing
After Sales expense

Total Operating Expenses

Operating Income

There are at least two ways in which this report is of interest. First, regardless of what the costs are, it demonstrates what data are available and reported to whom. Secondly, it provides some indications as to the cost structure of SPED operations, *given the assumptions upon which it is based.*

This report enables management to track trends in total SPED sales revenue and to see what manufacturing costs are incurred in producing the trucks involved. It is evident from this that, at overall SPED operations level, some attempt is made to reflect the cost of support activities e.g. Engineering and that it is not treated as an entirely 'general' overhead. However, a few comments seem relevant at this stage:

a) Manufacturing costs are not broken down into main works costs and SPED workshop costs;

b) All costs reported are 'standard' costs - as we have seen, SPED costs are only estimated due to lack of reporting of actual labour hours;

c) It is not clear how the Engineering costs are allocated.

Total engineering costs run at about 7% of total cost of sales plus operating expenses.

The annual charge for Engineering is £220k, which is presumably intended to cover all SPED design engineers plus an appropriate proportion of the general engineering costs. Noting that there are eleven engineers working full-time on SPED and that there are six other staff plus the Engineering Manager, it seems unlikely that even salaries are truly reflected in this allocation (even if SPED engineers alone are counted, £20k per year per engineer is unlikely to cover salaries).

4.7 Customisation and Variety

Having previously examined the impact of SPED work on the plant, particularly in terms of labour and disruptions to production planning and manufacture itself, it is instructive to see in some more detail just what the special requirements of customers are. This is no place to itemise in any great detail what the technical requirements of customers are - there are several thousand components in a typical truck and, as already indicated, once custom-design is involved, the technical scope is theoretically unlimited. It is of use to consider patterns in customisation though.

For this purpose, data are available from dealers, from SPED Engineering and from SPED Applications. Before going into more detail though, some useful insights are available from the more general comments of those working around the SPED area.

4.7.1 Attitudes to SPED

'We used to do anything': thus the first comment of the Applications Engineering Supervisor on SPED decision-making. Two major constraints were identified as having altered that: first, the increasingly tight legislation on FLTs that has, from a technical/safety point of view, limited what was possible; secondly, the ceiling on design engineering capacity has increasingly limited the number of quotations that could be worked on. There are also some elements that are so fundamental to the truck that they are considered non-modifiable outside the basic options e.g. drive axle and engine. Hyster have been criticised by customers for a lack of readily-available options as compared to Japanese suppliers 'who have benefitted from automotive industry experience and are able to offer a wide range'.

On a related point, the Sales and Administration Manager pointed out that the legislation has reduced the extent to which users and dealers can modify trucks themselves. Thus, whilst one effect of the legislation may have been to limit the extent to which trucks could be modified, it has nonetheless also *increased* the proportion of modification that can only be done in the factory.

The general procedure for handling a SPED quotation was outlined as follows by the SPED Applications Engineering Supervisor:

1) Assume that a feasibility study has been carried out at the end customer's premises;

2) SPED Applications suggest standard options wherever possible;

3) SPED Applications do an appraisal of whether to carry out work;

4) SPED Applications with SPED Design assess availability of Engineering design time.

By virtue of the domination of distribution by the dealer network, the bulk of enquiries are channelled through dealers. However, according to the SPED Applications Supervisor, the quality of specifications varies greatly. 'Experienced salesmen [*sic*] and dealers give detailed and helpful specs. Other don't. Sometimes we are at the mercy of secondhand information passed on by the field to desk sales to SPED Applications.' Enquiries vary greatly in the level of detail, even for similar degrees of modification. Some customers submit very 'heavy', detailed specifications. In the period January to October 1992, 2100 enquiries had been received.

4.7.2 The 'SPED Price List'

Being well aware that many of the enquiries that have to be dealt with are trivial in technical content but nonetheless demand some intervention by SPED engineers, the SPED Design and Applications groups have compiled a so-called 'SPED Price List' which attempts to push some of the decision-making out into the field. An existing document (dated December 1987 i.e very soon after the Irvine facility began production of the XL range) used for SPED Design reference, gives a list of commonly-requested SPED options and an indicative 'nett price' and delivery availability (in weeks). This attempted to provide a 'ready reckoner' for routine SPED jobs, at least insofar as quoting a price is concerned. At the time of the study, a new document serving a similar purpose was being compiled and this was to be made available to dealers. This list was more comprehensive than the 1987 document (i.e. contained more options) but it was not clear at the time of the study exactly which parts of the quotation, pricing and specification and design process would be taken out of the engineers' hands.

The new list contains 47 main items, most of which are yes/no options, some of which are choices from a few possibilities, one - the length of forks - which is to be specified for each case within certain limits. Most options apply to all series, except where this would be absurd e.g. Battery Discharge Indicator for non-electric trucks. They range from the relatively fundamental - fork length perhaps - to the very superficial - e.g. whether or not a toolkit is supplied with the truck.

4.7.3 SPED Option Usage

Clearly, a one-off cost is incurred when an option is designed. If it can then be re-used for another order, much of the extra work will be avoided. With this in mind, data were obtained on the usage pattern of SPED Options. A total of 1920 different options were on record as 'current'. In 1991, a year in which 1050 SPED trucks had been engineered for Irvine manufacture, 500 SPED options had been used. The pattern here was for most options to be used very infrequently. Even within the quarter of the options that were used at all, only 71 made double figures, and only one (the incorporation of a knob on the steering-wheel) was specified more than a hundred times.

What is also evident from the list of current SPED options is that many, similar modifications have had to be engineered anew, at least in part. For example, one involving changing the inclination of the uprights on which the forks are lifted occurs several times, in each case being a different part number, with different drawings and parts and having necessitated a separate design study. What appears as a single item in the list with an indicative price for quotation purposes may still signify a number of possible designs and potentially a new design when it comes down to detailed engineering. Bearing in mind that the combination of options is often the reason for SPED trucks to be subject to a full design study (so as to ensure compatibility of options) it is difficult to see how this requirement can suddenly be eliminated. Thus the SPED Price List will have a limited impact on the amount of design work required, although it may speed up the quotation process.

Most of the options, on the list of option usage and on the SPED Price List, refer to single features e.g. a different fork or a particular light. On both documents though, there are also entries that bring together a number of modified features under one option. For example, 'Cold store kit' may be specified, which involves a number of inter-related features that make the truck suitable for use in cold conditions. The detailed examination of a number of sales contracts (see 4.8) confirmed that SPED options are indeed often ordered in groups like this, where a number of features all relate to a common cause e.g. use in cold conditions. However, because of the tendency to treat these as separate and unrelated options for administrative purposes (e.g. BOM structuring), although everyone in design and marketing appreciates that they <u>are</u> related, it is difficult to identify and quantify this type of grouping of SPED options. There are similarities between such grouping and the 'option groups' of non-SPED features, but these application-related groupings can and often do cut across a number of option-groups e.g. cold-store-related options could affect engine, hydraulics and tyre option groups.

The SPED Design Supervisor commented that previous usage of SPED options is certainly no use for forecasting purposes e.g. for buying in long leadtime materials.

4.7.4 Dealer Modifications

Dealers modify 90% of the trucks they ship to end customers. These include trucks ordered specially on Hyster plants and trucks held in dealer inventory, and the proportion of trucks modified is much the same in each case. This means that, despite the number of trucks being custom-designed for factory manufacture, dealers still find it necessary to make some modification to 90% of what they are ordering from the plants. The dealers are spending an average of 11 hours per truck: this is similar to the number of standard hours SPED per SPED truck produced at Irvine and should be seen in the context of typical standard hours per non-SPED truck presented earlier i.e. 30-45 for most series. Modification thus adds 50% more labour to an 'average' truck.

4.7.5 'Evolving' SPED

As we have seen, truck orders 'turn into' SPED at the level of the MPS. There is also a good deal of evolution even after trucks are identified as SPED trucks. Of the 1050 SPED trucks engineered in 1991, 257 had alterations made to their specifications after initial ordering. Many of these had more than one change made, on more than one occasion.

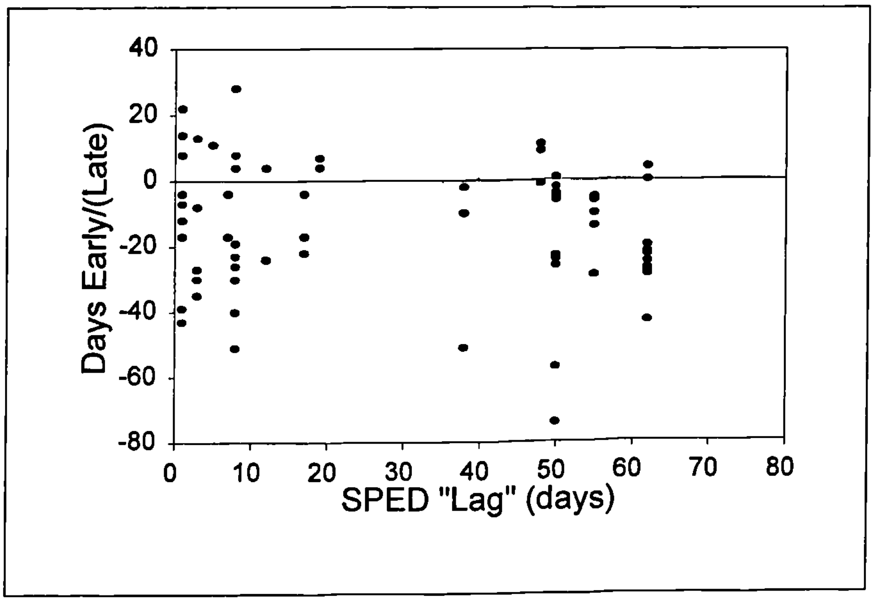


Figure 4.19 Delivery Performance versus Delay in SPED Notification

This could provide an explanation for the lateness in delivery of some trucks. With this in mind, the delivery data were analysed further to establish whether trucks that 'turned into' SPED were delivered late (and hence the dealers, to some extent, 'only had themselves to blame'). These data are plotted on Figure 4.19, where each point represents an individual truck, the delay between the order being placed and the SPED requirements being notified is on the x-axis, and the eventual delivery performance is plotted on the y-axis. Casual observation shows the extent of the delays in many cases - bearing in mind that requested deliveries were typically 100 days, half the leadtime is used up before notification. There is also bimodality about the delays - they are either a week or two months, with nothing much in between. There is no ready explanation for this. A regression analysis was carried out and this showed very poor correlation between the two variables i.e. a truck that is specified as SPED from the outset is just as likely to be delivered late as one that is specified as SPED well into the leadtime. But this analysis cannot show whether SPED 'late developers' jump the queue to the detriment of carefully-planned SPED trucks.

4.8 Contract Chronologies

This section comprises descriptions of three contracts that were examined in detail. Notes were taken of every memo and fax in the contract files, and details of costings, MRP BOMs and similar detailed material were collected. These were complemented by discussions with engineers, shop-floor supervision, sales and other staff. The first chronology is by far the most involved.

4.8.1 An Order for Five Trucks for a UK Public Sector Organisation

4.8.1.1 Chronology Outline

On March 6th 1992, an invitation to tender was submitted by the customer. Tenders were due by 30th March. The tender document consisted of 90 pages. The customer was a key account and so no dealer was involved. An initial specification was prepared by March 17th, but several changes were made; the customer refused the initial submission, Hyster re-specified using a truck from a smaller series and quoted price and delivery.

On June 3rd, Sales informed the plant that they had taken the order, indicating that due date for customer inspection was 4th September (13 weeks). The note commented 'You have already indicated that it is unlikely that we can meet this delivery schedule - could you please check this matter out fully and advise best possible delivery?'.

Correspondence continued throughout June. In summary, this concerned difficulties in identifying a special type of ignition-key; a number of special purchase orders for long lead-time items being made outwith the MRP system; the need for a special overhead guard resulting from the customer's opting for a high-specification driver's seat; and some confusion regarding the location of the fire-extinguisher. The specification was altered three times. The customer was persuaded to have a standard livery rather than special-coloured paint, but insisted on a yellow canvas cab cover; agreement was also reached that the keyswitch could be a standard one.

In early July, the customer reverted back to insisting that the keyswitch be special. The design of this and other special options were completed during July. SPED assembly took place during the last week of August. Inspection by the customer found small non-conforming items and requested that one truck, with corrections, be sent 'without delay'; however, they also requested that the rest be held until the end of September.

Somewhat alarmingly, on September 9th, Sales wrote to the customer asking, amongst other things, 'what lift height is actually required and what are the types and dimensions of loads' - evidently the 90-page tender document had omitted these technical details. Various other details were the subject of correspondence during early September. On October 8th, a number of points were still not to specification - these were a result of inconsistency between Hyster policy and customer specification. On October 12th, the invoice for the first truck was sent.

In early November, the customer requested that the keyswitch be changed as it was not to specification. This and other changes were requested for the remaining four trucks, yet to be shipped. Cabs and beacons were to be fitted (Hyster policy is not to, because of damage risk during shipment); the exact specification of keyswitch was required (Hyster's supplier had supplied an 'equivalent' to the one specified). The invoice for these four trucks was sent on November 17th, but information from the customer as to original source of keyswitch was sent to Hyster on *December 17th.* Communications about the keyswitch continued in February 1993 (when data were collected) by which time it seemed that the trucks had been delivered.

4.8.1.2 Commentary and Background

The choice of this contract was suggested by the SPED Applications Engineers. The Financial Controller felt it was 'fairly representative'; the SPED Design Supervisor felt it was 'a messy one'. SPED Design felt that this was a 'terrible' customer to work with, especially as they had 'deliberately looked for reasons to delay delivery' because there was a delay in their own project that had originally initiated the order. The particular customer purchasing agent who was buying the trucks 'doesn't know about lift-trucks - he probably buys the biscuits for their buffets as well' and, as a result, had to work to the letter of documents because he 'didn't know what was important and what wasn't'.

There were many problems with this contract. One was the canvas cab, although the

SPED Designers were not aware of any problem 'in this case'. Discussion with the SPED workshop supervisor revealed that, in fact, it was only at the *third attempt* that the subcontract supplier made the cab correctly. SPED Design 'sometimes' do a drawing of the specific cab or the manufacturer 'sometimes' comes into the plant to take measurement off the truck (it was non-standard because of the non-standard seat...). Alternatively, suppliers have a general arrangement drawing and are given dimensions only. It is considered 'not worth doing a full drawing for £550-worth of canopy'. A further complication arose due to the special light that the customer wanted - to fit this, a hole would have to be cut in the cab, letting the rain in! The position of the light was subsequently altered in negotiations with the customer. The whole issue was further complicated by the fact that the subcontractor also subcontracted-on some aspects of the work.

The fire-extinguisher also presented problems because of other non-standard options - 'a bastard' according to SPED Design. The key-switch generated a lot of activity, with the correct source being identified *9 months* after the initial tender, as a result of extensive detective-work. The customer was charged the material cost of £30 per switch. A number of costing anomalies were identified, particularly between the quoted 'Nett price' which is used to build up the quotation, and costs identified by the 'audit trail' e.g. the '£550-worth' of canvas cab appears to have cost £760. The trucks sell for about £18k.

The estimated SPED labour was 43 hours fitting and 16 hours machining. 14 days of SPED Design time were recorded.

4.8.2 Three Trucks for an African Customer

This was a relatively straightforward order for three large trucks. It is notable that the quotation was requested with the following comments:

> 'this customer continues to request special modifications...is about to order four trucks and another one is likely later in the year...'

Then, when the order was placed:

> 'We have had orders before to this specification..'

'This specification' included eight separate options, common to all the trucks, all of which were required because of the hot, dry climate.

4.8.3 Six Trucks for a Northern European Customer

This contract is, again, relatively straightforward (despite over 30 hours extra labour per truck). Most of the work was because the truck was to be used for loading containers. Most of the problems resulted from peripheral issues such as a particular type of electrical converter, where there was a delay in the customer's providing necessary information on operating conditions.

The whole contract was carried out under considerable urgency. At the end, the SPED Applications engineers had to write to the SPED Workshop:

> 'Due to the late change being made, we have no formal design for this option...[incidentally, one supplied by the same cab subcontractor as in 4.8.1]...we would be obliged if you would inform [us] when the work is nearing completion to allow the design group to note the work done, to enable them to produce a formal design in the future.'

4.8.4 General Comments

These contracts can yield many insights into many aspects of the firm's operations. As far as interdepartmental relations are concerned, some issues emerge:

- the formal, documented communications (excluding drawings etc) are largely between SPED Applications and the relevant sales functions or between SPED Applications and Materials (especially purchasing)

- *documented* involvement of manufacturing in any aspects of the tendering and design stage is negligible;

- a good deal of communication is required to do things ' the system' can't cope with e.g. pre-ordering, finding out applications details not collected in initial customer communications, circumventing normal procedures to speed up reactions.

It is interesting, if somewhat mischievous, to note that in one contract, the first written communication to manufacturing was from sales (with copies being sent to all other departments with even the slightest involvement in the contract) *after the customer had inspected the first finished product* and consisted of a list of things with which the customer had been dissatisfied.

Obviously, it isn't possible to capture the informal communications that went on to complement those that are documented. However, discussions of these contracts with manufacturing staff indicate that problems that arose with the manufacture of these trucks were dealt with in an undocumented way and, certainly in some cases, the groups or individuals who were the apparent sources of the problems did not know about them. This could indicate that manufacturing expect to have to 'make do and mend' to some extent. The frequency with which this happens cannot be established, but in limited contact with just a few contracts, several design or supplier errors were apparent. It would also appear that problems that do arise are related to peripheral options such as lights, keys, canopies and so on, rather than those related to the fundamental lifting operations. Hyster have established, regularly-used suppliers for lifting attachments but appear to have difficulties with some less fundamental bought-in parts. It is also notable that, in two of the three cases, delays on the part of the customer for various reasons had a significant impact on the timeliness of the engineering effort.

4.9 Case Analysis

This section summarises the analysis and recommendations that were made to Hyster as part of the project feedback, examines the case in the light of relevant aspects of the existing theory, and begins to develop new insights that arise from this case in particular.

4.9.1 What To Do About SPED?

Hyster found SPED a really significant problem. As we see from the data, delivery performance all round (i.e. for SPED and non-SPED trucks) was poor, labour capacity planning in the SPED area was next to impossible without incurring massive extra expense, materials procurement for SPED trucks was often very expensive and difficult, and no-one had much idea of whether the cost of SPED activities was justified by the revenue it generated. With very severe competition the norm, and a corporate response in the shape of, amongst other things, a slashing of lead-times in the offing, the SPED Problem was not going to go away.

4.9.2 Marketing and Manufacturing

The conflicts between the interests of manufacturing and of marketing as characterised by Shapiro (1977) are certainly present, but in much more subtle and localised ways than in his stark picture. To begin with, to speak of "Marketing" as a homogeneous function is not particularly enlightening. In this case we have Applications Engineers (Hyster Europe Marketing) working closely and in reasonable accord with SPED Engineering (Hyster-Yale UK within European Engineering). There is the relatively passive Sales Administration function, the far from passive Key Accounts direct sales team and, to speak of marketing in its extended form for the time being, the dealer network. Also, although the case did not extend to interviewing them, there are the Basingstoke-based central sales staff.

There is, it could be contended, a more consistent requirement on the part of manufacturing (Plant Manager, Manufacturing Manager, SPED Superintendent, Materials Management) for, in essence, a better picture of the future. The current volatility makes capacity planning, materials procurement and production control difficult for all the managers mentioned.

Neither is there an archetypical divide between 'marketing' and 'manufacturing' in conceptions of order-winners (at least as far as they were articulated). Applications Engineering and SPED Design engineering alike see the technical superiority and in-service performance of the product as Hyster's strength (perhaps not surprisingly). To some extent this is supported by the Plant manager's 'we beat our chests' attitude toward the firm's technical success stories. Clearly the original concept of the Irvine plant was based strongly on low-cost, low-price competition, but no-one seems to be making a case for that as a tenable competitive position, certainly for the truck series that are produced at Irvine. The Sales and Administration Manager is particularly concerned with delivery speed and reliability, although there is strong evidence of some misgivings on his part about the need for and wisdom of the corporate drive for shorter leadtimes, certainly across all the products. He also emphasised the customer-service aspects. From the interviews with Plant Manager and Sales Administration manager (in some cases together), if anyone emerged as the 'them' to their us' it was the dealer network. It was the dealer network who played off their labour capacity, skills and costs against those of the plant, the dealer network who changed the specifications of their orders at the last minute, the dealer network who obscure a clear picture of the market.

4.9.3 Custom-built and Custom-designed Products

The most obvious conflict in this case - indeed the reason for the study in the first place - was that between SPED and standard (or custom-designed and custom-built) product. Table 4.1 may be constructed from the case data in order to summarise the different demands of SPED and standard products. Most of the criteria are manufacturing-specific and this approach is derived largely from the product profiling approach of Hill (1993: 146-152). As will also be clear from the case data, a simple dichotomy between SPED and non-SPED is too simple a basis for analysis, and some of the other factors bearing on the extent of conflict will be discussed after the brief discussion of the extreme cases.

Table 4.1 Comparison of Tasks - Standard and SPED

	Standard	SPED
Process type	Flowline	Jobbing
WIP Minimisation	Essential	Desirable
Emphasis on capital utilisation	High	Low
Work content (labour time)	Low and predictable	Higher and less predictable
Work content (type)	Machine loading and operation - clearly defined	Skilled fitting, varied and not fully defined
Interrelatedness of features	Accounted for in design	Possible ambiguity
Quality standard definition	Complete and explicit	Some discretion
Cost predictability	Very high	Lower
Ownership of tasks	Main plant	Shared/abdicated
Dominant production technology	Machine-based	Trade skills and 'orchestration'
Materials requirements	Forecastable, scheduled supplies	Unpredictable, unique or occasional orders
Materials purchasing power	Strong	Weaker

That there are *differences* between the manufacturing requirements of the two extreme categories of product is unquestionable. What is more important here is to analyse the reasons for the differences to generate *conflict*. The starting-point for this is the notion of the focused factory (Skinner, 1974; Hill, 1993: 156-182; Hill and Duke-Woolley, 1983). So far as manufacturing processes are concerned, Hyster-Yale are attempting to adopt some focus, primarily by carrying out the custom-designed work in a separate workshop where they adopt a job-shop rather than line approach. Some manufacturing focus is lost, however, in that trucks are physically abstracted from the flowlines to be customised in the SPED workshop, then returned to the main works for upright fitting. Apart from the disruption to scheduling at the time of removal from the line and return to it, the blurring of ownership is contrary to the focus ideal of a clear task for each factory-within-a-factory.

Table 4.2 Comparison of Key Infrastructure Issues - Standard and SPED

	Standard	SPED
Costing	Standard costs for options	Standard costs for options plus est. SPED labour plus SPED material costs
Planned in-process leadtime	Three weeks	Four weeks (or five for 'heavy' SPED)
Quoted leadtime to customer	13 weeks	13 weeks
Materials	MRP	MRP with manual adjustment and 'pre-order details' to extend leadtime
Identification	Individual truck order number	Individual truck order number
Performance target/measure	Day rate	Day rate
Basis for planning	Options (MLIs)	Options (MLIs)
Rough-cut capacity planning	Labour hours per truck - series specific	Overall 'SPED Allowance' as % of plant labour requirements

More apparent is the lack of focus in infrastructural terms. The same costing, production planning and control, materials procurement and performance measurement approaches are used for SPED and non-SPED trucks. The 'standard' system has to be by-passed in some cases (e.g. materials for SPED options require a manual intervention in the MRP system). Table 4.2 is a summary of the modifications that are made in some key infrastructural areas.

The differences between the processes by which materials and components are obtained, for SPED on the one hand and for standard products on the other, are also instructive. For many SPED options, it is common practice for the SPED Applications engineer to issue Pre-Order Details before the orders for other materials are generated in the normal way by the MRP run. This is to overcome long leadtimes for some SPED parts. Thus there are two parallel systems for obtaining materials and components. For the main stages in the process, these are contrasted in Table 4.3.

Table 4.3 Materials Procurement - Standard and SPED

Stage	Standard Parts	SPED Parts*	Comments
Technical Specification	Hyster-Yale Eng. U.S. or European	Hyster SPED Design	Liaison with SPED Apps.
Selection of Vendor	Hyster-Yale European Purchasing	Hyster SPED Design	SPED Usually one-off deal, technically- based,
Negotiating Price and Delivery Terms	Hyster-Yale European Purchasing	Plant Schedulers (usually little scope for negotiation.)	SPED die is cast: price penalty due to lack of purchasing power, time pressure, one vendor.
Scheduling Delivery	MAAPICS/ Plant Schedulers	SPED Apps via Pre-Order to Plant Schedulers	Messy system. Risk of withdrawal from order.
Controlling delivery	?	?	

* Not all require design work; not all have long leadtime

There are different priorities here. Standard parts are procured within long-term relationships, from a position of considerable buyer-strength due to the volumes involved. The planned nature of the procurement means that there is time to benefit from centralised procurement: i.e. specification and vendor-selection are either largely separate or conducted together within long-term joint-development relationships.

SPED parts are often purchased from a position of poor buyer-strength: the essentially technical basis for vendor selection (often indistinguishable from component specification) combined with the fact that purchasing time is usually short, means that the scheduler does little more than rubber-stamp a de facto deal already made between the SPED engineer and the vendor. Once the SPED part is defined, it is common practice to specify the vendor and part-number on the drawing so that, if the option is repeated, the same vendor will be used (usually in the same rush). Hyster become 'locked in' to repeating the same deal.

Were the SPED business a minor sideline, the rather crude adjustments made to the 'standard' infrastructure would not be a cause for concern. In view of the real importance of SPED though, the adjustments won't do.

4.9.4 Inter-Series Comparisons

The proportion of SPED trucks and the degree of modification varies considerably from series to series and, insofar as SPED and standard trucks cause conflict, so these conflicts are apparent between series having different typical levels of customisation. Thus, for example, the H6.00-7.00 XL series is largely a custom-designed series. In 1992, 321 of these trucks were ordered of which 207 were custom-designed to some degree. Furthermore, these tend to be heavily customised (in terms of SPED labour hours). On the other hand, only 111 of the 741 A1.00-1.50 XL trucks produced in 1992 were customised, and most of these only slightly so.

Some data were available for the Nijmegen plant and these showed that the proportion of SPED units in the (few) series produced there is high - typically over 70%. (No data were available as to the labour hours involved.) On this basis, it seems that the H6.00-7.00 XL series has much more in common with Nijmegen-made series than with others made at Irvine. Other factors e.g. common components, may weigh more heavily when it comes to determining the 'break point' for allocating series to plants; nonetheless the requirements of the H6.00-7.00 XL series does seem to be out of keeping with the *stated* low-cost, standard-product philosophy of the Irvine plant from a manufacturing task (Skinner, 1969) point-of-view. (In the feedback seminar this suggestion was well received and was apparently already being considered by European management.)

4.9.5 Technical and Business Decisions

There appears to be no mechanism for making decisions about which SPED orders to pursue and/or accept, and which to decline. The Sales and Administration

Manager's view that (in the current economic climate) 'No-one's walking away from business' is echoed in other comments. Noting also that dealers and sales people are paid commission on sales revenue leads to the conclusion that the role of SPED trucks is, for many, the same as that of custom-built trucks i.e. to fill capacity and generate sales revenue (and sales commission).

The SPED Applications Engineers exhibited something like nostalgia in the comments made about the days when 'we used to do anything'; it is notable that it was safety legislation rather than any thoughts of profitability that, at least to some degree, curtailed the scope of customisation efforts. Clearly, SPED Applications and SPED Design are aware of the need to limit the amount of custom-designed work but the only criterion for declining work explicitly mentioned was a shortage of SPED Design capacity - again, nothing to do with profitability. Also, whilst SPED Applications claim to dissuade customers from specifying non-standard options, it should be remembered that their jobs exist only to the extent that custom-designed work is required. Too much success in deterring customisation may prove damaging to engineers' employment prospects.

This slightly cynical view of the decision-making process notwithstanding, there probably isn't much information available that would prove useful to the Engineers in making decisions on anything other than on a technical or self-serving basis. As we have seen, the methods for costing SPED can be criticised on a number of grounds; in addition to that, conversations with engineers about individual contracts revealed some confused usage of terms like 'cost' and 'price'. The business rationale among individual engineers is informed by little more than the vague notion that 'SPED is supposed to be paying its way overall'. Any connection between an extra effort to customise a truck and subsequent order from the same customer for profitable standard business is lost because (a) the dealers obscure the customers to a greater or lesser extent and (b) because SPED engineers never have anything to do with custom-built trucks and wouldn't know even if subsequent orders rolled in, in keeping with the 'loss leader' theory. Overall then, there is little chance of the decision-makers understanding the business context of their technical decisions as they relate to particular customers or market segments.

One way forward might be for Hyster to adopt a much more explicit approach to making *business* decisions about SPED. This would be based on a cost-driver analysis, which would identify which aspects of the SPED work cause extra costs and which don't. This would be linked to a more explicit understanding of the role of SPED in each instance. At the moment, the apparent role of SPED is to keep the factory going - to fill capacity. The role of SPED should be to make money - either directly or indirectly. The most appropriate place to make these decisions would be at the Sales Quote stage. This would modify the Applications Engineer's task to take on a more overt business role.

Their technical study would determine what the ideal solution to the application is. This might be heavily, moderately or slightly customised and various proportions of existing design. (Identifying these parameters somewhat presumes the outcome of a cost-driver analysis, but it seems likely that these will be key drivers.) Decisions would then need to be made about pricing, prioritising design and manufacture, and the business risk involved in proposing designs that deviate from the ideal in that they avoid some or all of the custom-design work, but that satisfy most requirements.

Table 4.4 Decision-making for Design-cycle and Material-cycle SPED

SPED (value or labour has)	Little or No New Design	Heavy New Design
Slight	Use pricing or promised delivery date to encourage dealer to do SPED or ensure option is easy to do on main assembly. line. Volumes may play a part - several trucks to same SPED spec may be easier than one-off using standard options	Unlikely combination? Charging more directly for design time might be appropriate here.
Moderate	Key issue here is SPED capacity. Encourage early commitment to SPED design (via pricing?) so that SPED can be planned in and materials procured without any panics.	Attempt to move design toward Semi-standard line-of-business or territorial 'bundles' i.e. via price differentiation etc. so that Design requirement is reduced.
Heavy	Large demand on SPED Assy. Again, strongly encourage early commitment. Volume may help, but likely to be made on project basis.	Out-and-out SPECIAL. Policy depends on customer. If isolated purchase, charge realistically for design work. If major engineering feat, document and publicise to enhance Hyster technical image.

The different approaches for different situations might include those shown in Table 4.4. Pressure is required either to drive the cost down or the value up. Driving the cost down means moving either to the left or to the top in the matrix, the respective emphases on vertical or horizontal movement depending on the cost-driver analysis. Increasing value involves either securing a higher price for the particular order, or using the order as a lever, with the same or different customers, to secure other profitable orders i.e. ones that fit with the manufacturing strategy.

Such decisions are difficult, requiring a good understanding of the relationship with each customer, as well as the technical requirement of each application. It could only work if the sales commission structure were to reward what's best strategically, rather than simply rewarding sales revenue (as seems to be the case currently).

4.9.6 The Cost of SPED, The Value of SPED

Much of the preceding discussion has highlighted the various ways in which SPED makes extra or different demands on the plant. This section will attempt to draw some of these together and provide a framework for constructively considering what the cost and benefit of doing SPED business is.

The approach used is based on cost-drivers. Cost-drivers are the events that cause costs to be incurred. In that specifying a truck (any truck, but especially one involving SPED) is a sequence of options, many of these option-points are cost-drivers. Several cost-drivers particular to SPED trucks have already been described in the previous sections on organisation and manufacturing. A fuller, though far from comprehensive, list of SPED cost-drivers and the activities associated with them is given in Table 4.5.

Table 4.5 Cost-Driver Analysis of SPED Products

Cost Driver	Possible Activities
Customer wants SPED truck evaluated	- Dealer/Sales contacts SPED Apps. - SPED SQ raised - SPED application study done - SPED Design discussion - SPED customer visit - Quotes required for bought-in parts. - Labour estimate required.
Customer Orders SPED truck - all SPED options exist	- SPED order placed on Applications Eng. system - Existing SPED MLIs used to order material and bought-in parts requirements. - Pre-order details for any long leadtime items - Truck incorporated into production FAS
Customer orders SPED truck including some new option(s)	AS ABOVE plus: - Design job raised for each option. - Design work carried out. - Potential vendors identified, quotes received, vendor selected for bought-in parts. - Pre-orders raised for long leadtime parts. - Possible further discussion with SPED Apps. - Manuf. Eng. involvement with process design. - SPED Apps estimate - SPED labour for new option(s).
Specification changes during design phase	- Repeat relevant parts of above
Manufacturing: SPED truck with existing options	- SPED work planned in. - SPED Supervisor intervenes to arrange for pre-assembly SPED work. - Truck removed from main plant to SPED Workshop. - Superv. schedules labour. - Obtain drawings/ instructions. - Components obtained/made. - Fitting. - Truck returned to main plant. - Reintroduced into flowline. - Repairs of damaged paintwork etc.
SPED truck with new options	AS ABOVE plus - Make copies of new drawings etc.

These cost drivers are the most obvious ones and this list assumes, for the most part, that there is no need for any clarification of design, that materials are available on time, that no unforeseen problems arise, and that the work carried out is within the capability of any of the fitters available. It also does not attempt to describe the more complicated situation where trucks return to the SPED workshop a second time. A full analysis would need to be conducted with the involvement of those closest to the processes and decisions.

The main message of this analysis is that material and labour costs are a poor estimate of what the real costs of SPED are. More specifically, this type of analysis can shed light on which of the decision-points are most significant in incurring costs. The sort of questions that might arise out of a discussion structured around cost-drivers are:

- If a customer has to have some SPED, does it really make much difference whether it is one option or fifteen?
- What costs are avoided (and incurred) when minor SPED work is done on the main works line?
- What are the economies of scale associated with making several SPED trucks all to the same design?

The detailed analysis of cost drivers is good as an occasional exercise for enhancing understanding of the effects of certain decisions. For day-to-day purposes however, some slightly blunter instrument is needed. Recalling the previous discussions of SPED products in the context of standard ones in the product-range and of the processes involved in designing and making trucks, it is suggested that the cost-drivers can be 'bundled' in some way relevant to these major areas of impact.

From these previous comments it will be recalled that, nominally 'special' trucks vary both in the degree to which the particular special features they have are 'special' to an individual customer's requirements and in the number and cost-content of SPED options. Novel features place demands on design time; multiple options or options involving a great deal of assembly work place demands on labour. As such it is suggested that each SPED order might be conceptualised as in Figure 4.19:

		Number or Labour Content of Options: Low	Number or Labour Content of Options: High
Novelty of Options	All new	Low SPED	Manufacturing SPED
	All existing	Design SPED	Total SPED

Figure 4.19 A Typology of SPED Orders

A rough typology of the impact of each job on the plant can be used to guide priorities, especially if combined with the consideration of the role of SPED, which was discussed earlier.

The suggestion is not that the cost of SPED should always be passed on to the customer. However, it is suggested that clear understanding of the mechanisms by which costs are incurred and an explicit quantification of these costs will enable better-informed business decisions to be made, taking into account the role of SPED for a particular contract or series.

One rather more immediate observation is that it is not altogether clear that a consistent use of the cost data that do exist is made within the firm. The SPED pc-based information system gives something termed the 'NETT PRICE' which, based on a few comparisons with quotes given for bought-in items, seems to be the cost to Hyster of the option. The total of these 'NETT PRICES' is then termed the 'TOTAL VALUE'. Detailed analysis of a few individual contracts indicates that there are also, on some occasions, significant deviations from vendors' quoted prices for bought-in items and the cost eventually incurred by Hyster. It is not clear how, and by whom, the 'SPED Price List' is to be used (simply due to lack of research time rather than any confusion at Hyster): however, it seems dangerous to compile a list of 'prices' when the basis of understanding of costs is apparently shaky. The assumption seem to be either that these are the components of prices to be charged to the customer or that there is a generally-applicable margin to be added on to this, which is, after all, usually the price to the dealer.

The overall argument here is that pricing can be used tactically by the factory to refocus its manufacturing strategy. The costing approach adopted will depend on the strategic value of particular lines of business - SPED/Standard, Dealer/Direct sales etc - and that such pricing policy can only be implemented with a rather clearer approach to identifying the costs of supporting these lines of business.

Chapter 5

Honeywell Control Systems Ltd

5.1 Introduction

Honeywell Control Systems Ltd is a division of the Honeywell Corporation, which has international interests in industries related to control systems. This case-study was carried out at the company's UK manufacturing plant at Newhouse, Scotland.

5.1.1 Company Background

The firm operates in a large range of business areas, spanning multi-million pound control systems for chemical works, replacement limit-switches for machine-tool safety guards and microswitches selling for a few pence to OEMs for incorporation into domestic appliances. During the 1980s in particular, the firm diversified out of its original core switching business into computers and other very diverse activities. With the business climate worsening in the late 1980's, there has been a certain amount of retrenchment into core businesses e.g. divestment of Honeywell-Bull computers. Honeywell was described by one of its senior managers as 'a multinational company trying to become global'. The common theme among the business areas in which the firm currently operates is control. The slogan on Honeywell's advertisements of the period was 'Helping you control your world'. Traditionally, Honeywell has been an engineering-based company, according to one senior manager at Newhouse, but has tried to temper that with a customer focus. In the USA, this is manifested organisationally by the following product divisions: Home and Building Control, Space and Aviation, and Industrial. Each division has its own research, marketing, manufacturing and sales activities. Within the Industrial product division there is an Industrial Components sub-division, which is of particular relevance to the present research. The structure of the international organisation is shown in Figure 5.1.

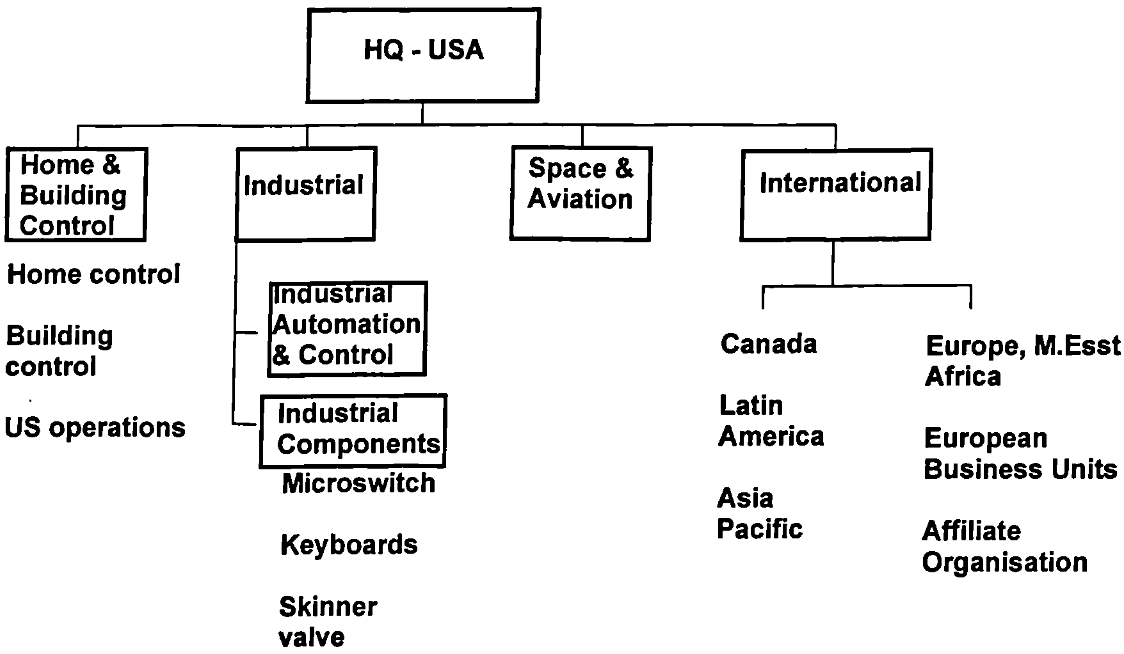


Figure 5.1 Honeywell International Organisation Structure

In Europe, the organisational response takes a different form. Rather than having product divisions with responsibility for all activities associated with their respective products, the research, marketing, engineering and production activities are separated from sales. The non-sales activities are organised into the same business units as exist in the US, with the exception that Control Components constitute a separate division rather than merely a part of the Industrial division. This is shown in Figure 5. 2. Sales within the territory are carried out by a separate 'Affiliate' organisation which is organised on geographic lines. There are three sales areas, as shown in Figure 5.2. Thus, product-based business units effectively 'sell' products internally to the geographically-based affiliates.

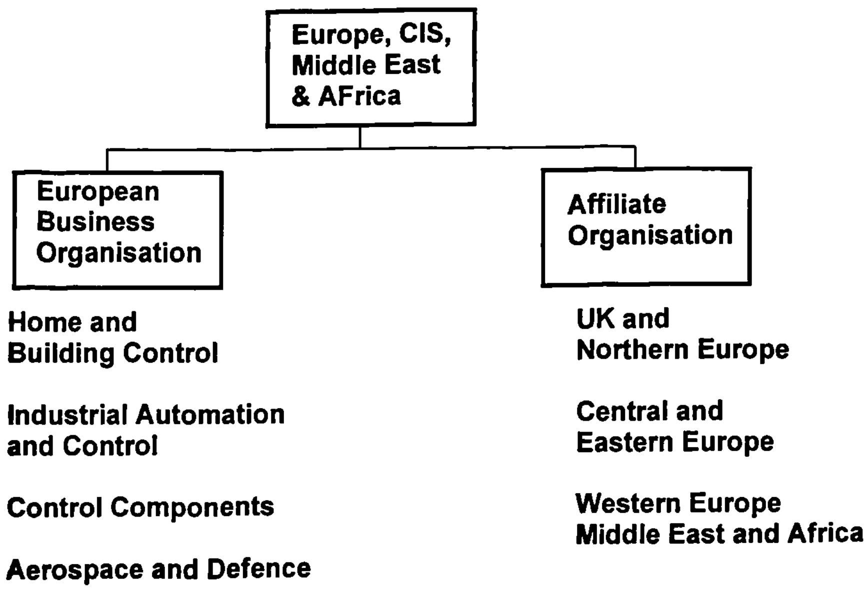


Figure 5.2 Honeywell European Organisation

5.1.2 The Newhouse Site

The Newhouse site accommodates three principal business activities. It is the firm's only UK manufacturing plant. It is also the location of the Centre of Excellence for

Control Components and the Residential Business Unit (for Home and Building Controls), each of which comprise marketing and engineering staff for their respective product-groups. This combination of marketing and engineering with associated manufacturing is continued throughout Europe and throughout the product divisions. Twelve locations in six European countries provide foci for different parts of the business. This is summarised in matrix form in Figure 5.3. From this it will be noted that three other sites, two in Switzerland and one in France, are involved in the Control Components Division. The division's headquarters are in Switzerland.

The Newhouse 'mission' was characterised by the General Manager of the Microswitch Centre of Excellence (C.o.E.) as being centred on electromechanical devices, with some involvement in solid state products. As Figure 5.3 shows, other locations within the division specialise according to component technology. The present research concentrates on particular aspects of the Control Components business, rather than the Residential Business Unit.

The Newhouse manufacturing operation has contracted a great deal in the past ten years or so. Much of this contraction was due to a narrowing of the range of activities i.e. subcontracting of many operations previously undertaken within the plant. Most control components consist of a switch or switches and such ancillary parts as housings and actuators. Whereas previously Honeywell manufactured many of the ancillary parts using extensive machining, die-casting, fabrication and similar processes, there is now much greater emphasis on manufacture of basic switches and final assembly.

Country	Site	European Business Unit (HQ in Belgium)			
		Home & Building Controls	**Industrial Automation & Control**	**Control Components**	**Aerospace and Defense**
Germany	1				Aerospace & Defense
	2				Marine Systems and Sonar
	3	**Division HQ**			**Division HQ**
	4	Building Systems CoE			
	5	Building Products CoE.; Home Control Products & Systems			
Netherlands	1	Combustion Controls CoE			
Scotland (Newhouse)	1	Home Comfort Control Products		Proximity Controls, Switches and Sensors	
Belgium	1		**Division HQ** Process Automation Control Centre		
Switzerland	1			**Division HQ** Pneumatic and fluid transfer valves	
	2			Proximity Controls	
France	1		European Factory Automation Centre		
	2			Switches and safetybarriers; Photoelec-tronics	

Figure 5.3 Manufacturing and Technology Activities in Europe

The plant has embraced many changes in the way it works alongside this reversion to core businesses. Notable on the shop-floor is the presence of manufacturing cells for assembly processes and a growing number of areas demarcated for direct delivery, to the shopfloor, of components from vendors. The shopfloor is divided into areas for (a) production of various basic switches and (b) assembly of various control component types. There is also a small injection-moulding facility where some ancillary parts for Home Control products are produced.

5.1.3 An Outline of Control Components Products

It is useful at this stage to identify in the very broadest terms the groups of products that comprise the Control Components range. These are shown in Table 5.1. Products in the groups use a variety of basic technologies. The oldest basic technology is the electromechanical limit switch, applied to all three groups. The newer technology that is being incorporated into components is solid-state.

Table 5.1 Microswitch Product Groups

Group	***Indicative Applications***
Domestic	Domestic appliances and automotive applications
Industrial	Machine-tools
AOM*	Civil and military aircraft, marine and rail transport

* Aerospace, Ordnance and Marine -
(later ATOM - Aerospace, Transport, Ordnance and Marine)

5.1.4 Context of the Study

The project described here began in July 1992. The first point of contact was the General Manager of the Microswitch Centre of Excellence, who championed the project from the outset. His responsibility covered marketing and engineering for Control Components in the three main product areas. The concern of the research with product-range and product customisation made a particular group of AOM products suitable as a subject for study. This served to narrow down the scope of the research to something manageable and to direct it toward a current concern of the firm. The group of products, the EN series of limit switches, involved a large amount of design and development work to support very low-volume customised products. A diagram of a typical switch is shown in Figure 5.4, and the overall height of such products is about 50-60mm. Whilst the general perception was that these were profitable products, there was at the same time a feeling that the degree of customisation was out of hand. There had also been some recent, high-profile cases of missed deliveries and quality problems.

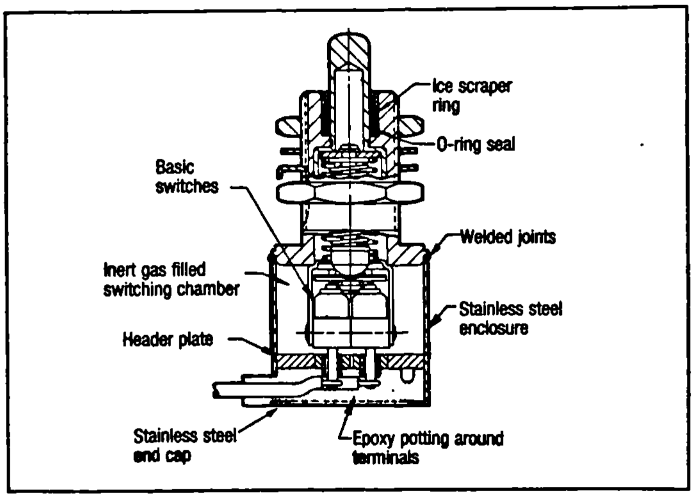


Figure 5.4 An EN Limit Switch

5.1.5 Research Process

The research began with an interview with the General Manager, who set the context of the work and indicated the key contacts. Thereafter, the work was coordinated through the Product Marketing Manager and interviews were conducted with the Product Manager, Manufacturing Manager, Engineering Manager, Design and Manufacturing Engineers, Production Control & Customer Services Manager, amongst others. After initial interviews, a good level of access was possible, particularly for the retrieval of documentary material. To begin with, the scope was quite broad, taking in AOM and EN products in total. After that, a few individual sales contracts were examined in detail.

At the time the research began, there was no intent to carry out a study with an explicitly longitudinal aspect, except insofar as historical trends of product sales, manufacturing process and organisational changes and the like could be determined from documentary evidence and interviews and then be used to put the present into context. However, in the event, the work was undertaken intermittently between July 1992 and late 1994, with the bulk of the work being carried out in the first six months.

There are a number of reasons for this extended contact with the firm. First of all, successive prime contacts were either moved or absent for long periods. Secondly, a programme of redundancies and restructuring took place and at various stages it was judged politically inappropriate to visit the site. Although in some respects these events disrupted the research, they also constitute rich contextual data that add to the case. Much of the quantitative data that follow in the rest of the chapter relate to mid-1992 or (in the instance of the historical data), periods of varying lengths leading up to then. The data relating to the organisational context, however, cover two years either side of the period of intensive research and, in retrospect, add many insights. With the benefit of hindsight, it becomes clear that the research was carried out in the middle of a very turbulent time for the very business being examined.

In the account that follows, the emphasis will be very much on how the business and people's perceptions of it were in mid 1992. However, where relevant to each section of the account, longitudinal observations will be introduced.

5.2 Strategy Statements

In such a diverse business as this, and especially bearing in mind the concern here with operations, it is necessary to concentrate on strategies of a more local scale. The Strategy of the Control Components Unit was set out in a short document presented by the General Manager at the first interview.

5.2.1 Control Components Strategy

The overall mission and goals of the Control Components business were:

- to be the leading supplier of electromechanical and solid-state sensors in Europe;
- to maintain revenue and profit in electromechanical and to grow in solid-state.

Quantified, the planned growth of revenue overall was:

1992	1993	1994
20%	7.3%	9.1%

Halfway through 1992, results were such that the actual growth estimated for the year was 4.3%. The profit objective (based on internal transfer-pricing) was to halve a 1991 loss of £1.1m, but it was estimated that, by the year end, this would increase to a loss of £1.8m.

A summary of the characteristics of the market segments indicates that the markets for basic electromechanical switches and AOM are 'flat or declining'. High growth areas are in the automotive, appliance, commercial aerospace and industrial automation areas. From this, key strategic issues identified were:

- increasing price competition
- 80% of product portfolio in mature/ageing markets
- low involvement with SME OEMs in industrial market
- globalisation of OEMs in appliance
- transferable technology: mobile, appliance, aerospace
- broad technology base to be converted into products.

Additional competitive advantages were identified as world class design & manufacture and the firm's distribution infrastructure. The resultant strategies identified include market penetration for both appliance and mobile markets, and 'invest to hold and maintain' in both AOM and Industrial.

These broad strategies are translated into implementation approaches, product-group by product-group. These are mostly expressed in individual product terms, but for AOM there are statements of intent to forward integrate switches/actuators, cost reduce the EN switch range and invest in New Product Development.

In contrast to the differentiated nature of the implementation approaches - differentiated as they are at product-group level - the same broad manufacturing and related measures are indicated for all product-groups. These are re-examination of make-or-buy decisions; the implementation of 'World Class Design', 'World Class Manufacturing', and Supply Chain Management; and the use of Total Quality Management, more specifically expressed as waste elimination, time compression and elimination of barriers to implementation.

A 'Summary of strategic tasks' includes:

- Increase product launch rate
- balance investment - e.g. long term growth in industrial vs cost reduction in AOM
- key account management
- strengthen marketing - research and communications; business development
- leverage engineering resource - reduce time-to-market

A 'Product Strategy' is given separate coverage but relates little to the AOM products. More generally it sees the technology being developed through its use in appliance products. There is also a general comment that Honeywell will 'provide systems capability', which presumably means a move toward forward integration.

Finally, Product Marketing is given particular attention (this is to be understood as relating to the Honeywell department/group of that name as well as (or instead of) a more general usage of the term). Points to note here are:

- in-depth understanding of vertical markets;
- management of the product life-cycle;
- focus on service and added value: supply-chain, technology, forward integration;
- provide flexible applications/product specialist support;
- assist in implementation of distribution channel.

All these are taken as general emphases for the Product Marketing function across all three major markets (Commercial, Industrial, AOM).

5.2.2 Marketing Communications

Within this brief review of marketing communications there will be a concentration on those documentary sources available at the time of the study. These comprise two basic types: general public relations material such as magazines for dealers and so on; and catalogues for specific product lines.

In two copies of the Honeywell Business Review (a UK publication), a vast range of areas of activity are described in advertisements and features: oil refineries, industrial heating and ventilation, IT cabling, domestic heating, and avionics, to name a few. Pervasiveness is a key theme.

Simple brochures describing particular product lines begin to develop market-specific emphases, but also illustrate more pervasive themes. From a brochure on domestic appliance switches (directed at appliance OEMs):

'....we at Honeywell MICROSWITCH have set an important mission for ourselves: to work with you to develop switching and sensing solutions that help you satisfy your customer's expectations.

As the world's leader in electromechanical switches and solid-state sensors, we can offer you one of the industry's broadest selections for your applications. In combination with this portfolio, our experience with your industry has given us a strong understanding of the unique issues you face. We understand the importance of providing you with affordable quality, delivered on time throughout the world.

Through a long-term partnership, we can help you deliver what your customer wants and help you remain competitive in the global marketplace.'

The brochure then outlines various issues of product technology and quality, on a number of pages whose margins are decorated with pictures of forty or so different switches and sensors. In what is by no means a catalogue of the range, Honeywell are nonetheless making a strong visual statement about breadth of product range in this segment.

From the brochure outlining one of the AOM areas, Marine, more specific and general themes emerge:

'Honeywell is one of the world's leading manufacturers of control

components and offers the most comprehensive range of sensors and actuators to the marine market. For over forty years, Honeywell has worked with customers to develop products which meet the unique needs of the industry.

For example, no other manufacturer can match Honeywell's selection of electromechanical switches for control and positioning applications. Whatever your operating or housing requirements, Honeywell can provide the best solution......

.......If an off-the-shelf product is not available, Honeywell specialises in custom designs to meet specific needs.'

Again, the brochure pages are embellished with illustrations of a variety of switches.

Moving on from general introductory brochures, more detailed information is contained in the product catalogue, which gives full technical information of the type required by, for example, design engineers wishing to select switches for an application. There are many catalogues, covering different product lines and application areas. The variety of products offered in these catalogues, particularly that of the AOM/EN products, is discussed at some length later on. The introductory notes will suffice at this stage. From the general limit switch catalogue (industrial):

'Automated production allows the flexibility to meet customer demands, supplying switches in batches ranging from 1 up to 100 000. Honeywell also specialises in custom manufacture and is constantly working with customers to find solutions to the most demanding application problems.'

From the AOM catalogue general introduction:

'A very important Honeywell service is custom design. This can vary from simple changes in flying lead length to complete product and purpose designed assemblies.'

And from the same catalogue's section on 'Panels':

'Honeywell has the capability to design, develop and manufacture complete switch panels for a variety of aerospace, ordnance and marine applications. The panels can be manufactured to customer's specification or custom-designed for the application by Honeywell.'

This sample of written marketing communication shows the emphasis placed by Honeywell on the breadth of its involvement in various industries, the breadth of particular product-ranges, and the company's willingness and ability to make customised products.

5.3 The AOM Market

The characteristics of the AOM market are unique and rapidly changing. Products are principally found on aircraft, both military and non-military, and on other arduous military and marine applications. There are a very small number of customers and historically a good deal of the business was with government departments or their subcontractors. For these products, the firm is thus acting as sub- or sub-sub-contractor to manufacturers working in a large contract, project management environment. The overall contract is often of very high value and is frequently subject to long negotiations before a contract is awarded. Once awarded, time has been of paramount concern in a very sheltered supplier community, but is now combined with other concerns e.g. price. This is particularly the case where cost-plus contracts have been replaced by fixed-price ones.

The UK market has also evolved in a particular way by virtue of having been technically constrained by British Standards and other non-tariff barriers e.g. of a political and diplomatic nature, particularly during the Cold War. Overseas competition has been low and this has strongly influenced the technical direction taken by designs. Whilst the UK customer base has remained separate from those of other European countries, Honeywell's UK AOM business has been relatively self-contained. Meanwhile, Honeywell's US operation has supplied products - often very similar to those made in the UK - conforming to US MIL-specs to European contractors. Having moved to a much more Europe-wide perspective, Honeywell in Europe now finds itself with many practically-duplicated products, one conforming to old British Standard and the other to US military-based specifications.

The role of the switch in many of these products also has implications. Usually forming a small part of a large whole, the switch will exist for a long time as an outline concept. Contractors' designers concentrate on the bigger design decisions first, and only design small details like switches later on. (To quote the Product Manager, 'the switch is the last thing to be designed.') This means that most of the constraints are imposed in advance and heightens the likelihood of switch customisation - the switch is designed around the contractor's product rather than *vice versa*. Also, this means that there is less time than might have been the case for Honeywell to detail a design and produce a prototype.

Having said that, whilst there is urgency in some senses and at some stages of the process - for example, to provide prototypes once the switch design *is* available - other aspects of the process are very protracted. Notable here is the usually long interval between the bid being made, which usually involves working up a detail design, if not a prototype switch, and the eventual shipment of products. In financial terms, this sees Honeywell making significant outlays in terms of design engineers' time and the production of prototypes, only to wait two or three years before any revenue is forthcoming. Although by Components division standards the unit prices are very high at over £100 per switch, volumes are minute (a few hundreds of any one variant in its whole life cycle). Even small reductions in the total volume required of any one switch can upset a delicate balance between the initial pricing and the total cost over the life-cycle.

The delay between bid and shipment is just one aspect of the protracted nature of contracts in the AOM business. Most projects will have a relatively short build period of a few years (if that) and then will be in the field, in service for many years. The nature of the business then shifts from supplying the contractor for a scheduled build programme to supplying either the contractor or the user with spares, perhaps for twenty years or more. Although volumes are never high, clearly the pattern of demand changes. The Product Marketing Manager described the market as very volatile and unpredictable in this respect, and characterised the firm's idealised approach as 'to minimise up-front work to achieve requirements' to be achieved by 'explicit training and investment to have "match-fit" engineering capability'. The risks associated with this are heightened by the move away from cost-plus pricing and the need for 'good bids' - i.e. ones that lead to profitable business - is increasingly emphasised.

Although the industries served have often been at the forefront of quality systems and safety and reliability considerations, recent developments have raised the standards to a great extent and in a relatively short space of time. Against a general background of more demanding product liability legislation, the industry is, according to the Product Marketing Manager, much more concerned about the technical demands on the product and what that means in respect of the legislation. In various ways, risk awareness is increasing and the potential supplier - Honeywell for example - will incur more cost 'to qualify technically'. Practical manifestations of this include the much more detailed written specifications and tender documents and extremely demanding requirements for product traceability. At the time of the research, a major contractor to whom a bid had been made was applying a great deal of pressure in the latter area in particular and, by the admission of the Product Manager, the necessary systems were not in place. As the Product Manager commented: 'That would involve developing a [traceability] system and a product at the same time, and you can't do that'.

For the reasons outlined above, many AOM markets are becoming increasingly open to international competition. The main new competitor has traditionally been strong in industrial and commercial applications, where lower specifications in terms of durability and protection against environmental attack, compared to AOM, are normal. Whilst there are markets where the high degree of protection is essential, there may well be some AOM segments where specifications (and prices) more in keeping with those of industrial and commercial markets are perfectly acceptable. In this way then, some Honeywell AOM products may be over-specified and over-priced.

The future of the AOM market was seen by the Product Marketing Manager as being in civil aviation, due to the worldwide reduction in defence spending. The products based on electromechanical technology will give way to silicon-based sensing, although the US division have invested relatively recently in production facilities for the electromechanical products.

5.4 Honeywell Operations - AOM Products

As discussed, the relationships between the various Honeywell divisions and functions are very complex. So as to avoid unnecessary confusion then, the emphasis here is on those functions located at Newhouse and those functions located elsewhere with a specific bearing on AOM business. After a brief overview of the organisation structure, a number of key business functions will be described in terms both of their organisation and of their processes. Where relevant, significant changes that have taken place during the course of the research will also be described.

5.4.1 Organisation Overview

The Scottish Operations are divided along a combination of product and functional lines. Marketing and design activities are grouped along product lines: thus there are separate marketing and design departments for Home Controls and Microswitch respectively. Production and associated functions for all the products come under one Director of Operations. Support functions - e.g. HRM and Quality Management - for the whole plant are then grouped under relevant managers. A chart of Scottish operations is shown in Figure 5.5 and this represents the structure in mid-1992. Under the Microswitch COE (Centre of Excellence) General Manager then, most activities are ostensibly organised along functional lines. There is Production Control for all products, Design Engineering for all products, and so on. Of particular interest here are the Product Marketing and Design functions. The CoE structure is shown in

Figure 5.6.

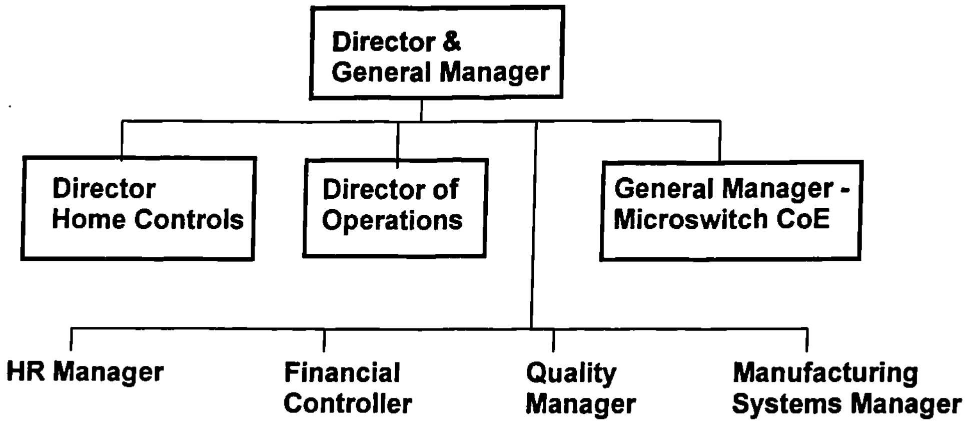


Figure 5.5 Newhouse Site - Organisation

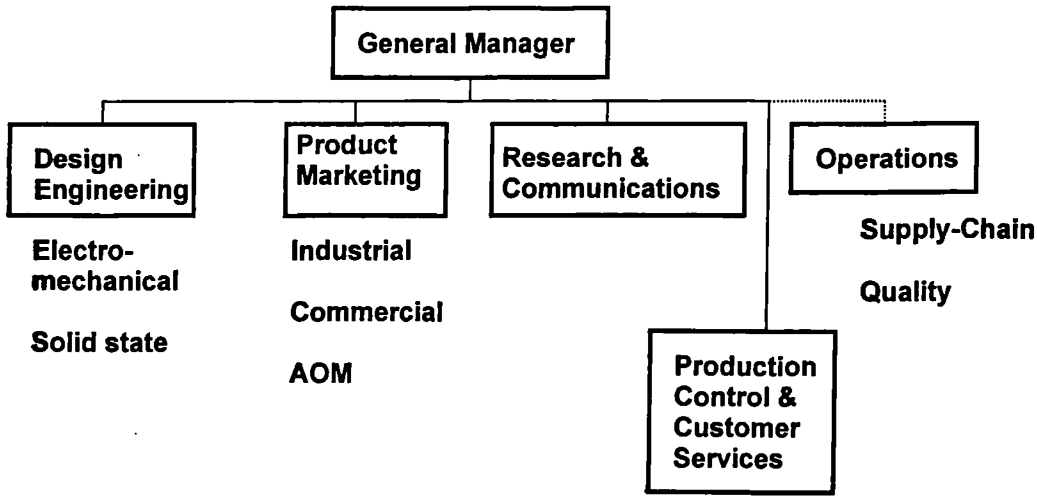


Figure 5.6 Microswitch Centre of Excellence Organisation

Product Marketing is divided according to the product groups Commercial, Industrial and AOM, with each of these areas headed by a Product Manager. Within the Design group, the sections involved in product design are the solid state and electro-mechanical sections. These specialise according to product technology rather than market. Also located in the same open-plan office, although reporting to manufacturing support management, are the Manufacturing Systems Engineers associated with the COE's products.

5.4.2 Sales

As shown earlier, the three Sales Affiliate groups are:

UK and Northern Europe,

Central and Eastern Europe,

Western Europe, Middle East and Africa.

The extent of coverage varies across territories and so, consequently, does the degree of specialisation of sales staff. In the UK for example, there are 18 branch offices and engineers can specialise in particular product/market areas; in Sweden, there are three offices and hence engineers are required to cover all the product ranges. The relatively loose formal link between affiliates and manufacturing means that affiliates are at liberty to buy components from any Honeywell plant worldwide in those cases where products are made in more than one plant.

5.4.3 Marketing and Design

These two functions are discussed together here because, for a number of reasons, the boundaries between them are rather blurred. They constitute the principal activities of the CoE. The concerns of this project require a more detailed discussion of how the Product Management and Design groups are organised, how projects are carried out, as well as further description of the AOM Product Manager's role. These are the subjects of the next three sections.

5.4.3.1 Bringing AOM Products to Market - Design and Product Management Interaction

The conception and development of an entirely new series is carried out by cross functional teams using a simultaneous engineering approach, according to the Engineering Manager. These teams involve not only design and marketing but also procurement, manufacturing and other functions. This had apparently been the approach for a recent project in the Commercial product group.

As the present research centred on the AOM product group and EN products in particular, it is the design process for those products that needs to be understood in some detail. EN products were described by the CoE General Manager as 'mature', having existed for over 30 years, according to one estimate given. In the opinion of the General Manager, one of the firm's great failings was, during the 1980's, to neglect new product development with the result that, in the early 1990's, the product range across all the groups is largely comprised of mature products, with 'little coming through in the way of "Stars"'. The current preoccupation then is to 'spin out the life cycles of mature or declining products whilst rapidly bringing on new technologies'. This applies to AOM products more than any, and the 'spinning out' of AOM life-cycles results in customising existing products to suit new applications. The Engineering Manager described the EN products as 'customised beyond recognition'.

The design process for AOM products then, is typically one of reactive customisation. It is carried out in a more sequential way, within a matrix structure whose principal constituents are the design groups specialising by technology (solid state, electromechanical etc) and the product managers specialising by product type (AOM etc). Design Engineers' time is allocated to projects by a process of negotiation between design section supervisors and the Product Managers.

Design work on EN products is invariably initiated by the customer and the Honeywell affiliate sales engineer, using a 'Sales Project' request. The term 'SP' is used throughout the firm to identify these projects but it is interesting to note that the form used is headed 'Sales Project data sheet: modification request'. The Engineering Manager, who had had responsibility for this design work only since early 1992 (less than a year before the research work began), explained that, up until then, there existed a 'Small Changes Group' (including most of the individuals now involved in design). The scope of this group's work in theory only extended to engineering changes that did not affect 'form, fit or function'. Whether this had ever been the case is difficult to say but, whether in the guise of the Small Changes Group or as a section of the Engineering Department, the engineers had clearly been accustomed to changing form, fit and function, often very significantly, for a long time.

5.4.3.2 A.O.M. Sales Projects

Despite the elegant concept of the matrix structure, in reality all AOM products used electromechanical technology and so all AOM design was done by the electromechanical section. Furthermore, one long-serving design draughtsman from the section did all the AOM work. He designed the switches, visited customers, chased parts, had prototypes made and tested, and released drawings. At the time the research began, there was concern that, successful as he was in coming up with a prototype switch that worked, he was something of a law unto himself and by his own admission, found the prevailing shift toward heavily detailed written specifications, traceability and documentation rather difficult.

A recent attempt to define the process more systematically had resulted in a flowchart of which a simplified version is shown in Figure 5.7. The stages shown in bold boxes were all identified as the responsibility of the one draughtsman. The process begins with the submission to the Product Manager of the SP Form. An internal report on SP activity indicated that SPs usually emerge gradually from discussions between Sales Engineers and customers and that it is difficult to identify when a 'technical enquiry' becomes a Sales Project. Furthermore, and for various reasons, the field sales engineer may delay submission of an SP even though the requirements have been established. The SP form requires a good deal of information from the sales engineer. There is 'Field Input', which comprises basic details of the date, customer, application and technical requirements of the switch. Included in these are sections asking 'Product Same as....', '......Except for....', i.e. the form is designed for modification of existing products. The second main section of the form comprises 'Sales/Business Data'. Included here are projected volumes for the first three years, target prices for certain volumes, and details of competition. Finally, 'Action/Response Required' indicates what the affiliate wants from the Product Manager - prices, samples, drawings - and in each case, when.

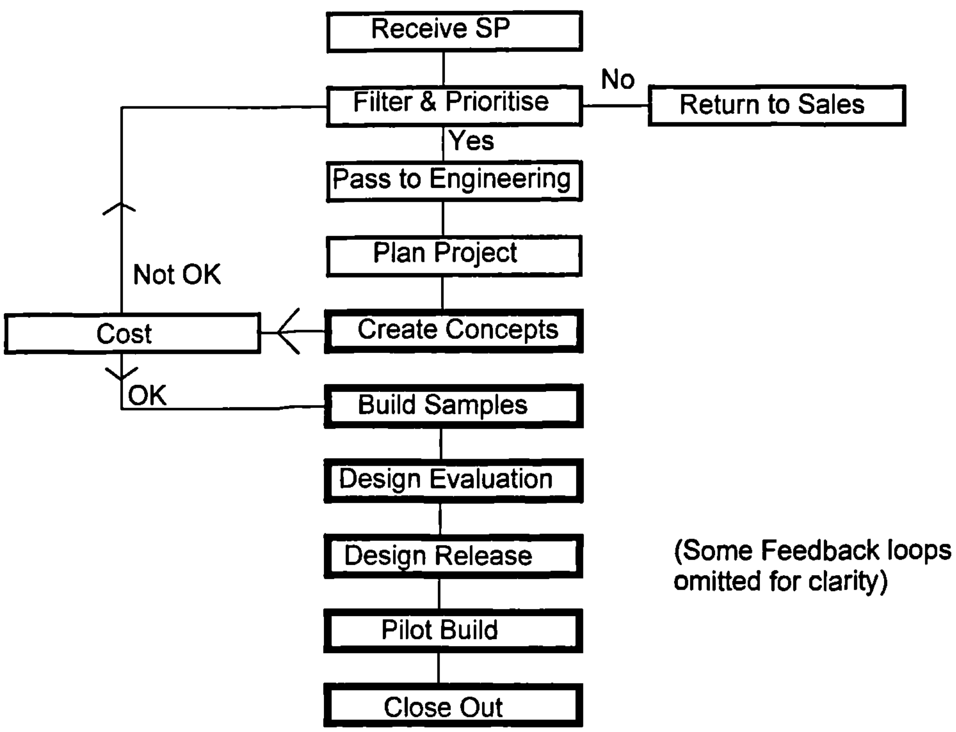


Figure 5.7 The AOM Sales Project Process

Given this information (or a small proportion of it, judging by some SPs seen) the Product Manager has to decide what to do with the SP and allocate resources accordingly. This stage is indicated on the flowchart as 'filtering', carried out by the Product Manager and Design Engineering Supervisor. The AOM Product Manager saw this process of filtering as testing the SP against the following criteria:

Does it fit the strategy?

Is it a customer we want to deal with?

Is it a market we wish to be in?

Is it derived from the catalogue?

It is also necessary to estimate revenues and 'balance' the engineering costs against the eventual contribution of the product once sales begin. This was conceptualised by a number of people in terms of a cashflow curve showing negative cashflow as money is spent on design followed by subsequent positive cashflow as sales take place (Figure 5.8) The idea of attempting to quantify the design cost was, according to the Product Manager, a relatively new one ('This hasn't been done before'). Aside from these more explicit questions, there is also a role for 'gut feel' as to which business to take on.

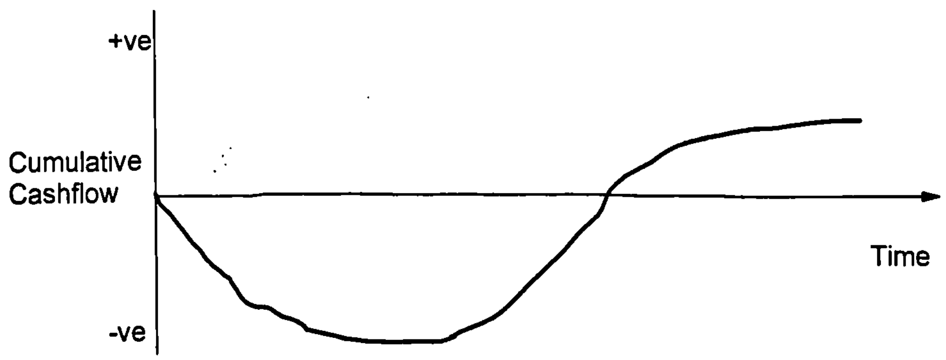


Figure 5.8 AOM Sales Project - Notional Cash-flow

A small study had been carried out on SP activity in recent years. The number of SPs was relatively small, as shown in Table 5.2. 'Successful' in this instance means that an order of some sort was placed, although this could mean only a prototype or pre-production order i.e. there is no information on whether production volumes, as projected or otherwise, were ordered.

Table 5.2 AOM Sales Projects - Recent Activity Levels

	1988	***1989***	***1990***
Number of SPs	57	52	45
Number successful	23	23	16
% successful	40%	44%	36%

The action required as a result of the SPs varies: it could be only a verbal quotation or concept drawing or it could be a firm price, design of tooling and supply of prototypes. The study showed that in 1990, response to SPs - in the form of an initial drawing - was achieved as follows:

65% within 4 weeks of SP

95% within 6 weeks of SP

Prototypes were 'typically' delivered 6-8 months after the *final* technical offer.

The Purchasing Agent most involved at this stage of AOM SPs confirmed that a quick response at the outset was necessary to be able to give a quoted price. He contrasted this with subsequent delays - 'The project may then lie dormant for a year or more'. The AOM Product Manager went further than this, commenting that there are some big investments before any orders are placed and that the lag (between design and orders) may be years. Citing a recent example, he recalled how tight the time pressures had been and that, as a result, risks had been heightened by 'cutting corners on the estimating'. Summing the situation up, he commented that 'all the risks are at Newhouse' - by implication suggesting that none of the risks are with the sales affiliates.

Another source of risk is that the financial 'balance' referred to earlier hinges on the sales volume over which one-off design and tooling costs may be amortised. In a business where any one product may sell only a few hundred units ever (and many of those over ten years into the future), a subsequent adjustment in volumes may make the difference between profit and loss for the project overall. Having made this comment however, the AOM Product Manager also pointed out that there is no information system by which an individual SP and sales subsequently resulting from it could be linked.

5.4.3.3 The Role of the Product Manager

The AOM Product Manager described himself as a link or 'window' between Newhouse and European and US Marketing. His principal concerns are, in his own terms, monitoring the Newhouse AOM business, in terms of volumes, revenues and contributions, as well as monitoring revenues resulting from various markets. In doing this, he noted the fundamental importance of transfer pricing and the high degree to which this is a matter of internal politics.

The Sales force in the UK included five or six dedicated to AOM sales, all of whom were from an engineering background. In each of the other European affiliates, one or two salespeople dealt in AOM products, sometimes exclusively, sometimes in combination with other product groups. He was keen to emphasise the technical nature of the products and markets (he himself was formerly a design engineer). Based at Newhouse, his estimate was that 20% of his time was spent 'on the road' - making affiliate and customer visits. These would be variously associated with development of target accounts and assisting with sales projects, potential or actual.

Turning to the activities at Newhouse, he described himself as sometimes feeling like a 'super-expediter'. As first point of contact for customers and sales affiliates for anything to do with AOM products, enquiries were wide-ranging. As described, during the course of the research, key design staff were made redundant and, as a result of this, the Product management role was increasingly drawn into detailed technical issues. Although some contract design staff were subsequently employed, these lacked the product knowledge required to work independently and had to seek technical advice from various sources, principally the Product Manager. Previously, there had been a weekly AOM Meeting, involving various functions, but this had lapsed. There was, as the research drew to a close, talk of reinstating these meetings.

Contrasting his position with that of his opposite number in the USA, he pointed out that in respect of product variety, whereas in the USA the problem is one of managing 1200 parts going into 250 end-products, here it is 1300 parts going into 700 end-products.

A recurring theme of discussions was the lack of information systems: 'We need a forum'; 'There's no summary information at a meaningful level [of detail]'; 'an information system is needed whereby all the detail is condensed into a brief chronology and the main business issues on one sheet of paper'. Then, commenting on a particularly problematic SP: 'We don't have a forum. There's a ten-minute meeting where people agree "we must do better" and then everyone goes away and does it again'. Other systems were also felt to be a weakness, for example procedures for tracing materials and components back to source. A current example was a project for a large UK contractor to whom it had been necessary for Honeywell to send their Sales Director, Engineering Manager and Control Components General Manager in an attempt to convince the contractor that Honeywell could assure quality. The Product Manager's reaction to the rapid systems development this implied was 'We can be 10 or even 20% smarter, but not 300%'.

This kind of pressure to improve systems had come at a time when the design engineering resource had been removed and so, just when there was a greater need to step back from day-to-day technical details and work on systems improvement, he had more detailed demands placed on him. In addition to that, a restructuring in January 1993 saw the AOM Business become separated from the other components businesses at a higher level i.e. rather than reporting to a Components Product Marketing Manager , the Product Managers for each product group reported to a business unit manager specific to the product group. The AOM business unit manager was located in Brussels, leaving the AOM Product Manager in Newhouse with less assistance from 'below' in the form of technical design assistance, and without (local) support from 'above' in the form of a Marketing Manager.

At June 1993, the Product Manager summed up his position as 'trying to cover many markets and many products'. Contract design staff were being brought in, funded by the customer, but only once the order was placed. As already discussed, there is a good deal of work to be done before an order is placed, and the original design study is 'done by scurrying around for whatever staff are available' and, by virtue of being done under these circumstances, may expose Honeywell to problems later on. There is also little prospect of continuity between study and final design if different staff are involved at each stage.

Another notable concern is the respective role of the US and European plants and organisations. The European and US markets for EN products are broadly the same as each other in terms of volume and revenue. However, the production volumes at the US plant are around 150 000 units per annum, or about ten times those of Newhouse. This results in lower unit costs to the USA and hence, as the Product manager noted in an internal memo in 'European affiliates tend to direct their "general sales" EN business straight to [the USA]'.

There is a note of envy in the description of the US AOM business, where Manufacturing, Marketing and Sales all report to one business unit manager and 'the strategies are all lined up .... it's one big machine'. Salespeople in the US concentrate on particular lines of business *within* AOM, compared to the UK where salespeople cover all of AOM, or in some parts of continental Europe where salespeople try to cover all product groups - AOM, Industrial and Commercial.

This contrasts with the 'fragmented' organisation in Europe, where affiliates are able to 'play off' UK and US factories against one another. The affiliates want 'faster response, lower prices, new products' whilst the factory wants 'more business (of the business we want), standard products and forecasting'.

5.4.4 Manufacturing and Procurement

This section adds more detail to the description of Newhouse Operations. Beginning with a brief overview of the organisation, it then places the Newhouse manufacturing plant into the context of the broader supply network. The Newhouse manufacturing activities are then described and their performance reviewed.

5.4.4.1 Organisation and Overview

The organisation of Manufacturing at Newhouse is shown in Figure 5.9. The structure is quite 'flat', with the managers reporting to the Operations Director and their own immediate subordinates being cell-leaders. Most managers have responsibilities delineated on a product rather than process basis.

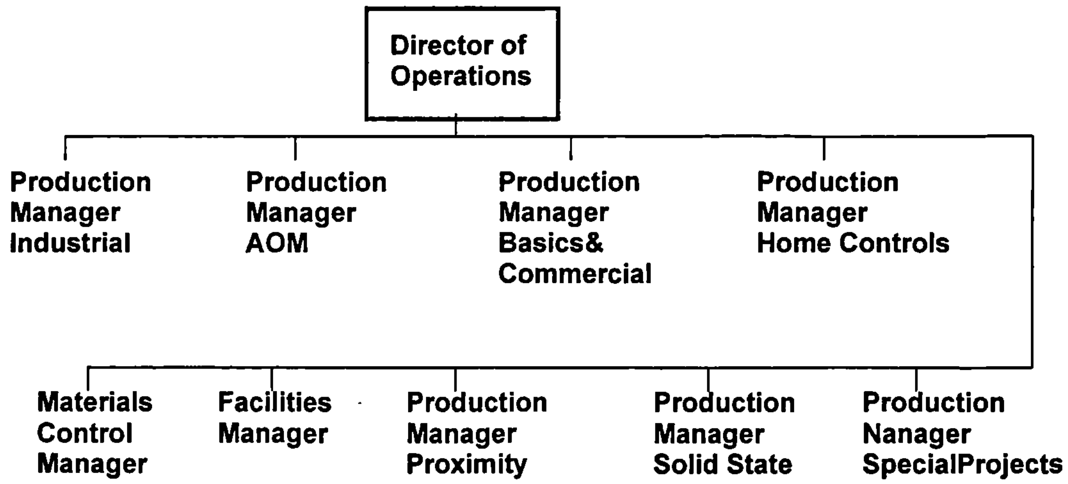


Figure 5.9 Newhouse Manufacturing Organisation

Procurement involves two main sections. One deals with strategic procurement, which involves identifying sources for new components. The buyers here (six at the time) are allocated particular product groups. The other group takes over once suppliers are identified and conditions have been agreed and are responsible for scheduling and day-to-day planning and control of supply. These buyers (nine at the time) specialise according to commodity type, so whereas one strategic purchasing agent will be involved in a new product at the outset, the routine supply of materials once the product is established is divided between a number of buyers.

5.4.4.2 EN Parts Sourcing

As previously related, there has been a concerted move to sub-contract 'non-primary' processes - die-casting, plating and many machining processes - and so the role of procurement has become more significant. This has been carried out under the 'Supply-chain optimisation' initiative. More specifically, EN switches consist of 75% bought-in parts, according to the AOM strategic procurement agent. Cross-checking this with a report on orders and inventory current at the time, of the 1149 EN components listed at the time, 880 were indicated as being 'bought' rather than made - 77%.

For many classes of products, particularly the 'basics' that form the core of the control component assembly - the finished EN switch, say - the majority of parts are bought in, and the majority of these bought from Honeywell in the US. This is important because Honeywell US are, in effect, custodians of the technology that gives the switches their functionality, and are also suppliers of the high-price parts to Newhouse. Parts bought in locally in the UK tend to be lower-value items such as fasteners and cables. The US plant thus plays at least two roles: one as competitor with the Newhouse plant when European affiliates are looking for a source for EN and other AOM products; secondly, as a supplier to Newhouse of a large proportion of parts for EN switches assembled at Newhouse, as shown in Figure 5.10. In the first role, the AOM Product Manager has pointed out the significant disadvantage Newhouse has compared to its US sister plant, both in material cost and assembly cost. One comparison of costs for production of a well-established EN product has the

US cost at 53% of the Newhouse cost. Aggregate volumes are very different: 10 000 per year at Newhouse compared to 150 000 per year in the USA.

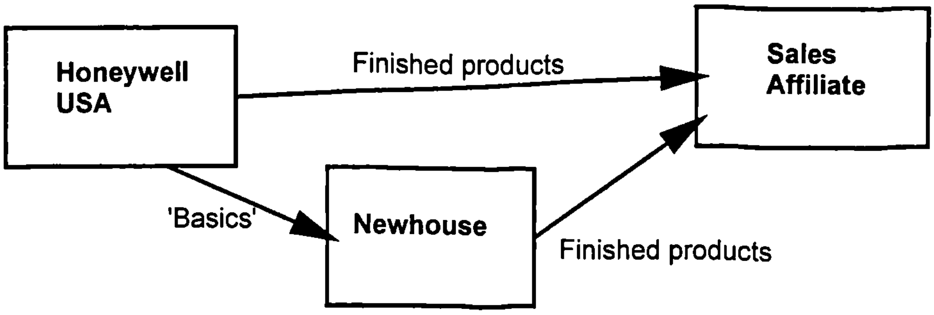


Figure 5.10 The Newhouse-USA Relationship

Again, emphasising the organisational difference between the USA and Europe, the AOM Product Manager commented that EN products are 'pushed by the US operation - they have a coordinated marketing strategy'. He also contrasted the US operation's relatively limited involvement in highly customised products with the situation in Europe, where there is high variety due to a 'fragmented' market.

5.4.4.2 Newhouse Manufacturing Processes

Having put the Newhouse EN operation into context relative to the rest of the EN activity, it is now useful to look in more detail at the manufacturing process, in particular assembly, relating to EN products. The AOM and, within them, EN products are a small part of the range made at Newhouse. Section 5.5 will go into some detail about the products, but for the time being the key issues are that AOM/EN products are low-volume, high variety and mostly high value compared to the rest of the products.

There are two stages in the production of an EN switch, as shown in the simple process flowchart, Figure 5.11. First, the 'basic' switch is made. This is then incorporated into a housing and the relevant connectors and other accessories are added. The first stage is common to other types of switch and is carried out in an area of the plant dedicated to it.

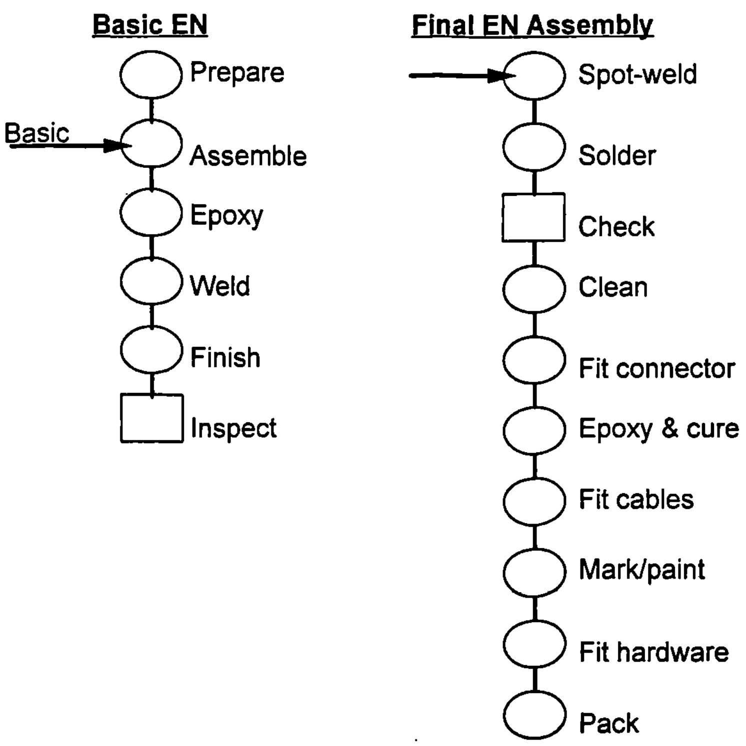


Figure 5.11 Simplified Process Flowchart - EN Switches

The Basics area produces about 10 000 basic switches per week, for use in AOM and industrial final products. It will be clear from this that only a small proportion of these are eventually used in AOM products (average 200 units per week). Although they are produced in the same area using similar processes, the basics for AOM are specific to AOM i.e. one basic is never used for both AOM and industrial switches.

Basics are put into stores and withdrawn for 'kitting' when a batch of final switch products is to be made. The final assembly of AOM products is carried out in an area of the plant, and by operators, dedicated to AOM products, and it is these who build the 'kits' of components from the stores items. A simple factory layout diagram is shown in Figure 15.12. It shows that the AOM Assembly area is self-contained and separate from the basics area. Apparently, there had been an initiative to move all 'small-to-medium batch' products to one area of the factory, but AOM was, in the event, the only one to actually be relocated. During the research, there was a move toward decentralised stores and the direct delivery by vendors of some parts direct to the point of use.

The processes are documented by Honeywell in process flow-charts and detailed job instructions. Confidentiality does not permit the inclusion of these in this account. All the processes are carried out using hand tools and small bench-size machines e.g. welding and epoxy sealing equipment. Based on these flowcharts, production of a typical basic switch involves 26 separate operations; subsequent assembly into an EN switch involves a further 51 operations.

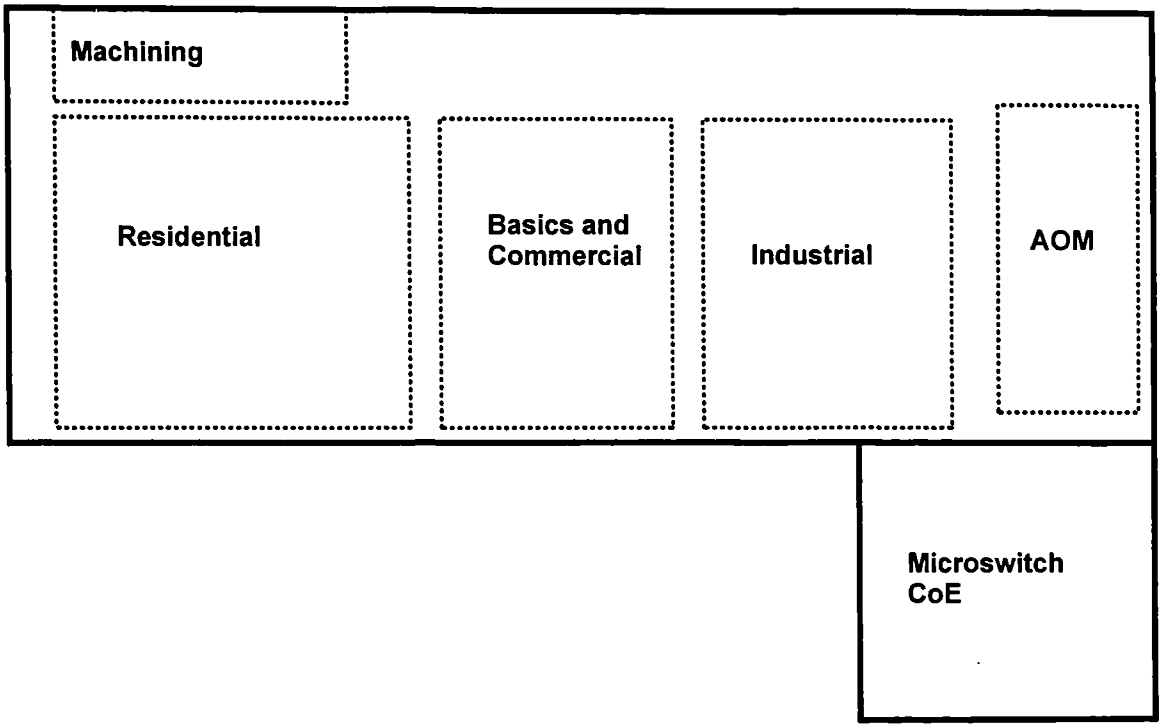


Figure 5.12 Newhouse Plant Layout

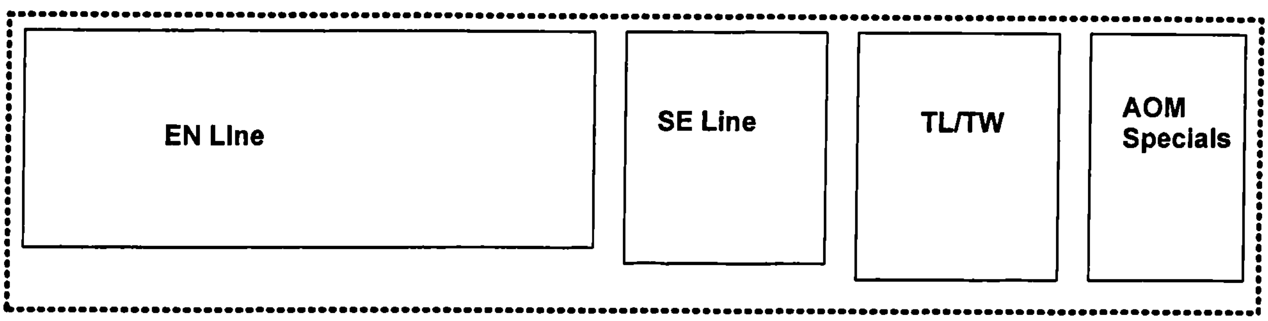


Figure 5.13 AOM Section Layout

The AOM area is organised on a product basis: there are distinct areas for EN, SE, TL/TW and 'AOM Specials' respectively (see Figure 5.13). Within the EN area, for example, there is a loose process layout, with soldering benches, ovens and sandblasting equipment grouped together. Switches will pass through a number of workstations. The process instructions stress the frequent requirement to correctly orient parts in the assembly, and to use the correct temperature and time for heat-treatment operations. Although thoroughly documented then, the conformance quality of these processes depends on the skill and diligence of the operators in their execution.

The constant novelty of products that arose due to the frequent requirements for customisation and the long gaps between orders, even for established products, posed particular problems. According to the AOM Production Manager: 'Most assembly jobs are being done for the first time, so there isn't the luxury of a trial build'. This makes demands on manufacturing and design engineers.

Parts shortages presented a major problem. The Production Manager felt that the biggest problem was with purchased parts rather than those produced at Newhouse. Other departments supplying AOM Assembly 'know the importance of [delivering on time]' but 'bought-in items take their place in the queue'. This made scheduling and capacity management difficult: for example, at the time of one visit, only three operators had been scheduled on the section, but were having to work overtime to cope with a peak in workload resulting from the sudden arrival of a delayed order of bought-in components.

5.4.5 Delivery Performance

The issue above all that had drawn management attention to the AOM products was poor delivery performance. According to the Production Manager, AOM delivery overdues were 'off the chart'. Analysis of the current order status indicates delivery problems among many products, not just the AOM ones. The reports available quantify delivery performance in a bewildering variety of ways: by number of lines (products), number of units, sales value and transfer value against requested delivery, promised delivery and normal leadtime. (The report contains so many different measures for each of 22 product groups that the Production Control Manager produces his own report on a simple spreadsheet, summarising trends using one measure for each group.) Despite the thoroughness of quantification, the performance is still a problem. At the time of the research, the value of EN overdues to promise constituted 20% of the total value for all components. From another source of data, it appeared that 47% of the works orders live at the time (July 1992) were overdue to customer request.

Requested delivery speeds were very variable, ranging from a few days to over a year. (The data were extracted from a computer order-status system that covered all the products in the plant, from one-off ENs to 1 million-off commercial switches, and the credibility of some data was questionable. However, it was the best available, both for this research and for plant production control purposes.) Figure 5.14 shows the profile of requested leadtimes for orders live at July 1992. Most are quite short - up to three months - but a considerable peak occurs at one year. This is due to the way the system is circumvented to indicate blanket 'call-off' arrangements. There are, however, leadtimes across the range.

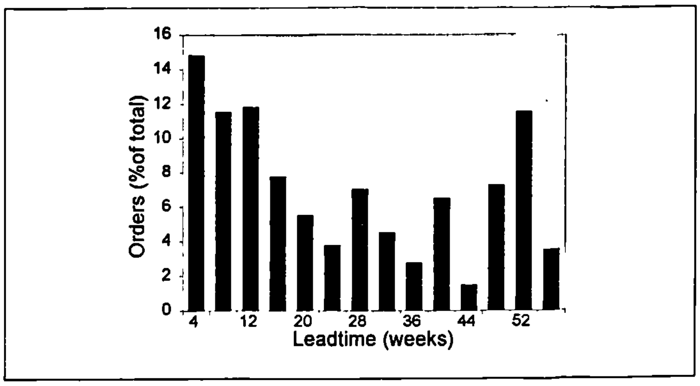


Figure 5.14 Requested Leadtime Profile - EN Switches

5.5.5 Products

Turning now to the concern of this research with product-range management and customisation, this section will describe and quantify the main product groups in the Control Components business, with particular emphasis being given to the AOM products. A later section will expand on the issue of customisation.

5.5.5.1 The Three Product Groups: Volumes, Variety and Revenue

The three main product groupings were characterised early on in the research as in Table 5.3. The CoE General Manager summarised the product range as comprising around 10 000 unique products in '50 to 80 product "families", depending on who you ask'. Here, AOM products, will be compared with other products.

Table 5.3 The Product Groups - Prices and Volumes

Product Group	Typical Price	Typical Annual Volume
Commercial	<£1	millions
Industrial	£5-£10	100 000+
AOM	£50-£100	10 000 - 20 000

For AOM products as a whole, the volume trends are as shown in Table 5.4. Data for EN switches for ten years are in Table 5.5 and, graphically, in Figure 5.16.

Table 5.4 AOM Products - Volume Trends

Product	1987	1988	1989	1990	1991
EN	13 912	13 445	15 814	14 441	10 246
SE	93 200	127 800	176 626	147615	83 248
TL/TW	82 226	75 775	51 493	42 513	36 481
38AS	39	1 338	2 183	1 263	112
AF	610	246	494	473	193
99PB	541	1029	621	295	706
Gear Sel	137	226	169	145	135
Panels				10	94

Table 5.5 EN Switches - Volume Trends

Year	80	81	82	83	84	85	86	87	88	89	90	91
EN Volume ('000s)	8	9	14	12	11	13	14	14	13	16	14	10

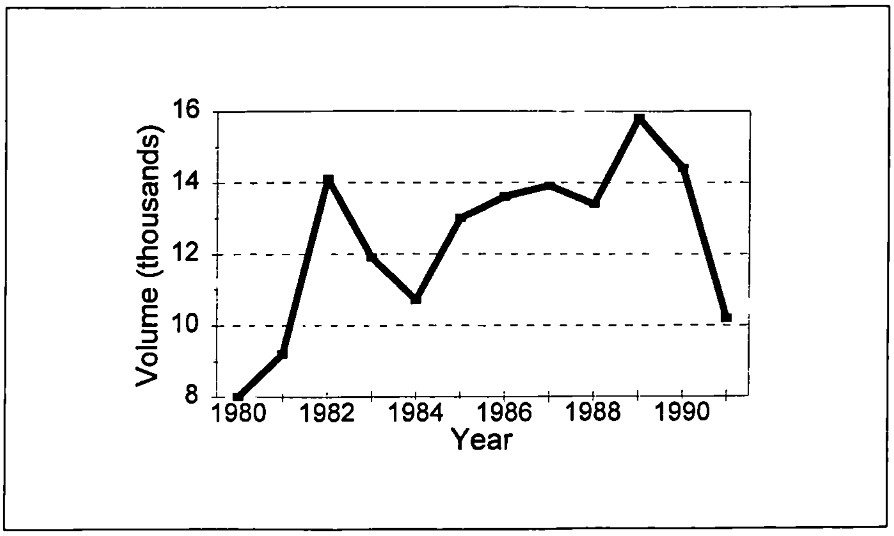


Figure 5.16 EN Switch Volume Trend (Newhouse manufacture)

As at mid 1992, the Newhouse EN production for the previous 12 months was 10 196 units with a sales value of £ 815 000. 212 different products were listed, with 132 of these having been produced in the year. A profile of annual volumes per product is shown in Figure 5.17. The year's production for the highest volume item is 586 units.

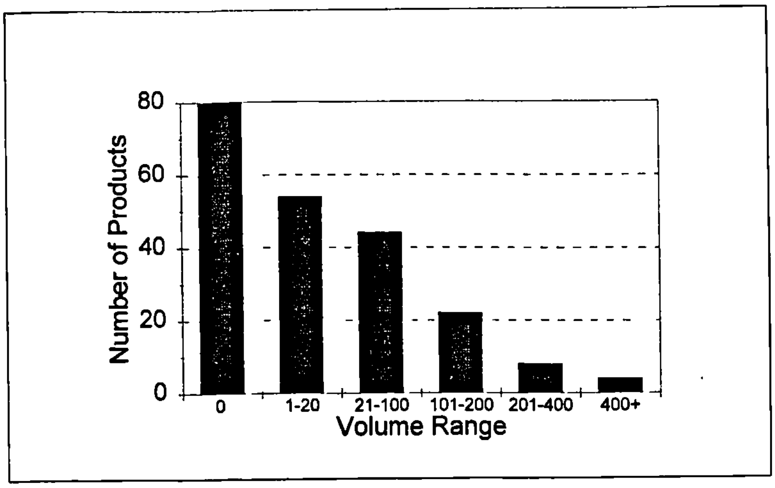


Figure 5.17 Volume/Variety Profile - EN Switches

From these graphs, it is possible to confirm that volumes are declining in practically all groups, and the annual EN volumes are as previously estimated from other sources. Although complete comparative data for other product groups were not collected, the other extreme in terms of volumes is the Commercial group, where *individual products* can have annual volumes of 100 000 - 500 000. (e.g. V5 products - 234 items (same as EN) and unit costs of 20p.)

As at May 1992, orders worth a total of £4m were promised. Some significant constituents of this are shown in Table 5.6., which again points up the different nature of the three groups: with the number of lines of similar order, and each making around 10% contribution to the value of the then-current order-book, the volumes involved in each case are orders of magnitude different - thousands, tens of thousands and millions respectively. In terms of units actually shipped during a week, there is a similar story, told in Table 5.7. These confirm that AOM/EN is a very different business and also a very important one in terms of revenue.

Table 5.6 Volume, Variety and Value - May 1992 Order-book

Series	Product-Group	Lines	Units	Value (£000)	% of total value
EN	AOM	249	3 691	330	8.2
CE	Industrial	339	32 000	280	6.9
V5	Commercial	282	2 400 000	466	11.5

Table 5.7 Volume, Variety and Value - One Week in May 1992

Series	Product-Group	Lines	Units	Value (£)	Units/ line
EN	AOM	27	167	11 000	6
CE	Industrial	62	2 415	28 000	400
V5	Commercial	11	105 000	28 000	10 000

5.5.2 Product-Range Structure and Reporting

It is instructive, within such a complicated product-range, to look at the ways in which the various departments and individuals divide up the products, for various reasons.

The three-way split initially articulated by the CoE management (AOM, Industrial, Commercial) is reflected in the structure of the marketing group - there were product managers for each of the groups. This is also reflected in the level at which product marketing/technology strategy is articulated.

In the plant, production management responsibilities are divided up along a mixture of product and functional lines (see Figure 5.9 earlier). Although there are production managers with technology- rather than product-focused briefs (e.g. 'solid state') there is a production manager for each of the main product-groups.

Table 5.8 Strategy, Product Management and Production Management Grouping

Strategy Document	**Product Management**	**Production Management**
AOM	AOM	AOM
Industrial	Industrial	Industrial
Commercial	Commercial	Commercial
		Various Technology-based

The information systems divide the products up in a variety of inconsistent ways. Reporting of delivery performance is done at a higher level of detail in what are termed 'forecast groups'. There are 22 of these covering the Components business; AOM finished products are divided into 7 forecast groups. Product management provided sales data at a similar level of aggregation, but the groupings are not identical to the 'forecast groups' in every case. The Catalogue for AOM products breaks products down into series, some of which map directly onto the 'forecast groups'. The stock status reporting system uses yet another level of and basis for aggregation. These are all summarised in Table 5.9.

Table 5.9 Grouping of AOM Products for Information Purposes

Delivery Performance	**Product Management Information**	**Catalogue**	**Stock Status Report**
7 Forecast Groups	9 groups	13 series	4 major groups

Although the management is reasonably well 'lined-up' behind the product groupings, the information systems do not enable any consistent trail to be followed through at more detailed levels.

5.5.3 AOM Product Variety

Within these various aggregated groups exist unique products, and that is the level to be considered now, within the framework of the product catalogue for AOM. First, the variety as described by the catalogue will be quantified as far as possible. Secondly, the actual variety apparent from recent business will be quantified and compared with the range given in the catalogue. This is summarised for the series as set out in the catalogue in Table 5.10, from which it is clear that there is a very inconsistent relationship between the catalogue listing and the variety in production.

The degree of precision with which the catalogue states the number of options varies from one extreme to the other: for series 991 it is 'this range of three pushbutton switches'; for panels it is a general statement of the firm's ability to 'design, develop and manufacture complete switch panels'; in between there are more or less exhaustive listings of specification options that can be combined to give a finite number of switches. In most cases, these finite possibilities are added to by means of general footnotes such as 'a wide range of standard housings, mountings and customised designs for specialised applications are available, on request'.

Table 5.10 AOM Series - Apparent and Actual Variety

Catalogue Series	***Variety Apparent from Catalogue***	***Actual Variety*****
SE	3 switches 6 auxiliary actuators	
XE	10 switches 2 auxiliary actuators	
38 AS	5 switches	
9 EN	design your own - est. 60 000 permutations	35 listed, 17 active in current year
401 EN	4 models given	4
402 EN	4 models given, with 'alternatives available'	16 documented, 6 active in 2 years
AS	2 models given	27 documented, 9 active in 2 years
TL	approx 300 options possible	Inventory report has total of 188 TL & TW lines active
TW	approx 350 options possible	
901AF/902 AF	3 models given	?
991	'This range of three..'	20 different models active
Gear Selectors	Vague	9 different models active
Panels	We will do anything	?

** *Note:Actual variety based on available recent production history, using various documents*

5.5.4 Customisation

The previous section has detailed the way in which, via the catalogue at least, the AOM range is presented to the customer. Customers will request customised products when what they want is not available as a standard product 'from the catalogue' and they are willing to pay the higher price of a customised switch. The extent to which customers are driven to consider customised products will be determined by the coverage of the standard range - the greater the coverage, the less need there will be for customisation.

There are a number of pressures, discussed earlier, that make customers increasingly likely to ask for customised switches. The basic product is old now, and customers wishing to achieve extra performance can only do so by moving away from it. Also, the increasing tendency to design the switch around the product rather than vice versa often leaves the customer little choice but to specify customised switches. Finally, the increasing competition amongst switch suppliers has implications in the following ways:

a) suppliers unwilling to customise products won't get the business

b) suppliers may seek out customised switch business deliberately, on the assumption that, where heightened competition exists, the entry barrier will be stronger where customised rather than standard products are being supplied. (One Honeywell manager claimed this to have been the rationale for the firm's policy in recent years).

Whether producing customised products because of the irresistible market forces or as part of a deliberate strategy to keep competition out, it seems essential to know when and how customisation is taking place.

However, all attempts to identify categorically which EN (this discussion will be confined to EN switches for now) switches were 'standard' and which were 'special' proved unsuccessful. A few could be identified as standard - they were the original basic products, as produced in volume for many years, some in the USA as well as the UK. Some 9EN (European) products were deemed to be standard because they were built up from the options offered in the catalogue.

This is where another problem arose. Because the product part number of this type of switch can be analysed to determine the product specification, this enabled customers to re-source switches easily, both from firms other than Honeywell and from the USA rather than UK (this is another way in which affiliates may 'shop around'). Furthermore, there is a growing trade in counterfeit spares for aircraft and a part number that is essentially shorthand for a product specification is helpful to a potential counterfeiter. Therefore, for some years there has been a policy of assigning any new product variants a different type of part number, which an entirely non-signifying set of alphanumerics. This unfortunately applies to any product, whether a 'standard' one that hasn't been produced before (not unlikely, bearing in mind that there are 60 000 possible permutations for the 9EN series) or a heavily-customised one. From the part-number then, it is no longer possible to determine the degree of customisation involved and hence not possible to quantify the proportion of customised versus standard products in aggregate terms. (91 of these were listed, of which 59 were in production in the current year).

The number of live EN projects is very small compared to the possible number of permutations of the catalogue options. Even requests for new combinations of these was treated as considerable novelties. Each project then, had a distinct history and, as such, it is instructive to examine a few contracts in more detail. The following section does this.

5.6 Contract Chronologies

This section gives summary chronologies of three contracts - SPs - that had recently been designed and had reached various stages of manufacture. These relatively digestible summaries have been derived from examination of every piece of documentary evidence available in the file for the SP concerned and from discussions with engineering, product management, manufacturing and other staff.

There were several reasons for studying these contracts. First of all, studying specific contracts improves and tests understanding of the general principles and systems used. Secondly, it helps to determine (to some extent) the patterns of communication, the timing of and responsibility for various activities and the apparent competitive issues and basis for decision-making. It may also be possible to identify some ways in which customisation projects go beyond the capabilities of the firm, where that is the case.

The contracts were chosen in consultation with the AOM Product Manager. Whilst there had been willingness to discuss general issues very freely, there was much more reluctance to give access to individual contract details. The reasons for this are not clear. There may have been a natural reluctance to be subjected to scrutiny, particularly bearing in mind the prevailing threat of redundancies; there was a (to some extent justified) concern that specific technical details would hinder the understanding of the documents; there was also some embarrassment at the state of the 'filing system' of the by-then-departed design engineer. Nonetheless, once these had been overcome, free access was given to whatever it was possible to find.

The contracts chosen were two SPs for ENs that were considered 'fairly typical' and one SP for AOM control panels that, whilst straying outside the firm's remit for the project of EN products, had been raised a number of times in conversation as an example of how customisation had caused great problems.

5.6.1 Two Customised ENs for a North European Sales Affiliate

This contract history, although relatively uncomplicated, nonetheless shows a number of the features supposed to be typical of the AOM/EN business.

It is protracted. So far as can be established, from an initial request in November 1991 it took 15 months for the first production parts to be shipped, and the OEM phase is scheduled to go on until the end of 1995.

Projected volumes are small and firm orders placed are even smaller. From initial projections of 150-200 units in total, orders for the initial build period are for less than 100 units in total, called off in ten separate lots over a period well in excess of eighteen months.

It takes place in the context of a relationship involving the sale of other products, possibly including non-AOM.

Design resources were a very significant constraint. The project stopped dead until threats and managerial intervention were used to secure designers' time. Part of the threat used both by the Sales Engineer against marketing and by the Product Manager against the Engineering Manager was 'going to Honeywell US'. The US operation was portrayed as the fast-acting outfit who would do it quicker and cheaper (although there is presumably some reason other than charity for the sales engineer to tolerate such delays from Newhouse).

Delivery of drawings, quotes and samples were pushed back, delayed and missed on a number of occasions. The project limped from crisis to crisis.

Due to various of the above factors, the project absorbed considerable management time.

The Design Engineer was the usual point of contact for the Sales Engineer.

There is no evidence of any business evaluation of the project to assess whether it is worth doing either in itself or in the context of the relationship with the customer. Notably, it is the Design engineer who is obtaining costings from the Accounts department and who communicates these and the transfer prices to the Sales Engineer. It is the Product Manager who communicates the 'commercial offer', with Transfer prices drastically reduced, four months after the Design Engineer's costing and pricing has been sent. Although an estimate is made of the design costs (£9500), no assessment is recorded of the overall viability of the project. A rough estimate made as part of the research of net cash inflow for the firm orders received (disregarding time value of money) has estimated design costs at five times the 'profit' based on transfer prices (£1877) i.e. the project loses money overall. Bearing in mind the extended nature of the delivery pattern, the situation will be considerably worse than this in that some of the cash in-flows will be several years after the outlays, certainly for the initial design work and, depending on the approach adopted to producing requirements of three off at a time, possibly for some of the production.

5.6.2 Contract 2 - An SP for Customised ENs for a UK Sales Affiliate

This contract involved a UK sales affiliate and a customer in the railway rolling-stock industry.

On July 3rd 1992, the SP was submitted. It was completed fairly comprehensively and outlined the technical details, describing the switch needed as 'same as...except for...' an existing EN product, the variations including special contacts, leadwires and a particular operating force. The volume projection was only made for year 1 and was 50 units. Immediate action required was a firm price, a drawing, and a 'statement of intent to proceed' within 2 weeks. A target price was specified.

On that day, the AOM Product Manager replied to the Sales Affiliate, saying that he would raise the SP at an imminent meeting but adding

> 'whether a [specific switch type] is appropriate the projected revenue

> stream (£4k sales per annum) is poor and cannot support the required engineering. On this basis we must close out [reject] the SP'

A week or so later, the Sales affiliate responded, expressing 'disappointment':

> 'I thought railways were a market of interest to us and that the product I needed was a combination of existing parts in a new variation. The option of using a [switch type] seemed simple and straightforward - a question of knocking up a drawing and doing a production release...'

Further on he added:

> '[Honeywell USA] have agreed to respond to an SP for 50 pieces of the part I want (a pleasant surprise).'

There is no record of anything else until October 15th, when the sales affiliate tried again, writing to the Product Manager (and sending copies to senior Sales and Product management):

> '..you mentioned you wouldn't be prepared to do it [the SP] due to the small revenue resulting from it.....I need you to support me for the greater Honeywell cause. To Sales, [customer] is a key major potential account....I am close to securing a £290k contract with [customer] for [other products]...I am trying to promote us as a company who can

> supply all their switch and sensor needs, I don't want competitors getting <u>any</u> visibility in the account. ....the target price..is also quite generous, I believe....Please review this...this is an immediate requirement.'

A flurry of activity ensued in late October and early November. The Design Draughtsman specialising in AOM asked Honeywell USA to give a price for the basic switches to go into the finished switch, and Newhouse strategic procurement to give prices for other necessary bought-in parts. The USA response was that, because of the unusual operating force, special tooling would be needed, which could not be justified for 50 units. Newhouse replied, asking what the tooling cost was. The USA quotation came on November 12th. On November 13th, the Product Manager replied to the USA, complaining of the large mark-up and asking them 'to advise whether calcs are correct...we are under considerable pricing pressure and need as much help from [Honeywell USA] as possible.' On the same day a bill of materials was made out, and on 16th November, a commercial offer was made by the Product Manager to the Sales Affiliate - for 50 units in one shipment - and promising drawings by November 20th.

Nothing else is recorded until 29th March 1993. The switch has been given a new-style meaningless part-number. The customer is about to order and has made enquiries of the sales affiliate over changes to the details of the design: '..a response is required V. URGENTLY.' The Design Engineer agreed to do changes on 8th April. On 20th April, the products were ordered, and on 30th April, the design was formally released. On 4th May, the procurement agent received quotes for parts 'all 8-11 weeks delivery'. The switches were eventually shipped on 12th July, a year after the SP was first written.

5.6.3 Contract 3 - An SP for Two Customised Control Panels for a UK Sales Affiliate

The product involved here is not a simple AOM switch, but two panels, each involving a number of the simplest of the AOM switches. The documentation on this contract was very extensive, so even a summary of the main events in the chronology would be excessive. A very broad summary of the contract will be given instead.

The prices of the panels were of the order of £600-£700 each, and the total cost of the switches contained in each was about £30. Each assembly involved 30-40 components, of which six or seven were the switches. The costings carried out using the standard costing system generally applied throughout the plant indicated that labour costs for the manufacture of the switches themselves totalled £4 for the whole panel. A further labour cost for final assembly was indicated as being approximately £30 , including overheads.

The project goes back at least as far as November 1989, when the Product Manager was able to tell the Design Draughtsman that he intended to quote prices for the panels, for '135 off of each starting September 1990'. During the next few months, there appears to have been parts shortages, even for the small quantities required for prototypes. Again, 'the longest leadtime part is [from] Honeywell USA' ; a great deal of effort (on the part of the Product Manager) went into identifying sources for new components - 13 suppliers were identified in the earliest parts listings of March 1990.

The prototypes and early production quantities were built but problems arose in testing at the customer's premises. The panel was 'put on hold' in April 1990, although 50 had been made and would require reworking to overcome the test problem. The customer then added to the problem by making other late design changes, at the same time applying pressure for prompt delivery.

Honeywell found that they needed more rigorous in-house testing than anticipated and so had to sub-contract this supplementary testing, at a cost of several thousand pounds. Delivery problems then became more high-profile and there was a succession of meetings over the next few months. Records show that shipments began on 19th September 1990 and continued in small quantities - usually between two and seven at a time - right up until the data were collected in March 1993. But over much of that time, there was a succession of quality problems and ever-increasing test requirements that saw many of the units being returned, and many design changes. Parts shortages plagued production and there were repeated attempts by various people to clarify just how many acceptable units, to the most up-to date specification, had actually been sent to the customer. In June 1991, further subcontract testing was required, at a cost of £20 000. A price increase was negotiated in February 1992, followed swiftly by a change of part-number for one of the now-drastically-revised products.More test failures occurred in April 1992 and more late deliveries were evident in May 1992; 20-30 units were reworked to bring them up to the latest specification. In June 1992, it was found that a batch had been made with one of the switches upside-down. And so the rework continued and the customer was short of panels to the correct specification.

The production of the switch had involved a new range of skills in wire harness fitting and this had presented a challenge to the operators, who spoke with wry smiles about the jigs and aide-memoires they had made to help them with the assembly. The large number of parts, from a variety of sources, also presented difficulties. A number of the test failures were due to misunderstandings about the properties and application of the bought-in components and the systemic effect of combining them. The complexity of the build, with a BOM of effectively four or five levels, was something entirely new to everyone concerned. The Production Planning Manager doubted whether the BOM was right, even in early 1993! And the Product Manager rued not having drawn up a 'family tree of which parts go into which panel' right from the start. In 1992 he described the contract as 'a bad scene...We never want to do anything like this again....It's tin-bashing really'.

5.7 Case Analysis

This section concentrates on the analysis of those issues that emerge particularly strongly from this case. Issues relating to more than one case are covered in the Chapter 8.

5.7.1 Explicit Business Strategy

Honeywell's Control Components business had the most comprehensively documented strategy of any of the business units examined in this research. However, nowhere was the term 'manufacturing strategy' used, at least not on paper. The only reference made was at an early interview with the Microswitch CoE General Manager, who commented that Honeywell were 'good at World Class Manufacturing, good at manufacturing strategy, but not so good at linking the two together'.

The written Control Components Strategy is clearly informed by the BCG Growth-share matrix (Henderson, 1970; 1973), notably in the way it takes a product portfolio approach to dividing up the business into Industrial, Commercial and AOM product/market sectors or business units, and in the use, in strategic summaries, of such language as 'invest to hold and maintain'. These divisions into business units are also used for the assessment of the firm's market share and position relative to main competitors.

Although somewhat inconsistent or opportunistic, the strategy documents do discriminate between the product groups in respect of marketing and, to some extent, technology strategies. For example, in the Commercial product group there is an explicit intent to penetrate the market by 'focusing' on global OEMs; in each product group, particular switch types or technologies are identified for cost reduction or development. There is also some attempt to draw linkages between marketing and technology strategies e.g. the intent to use the appliance market within the Commercial product group as a vehicle for the development of solid-state technology.

Despite the simple division of the business into three product groups in most documents and conversations, there is evidence, both from the original Control Components Strategy document and, increasingly strongly from later developments (after the research period proper) of tension between business units and strategies aligned on markets and those aligned on technologies. This was present in the early characterisation of the Newhouse 'mission' as being based on electromechanical products, rather than on any of the product market segments such as Industrial or AOM. Closer to the time of writing, the situation had evolved to the extent that the Control Components Business had the following 'product sales groups':

Industrial

Optoelectronics

Commercial

AOM (ATOM)

Fluid Controls

Thus the original three customer-based and largely mutually exclusive product groups have been supplemented by one based on a particular technology and one on a particular control situation. This is perhaps a result of the attempt to build the business by using *applications* as vehicles to develop technologies, rather than by simply trying to develop new products in the same product/market groups. (It is of interest to note that the Strategy document states that '80% of the product portfolio in mature/ageing *markets'* (emphasis added) rather than, as might be expected, '80% of the *products* are mature'.) This mixture of customer-based and technology-based separation of activities is also evident in the organisation of manufacturing operations, e.g. one manager for AOM production (customer basis), another for solid-state (technology basis).

This arguably represents the emergence to the surface of a way of thinking of the business that was at work, although less visibly, beneath the neat veneer of 'We have three product/market businesses'. Honeywell is a technology-based firm, currently going through a belated effort to rapidly update its products. After years of managing its 'product portfolio' in a relatively benign business climate it has undertaken a radical revision of what it *does* as a firm, as evidenced by the move to subcontract many of the processes formerly carried out at Newhouse. This, and the newly-emerging divisions of activities on lines other than product/market, is a response both appropriate to the situation in which the firm finds itself regarding the maturity of most of its products (or markets - see above) and in keeping with current trends in strategic management i.e. the core competence approach (e.g. Prahalad and Hamel, 1990). The establishment of a fluid controls group is in keeping with the core competence approach of developing underlying know-how that is applicable to a number of (possibly ephemeral) product-markets (De Leo, 1994) .

This may be a highly appropriate strategic shift, but Honeywell must be clear that it is happening and not mix the approaches without caution. A renewed interest in developing new technologies and competences will accelerate the replacement of an ageing product range, but should not be allowed to obscure the business differences between the markets to which products are eventually brought. This has particular implications for manufacturing strategy, which is discussed further below.

5.7.2 International Organisation Issues

Also relating to the level at which strategy is defined is the involvement of the Honeywell USA EN operation. Whilst the Newhouse business is ostensibly autonomous and able to define and implement its strategy for the EN business as it sees fit, in reality the US operation looms large. Although the account of the USA operation given by the Newhouse staff may be based on a somewhat rose-tinted view, it seems uncontentious that it is a high-volume and relatively low variety activity which operates at much lower unit costs and has much closer control over its sales and distribution channels. The Product Manager sums this up as follows: 'the strategies are all lined up...it's one big machine' - as compared to the 'fragmented' European situation, where the situation is closer to market than to hierarchy (Thorelli, 1986). Whereas the US operation seems to have staked out a clear competitive position for itself, the Newhouse EN manufacturing operation falls into what Hill (1993: 61) might term a strategic vacuum, created by the lack of control over sales and the by comparison much stronger and clearer competitive position of the US operation, in its roles as both competitor and supplier to Newhouse.

Many of the basic switches that provide the functionality of Newhouse-assembled EN products are supplied by the USA. With the apparent corporate shift away from a product/market emphasis toward a renewed interest in technology and product-technology-based competences, and noting that the US operation is still investing in its electromechanical switch manufacture, Newhouse's role as local customiser-and-assembler-to-order looks likely to continue. Furthermore, it seems likely to move farther away from involvement in upstream manufacture and, arguably, become more vulnerable as a viable operation.

The other European locations with an involvement in Control Components include one or more of the newer basic product technologies in their repertoire (see Figure 5.3). They are also concerned solely with the Components business, unlike Newhouse, which has both Components and Home and Building Controls activities under its roof. With basic electromechanical switch manufacture and successor technologies increasingly centred elsewhere, Newhouse's role is open to debate, especially if its mission is characterised as being centred on electromechanical devices. It is the location for the Microswitch Centre of Excellence but, even during the period of the present research, certain key members of the electromechanical design staff as well as the market research and communications manager were made redundant and the

Product Marketing Manager responsible for AOM and Industrial products moved to reside in Brussels. It is increasingly difficult, certainly for AOM products, to determine where within the Centre of Excellence the excellence remains.

5.7.3 Manufacturing Strategy and the Implications of Low Volumes

Despite various combinations of technology and market conditions, and technology and marketing responses that are differentiated accordingly, the strategy documents set out the same manufacturing initiatives for all three product groups (see Table 5.11). Under the umbrella 'World-Class', this cluster of manufacturing-related initiatives is grouped under the headings of Design, Manufacturing, Supply-Chain and TQM and includes a comprehensive selection of recently in-vogue manufacturing techniques e.g a focus on primary processes, FMEA, SPC, Cellular manufacturing. Whilst there are some technology and market factors that are stated as being common to all product groups - increasing price competition, transferable technology - it has to be recalled that in manufacturing terms the businesses are very different to one another. There are many ways in which the manufacturing task (Skinner, 1969) differs from one group to another. At this stage in the analysis, consideration of volume and variety can be used to characterise the manufacturing task, and there is extensive evidence throughout the case that there are orders of magnitude of difference between the groups on these dimensions. It seems doubtful that identical manufacturing responses are suitable to each product group.

Table 5.11 Business Strategy and Manufacturing Strategy

Business Unit	***B.U.Strategy***	***Implementation***	***'Cost to Serve' i.e. Manufacturing***
Commercial	Invest to Grow	Various Product-Specific Initiatives	World-Class Everything
Industrial	Invest to Hold	Various Product-Specific Initiatives	
AOM	Invest to Hold	Various Product-Specific Initiatives	

The project was explicitly directed at product customisation, and AOM/EN products were identified as a suitable focus for that subject. In subsequent discussions however, the Product Marketing Manager referred to the project as the work 'on low volume product'. Other product groups involve the production of customised products in very high volumes. For example, the appliance market, within the Commercial product group, may involve production of hundreds of thousands of one customised switch for a domestic appliance OEM. Bear in mind also that one Product Manager, when asked what were 'standard' products, commented (apparently in all seriousness) that 'Standard products are whatever we make the most of'. It is useful to consider how much of the difficulty results from the low volumes *per se*, and how much from the fact of the products' being customised. Starting with the production process itself, the AOM section is well-suited to producing low volumes. General-purpose machines and multi-skilled operators, a standard production batch of ten units kitted to order: these are all features that would be expected from a process type (Hill, 1993) chosen on the basis of low volume and high variety.

The most notable infrastructure difficulty was that production planning and control was carried out on the same system for the whole plant. The confusion of information systems made it extremely difficult to gain clear visibility of the AOM or EN production issues. Furthermore, these information systems were singularly useless when it came to communicating multi-level BOMs. The prospect of defining clearly a product structure for the switch panel products discussed earlier was clearly a new departure and, as such, it is perhaps unsurprising that there were difficulties in communicating between design, materials management and the shop floor. Furthermore, performance is measured in terms of switches completed. This is seen on the shopfloor as somewhat meaningless, bearing in mind the length and complexity of the assembly process.

5.7.4 Marketing - Manufacturing

The literature discusses at considerable length the conflicts between the marketing and manufacturing functions (e.g. Shapiro, 1977; Crittenden, Gardiner and Stamm, 1993). The evidence here indicates that this is not the most important boundary. The Product Manager is nominally part of marketing but speaks of 'we' as including him and the shop floor against the 'them' of the sales affiliates. Geography is important - 'all the risks are at Newhouse' rather than 'all the risks are with manufacturing'; apart from the affiliates, the other target is the Honeywell US operation, which is not surprising considering the very powerful position the above analysis shows them to hold, both as competitor and supplier. There was, by comparison, very little discussion of

Honeywell's competitors.

The Product Manager's characterisation of what sales affiliates want - 'faster response, lower prices, new products' - is exactly in keeping with the literature on marketing-manufacturing conflicts, although surprising again in that the comment is made by someone nominally within marketing. It is also between sales and marketing, rather than between marketing and manufacturing, that the largest gulf seems to exist in respect of understanding the implications of customisation - although the apparent naivety as to the engineering and production consequences may be convenient rather than genuine.

5.7.5 Product-Range and Customisation

European marketing communications clearly stress high product variety and customisation at just about every opportunity. There is some evidence that this has been an explicit strategy, intended to raise entry barriers. There is other evidence that this has been a gradual drift or, even if originally intentional, has gone too far ('customised beyond recognition'). Interestingly, although the Control Components Strategy document mentions 'new product development' for all three product groups, it never mentions product range breadth or customisation. The only reference made to a related subject is the explicit statement of intent to 'forward integrate' AOM switches, which will usually involve customised solutions.

The firm's experiences of becoming involved in forward-integrated customised products in AOM, notably the control panel type of product, shows some important inconsistencies. These products are presented, for example in the catalogue, as just another series in the AOM range. The reality is that a very small number of different models have ever been made. The very significant example, described above (5.6.3), of two panels produced for one UK customer is illustrative of the reality of Honeywell's undertaking this kind of business. This became the most high-profile example of poor delivery performance in the whole plant, leading to exchanges between the Directors of the two firms. It was, according to the AOM Product Manager, 'a bad scene'; 'We wouldn't do this sort of business again - it's tin-bashing really'. Apart from involving hardly any material-conversion processes that Honeywell have any particular ability in, the multiple-level BOM in itself was something that caused a great deal of difficulty. The plant's manufacturing information system revolved around products of two to three BOM levels at most. The AOM Product Manager, on reflection, rued never having drawn up 'a simple family tree of which parts went in which panel' as a basis for communication between engineers, procurement and the shop floor. Most products were such that everything could be clearly understood from one assembly drawing: the medium of the structured BOM had not become a basic communication tool, as it is in many other industries. The Production Planning Manager commented that he had doubts as to whether the BOM had *ever been* correct.

This product drew on very few of the firm's strengths and played on many of its weaknesses. The Honeywell switches that were incorporated into it were the very simple and very old TL/TWs and offered no particular distinctive advantage over anything a competitor could offer. The rest of the process steps involved were just the type of thing that the firm had relatively recently gone to considerable lengths to stop doing. This led to an unusually complicated procurement exercise involving the purchase of parts, few of which were similar to parts purchased for other products e.g. the fabricated sheet steel panel housings. The assembly process was of a very different nature to those in which considerable expertise had been developed, such as the specialised welding used in EN assembly. One notable difficulty was with installing the harnesses of cables leading from the individual switches to the external connectors: this involved a special aide-memoire jig to be developed on the shop floor so that the cable routing could be consistently carried out.

Not only in production did the panel product exceed Honeywell's capability. A number of the panels delivered fairly early on failed tests at the customer. Honeywell had initially underestimated the testing regime and had to go to sub-contract test-houses offering the specialised testing facilities required by the customer. The product also had to be redesigned to enable it to pass these tests, incurring considerable delay and extra expense.

5.7.6 Sales Project Decisions

The criteria that the AOM Product Manager reckons to apply to SP decision-making are problematic. In particular, the questions 'Does it [the SP] fit the strategy?' and 'Is it derived from the catalogue?' are difficult to answer. Also, there are very big problems with 'balancing' engineering costs against projected revenues.

It is not clear that there *is* any strategy, certainly not for customisation and arguably nothing coherent for EN or AOM products more generally. From the Control Components Strategy document, we have the 'invest to hold and maintain' policy for AOM, plus the more specific statements of intent to forward integrate switches, cost reduce the EN range and invest in New Product Development. It is evident that at least some of the forays into forward integration have been disastrous - unsurprising in that many of the capabilities required for forward integration are precisely those that Honeywell has either never had or of which it is and has been rapidly divesting itself. A broad programme of cost reduction on EN switches may or may not be appropriate, but it is difficult to see how this policy can inform any decision about which SPs to pursue and which to reject. Similarly, intention to invest in New Product Development does not help any individual SP decisions - nor how that or the 'invest to hold and maintain' policy is effected through making redundant the engineers who designed the products.

Determining whether a proposed SP is 'derived from the catalogue' is also difficult. Firstly, as outlined above, there is no consistency from series to series as to what is included in the catalogue in the first place. In some instances the catalogue is quite clear and exhaustive and it would be apparent when a new product represented a departure from the catalogue and, in some way, how much of a departure. In other instances the catalogue entry amounts to an invitation to design your own switch and, as such, most things imaginable could be construed as being 'derived from the catalogue'. Secondly, even where what is 'in' the catalogue can be defined with some certainty, there is no indication as to how far, or in what way, new products are permitted to be 'derived' from it.

Estimating costs and revenues for the purposes of some kind of business assessment is problematic. Determining costs entails the following difficulties:

- small changes in volumes affect unit costs significantly, especially where tooling is required

- the typical delay before the start of production and the long, intermittent production life make costing, more than usually, a matter of predicting a distant and probably very different future

- costs often have to be estimated without a trial build

- once production begins, actual labour cost reporting is poor and not reflective of engineering /management time

- there is little or no information on design costs

Revenues are unpredictable because:

- there is a long life-cycle even for OEM production
- after-market volumes and prices are largely unknown
- customers' projects are subject to delays , which has knock-on effects on the timing of Honeywell's revenue stream.

Furthermore, linking the two together is made very difficult because of the absence of any information system that explicitly connects an SP, with its associated design costs and projected volumes and production costs, to the information on actual volumes and costs of switch or switches that are produced as a result of the SP. This not only makes it difficult to control individual contracts, but also to learn in any objective way which types of business are the most rewarding. No wonder then, that the Product Manager repeatedly bemoans the lack of useful information; also no wonder that 'gut feel' is still seen as an important tool in deciding which SPs are attractive.

5.7.7 Design Cycle and Material Cycle

Information concerning costs of the design activities and values and timing of the revenue stream from production are but one facet of the relationship between design of a new AOM product variant and its manufacture. The unusual characteristics of the business also influence what the important issues are at each stage of a contract, how this affects relationships with customers, and how design and manufacturing activities are best managed to achieve success.

A number of respondents indicated that being responsive technically at the design stage is vital to winning business. This includes the solving of customers' problems and doing so quickly - in the form of submitting drawings and possibly prototypes. Delivery of production volumes may not begin until a year or two after this stage and so a great deal rests on trust in uncertain circumstances. By the time production proper begins, it may well be very difficult or impossible for the customer to change supplier and so such factors as delivery speed and delivery reliability can only be promises about a quite distant future on the part of Honeywell.

In the situation where a relatively small number of customers keep coming back to Honeywell - through lack of alternative, lack of incentive to seek out any alternative, or a combination of the two - these customers have the chance to build up experience of how well Honeywell perform when it does come to delivering production volumes. Thus there are two indicators of performance in the material cycle (Harrington,1973) in any given contract - learning from the material cycles of previous contracts and indications as to the likely performance from the design cycle. This contrasts with a very short-cycle ship-from-stock type of business where customers can learn very quickly and with very little cost how well suppliers perform. As such, it is misleading to talk in simplistic terms about order-winners (Hill, 1993).

This view gains more weight from the fact that, in the UK at least, the number of customers is very small and, far from making atomistic sales to customers making simple decisions based on price, delivery etc of the current offering, transactions are carried out in exceedingly complex, enduring and multi-faceted relationships. From the small number of contracts examined in more detail, it will be clear that the sales force are (ostensibly) interested in relationships and accounts as much, if not more, than individual products:

> *'I am trying to promote us as a company who can supply all their switch and sensor needs, I don't want competitors getting any visibility in the account. I need you to do this SP for me even though it isn't very financially attractive to you.' (from a memo from a field sales engineer to the AOM Product Manager).*

This point will be developed further in Chapter 8.

As is apparent from the shop floor observations in the case, there is 'rarely the luxury of a trial build'. Even when there was a design engineer intimately involved with all the SPs, the long wait between prototyping and the start of full production meant that considerable effort was involved in re-learning what had been established during prototyping. Also, as prototypes were usually produced in the model shop, rather than in the production shop, not all that had been learnt would be applicable anyway. Following the move to ad hoc and temporary design engineers, the amount of continuity between design and production was even further reduced.

Although the generic EN switch process was fairly thoroughly documented in process sheets and subject to FMEA analysis, none of the listing-specific process variations were formally documented. In view of the large number of unique special products and the often long intervals between batches, it was often necessary to 're-learn' hard-won lessons on listing-specific process idiosyncrasies. This approach, referred to by the management accountant as 'hand-crafting' means that there is perpetual difficulty in predicting the work content and cost of products, particularly but not exclusively the first time they are made.

5.7.8 Summary of Honeywell Case Analysis

Honeywell's Newhouse AOM/EN operation is at something of a crossroads. It has a very mature basic product technology, newly complex and competitive markets becoming more European-centred, and a potentially troublesome relationship with its US sister operation which, through larger scale and more purposeful organisation, holds a powerful position both as a supplier to the Newhouse plant and as competitor with it for higher-volume more standard EN products.

Newhouse has either to compete with this (and its newly-active external competitors) by trying to do the same thing - investing to produce higher volumes of 'standard' products at lower cost; or it has to find another way to compete. All the indications are that there is no willingness to pursue the former course of action, viz withdrawal of Product Management and Engineering resources from the business and the subcontracting of many EN-related processes. Even were there a will to invest in high-volume plant, the more fragmented European market is unlikely to offer any prospect of this type of business.

Positioned as it is in a much more fragmented and dynamic European market (despite corporate ambitions for 'global' reach), Newhouse's AOM operation must act accordingly. It is essential that the plant fills the apparent vacuum in manufacturing strategy and explicitly positions itself to compete in such markets. In many regards, this is a matter of manufacturing infrastructure design (Hill, 1993: 212-262; Hayes and Wheelwright, 1984) rather than investment in process equipment, and will be relevant well beyond the allegedly-imminent demise of the electromechanical limit switch as base technology of the AOM products. Put another way, an infrastructure designed to achieve, say, fast delivery of low volumes of the current products will also be suitable to provide the same competitive criteria for products based on solid-state technology and should thus be seen as a long-term development that will provide sustainable competitive benefit.

The AOM range must be reviewed by Sales, Marketing, Engineering and Manufacturing, and much more explicit decisions be made about which products are custom-built and which are custom designed. Conflicts between these are at the heart of many of the problems experienced; the distinction between 'standard' and 'special' products is less relevant and less meaningful. It is evident that fast response at the design stage for custom-*designed* product is important. This can take the form of concept design, quotation, detail design, prototype. This is shown schematically in

Figure 5.16. Newhouse must, through provision of facilities, information and people, become the best at this for AOM products. Many more of the customers than has been the case will be new to Honeywell and, whereas a long-established relationship might have been sufficient with existing customers, the response to initial contacts will count for a good deal with new customers. Responses such as that to described in the chronologies above will not engender confidence.

Figure 5.16 Different Pre-Production Activities for Custom-Build and Custom-Design

Project Type	**Key Activities in Approximate Sequence**					
Custom-Designed	Design	Deliver drawings	Deliver Prototypes	Iterate Design	Issue Design	Production
Custom-Built	Engineer Application	Deliver Sample	Iterate..........			Production

When it comes to supplying prototypes of custom-*designed* products, and samples of custom-*built* products, procurement and supplier relationships are important. And, if this is to be a source of competitive advantage, it is unlikely to be realised by having to 'scurry around' for ad hoc design engineering staff - explicit provision must be made. (This is one aspect of the suggested way forward that may need to remain technology-specific i.e. designers may need to specialise in electromechanical or solid-state technology, although much of the work is nothing to do with the core switch, but with the housing, connectors and other distinguishing features.)

In short, as well as developing strategies at the levels of products and markets, of technologies and core products (such as fluid controls) Newhouse must explicitly differentiate its AOM manufacturing and procurement strategy to make it highly responsive regardless of base product technology. It must move on from seeing manufacturing as a 'cost to serve' markets.