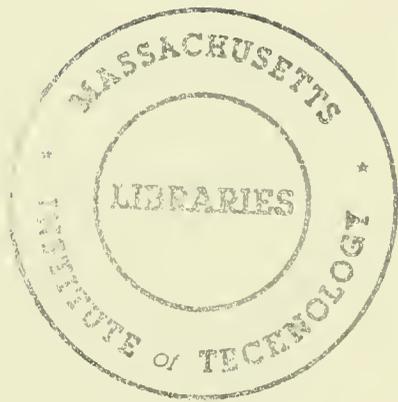
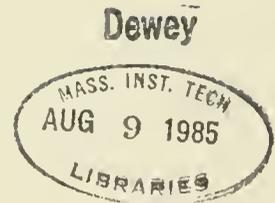


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MANUFACTURING STRATEGY:
A METHODOLOGY AND AN ILLUSTRATION

Charles H. Fine
Arnoldo C. Hax

Sloan School of Management
M.I.T.

June 1985

WP #1667-85

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Abstract

A manufacturing strategy is a critical component of the firm's corporate and business strategies, comprising a set of well-coordinated objectives and action programs aimed at securing a long-term, sustainable advantage over the firm's competitors. A manufacturing strategy should be consistent with the firm's corporate and business strategies, as well as with the other managerial functional strategies. We present a process and a structured methodology for designing such a manufacturing strategy. This methodology has been successfully tested in actual manufacturing environments. An illustration is given based on work at Packard Electric.

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1. Introduction

For most industrial companies, the manufacturing operation is the largest, the most complex, and the most difficult-to-manage component of the firm. Because of this complexity, it is essential for firms to have a comprehensive manufacturing strategy to aid in organizing and managing the firm's manufacturing system. This paper provides a process and a structured methodology for conceptualizing and formulating a manufacturing strategy.

The manufacturing strategy cannot be formed in a vacuum; it affects and is affected by many organizations inside and outside the firm. Because of the interrelationships among the firm's manufacturing unit, the firm's divisions and other functions, and the firm's competitors and markets, it is necessary to carry the process of manufacturing-strategy design beyond the borders of the manufacturing organization in a single firm. Figure 1.1 illustrates the extent of these interrelationships and emphasizes the two basic types of interactions that must be considered for manufacturing strategy design. First, in developing and implementing the manufacturing strategy, the manufacturing function must work in concert with the finance, marketing, engineering and R&D, personnel, and purchasing functions. Cooperation and consistency of overall objectives are the keys to success in these types of interactions. Second, manufacturing strategy design requires careful monitoring of the markets external to the firm in conjunction with the aforementioned functional groups within the firm. For example, manufacturing managers, in conjunction with the engineering group, may monitor developments in the electronics industry so that they are aware of new applications of electronics to process technology in their industry. Similarly, manufacturing, in conjunction with marketing, monitors the product markets in which they compete so they are aware of the product improvements and product introductions of their competitors.

These observations suggest the necessary elements of manufacturing strategy

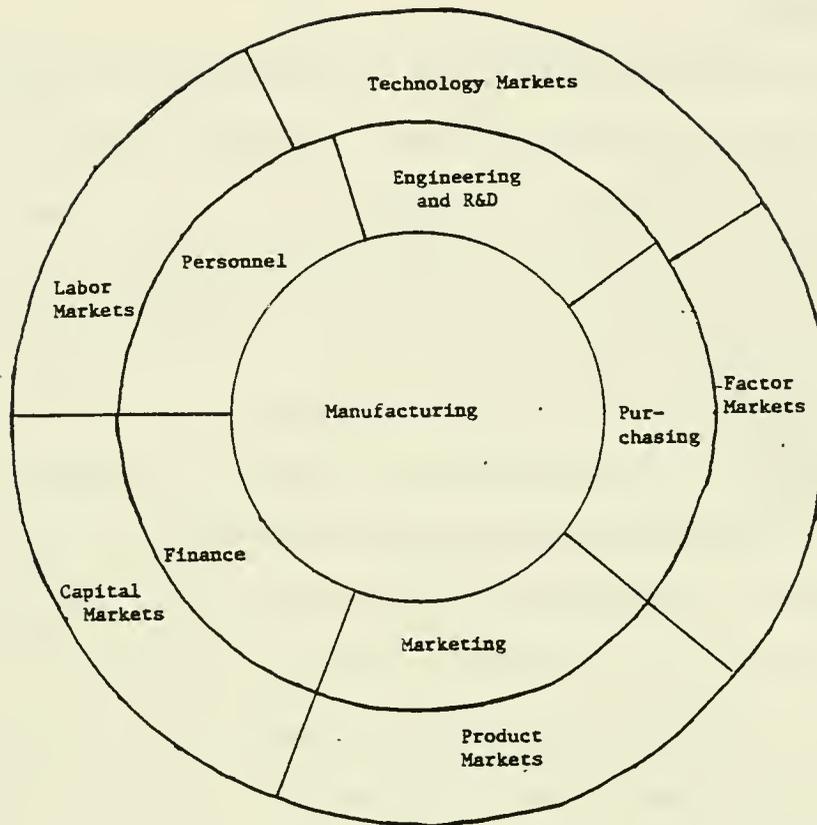


Figure 1.1 The Interface Among Manufacturing, The Remaining Functional Groups, and the External Markets

design and an outline for our approach to the problem. Following this suggested line of thought, we begin (in Section 2) with a brief discussion of the corporate strategic planning process and some of the conceptual issues that are important for manufacturing strategy design. Our principal contributions are in Sections 3 and 4 where we define and elaborate on the major strategic decision categories in manufacturing and provide a highly structured, and successfully tested, methodology for manufacturing strategy design. Section 5 contains a brief conclusion.

2. The Corporate Strategic Planning Process

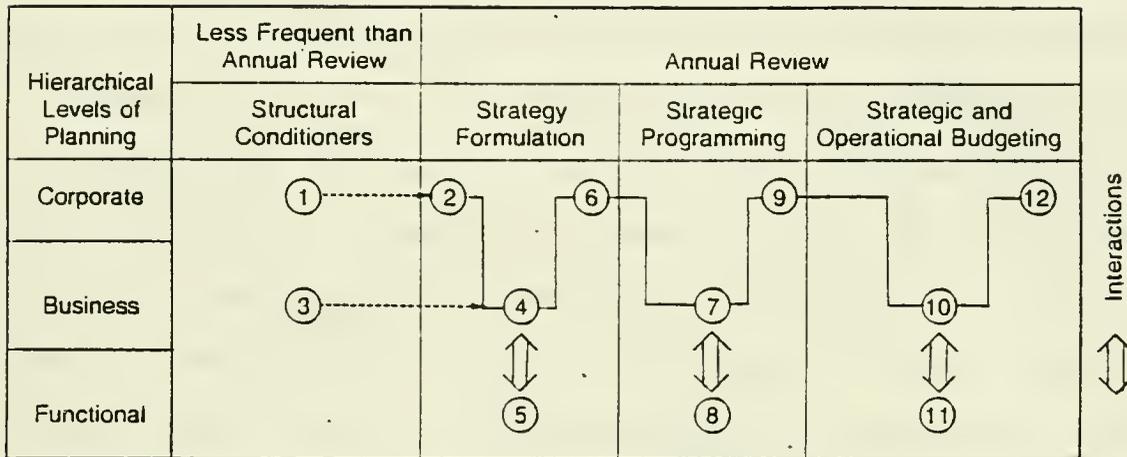
A strategy can be either articulated formally, with the help of a structured planning process, or stated implicitly by the actions of the various managers

within the firm. The essence of strategy is to achieve a long-term sustainable advantage over the firm's competitors in every business in which the firm chooses to participate.

The corporate strategic planning process is a disciplined and well-defined organizational effort aimed at the complete specification of corporate strategy. It identifies all the major tasks to be addressed in setting up corporate strategy and the sequence in which they must be completed. The specific characteristics of the planning process to be adopted by a firm depend on the degree of complexity of the firm's businesses, its organizational structure, and its internal culture. However, it is useful to recognize some fundamental tasks that can guide the strategic planning process of most firms. These tasks, described briefly in Figure 2.1, address the three basic hierarchical levels of the firm: the corporate, business, and functional levels. (For a comprehensive discussion of this subject, the reader is referred to Hax and Majluf [1984a,1984b].)

Each hierarchical level of the firm has a distinct and important role to play in the effort to achieve competitive advantage. Within the context of this paper it is appropriate to ask the question: at what level does the firm design its manufacturing strategy? The answer, obviously, is at all three hierarchical levels.

The corporate level, in its statements pertaining to the vision of the firm and its strategic thrusts, identifies the role that manufacturing should play in the pursuit of competitive superiority. Normally, the manufacturing objectives are expressed in terms of the four major dimensions of performance measurement used in formulating manufacturing strategy (Wheelwright [1981]): cost, quality, delivery, and flexibility. There are important trade-offs to be made among these objectives, since it is not possible to excel in all of them simultaneously. Defining the central manufacturing competitive thrusts and the tasks to accomplish them is at the heart of manufacturing strategy



1. The vision of the firm: corporate philosophy, mission of the firm, and identification of strategic business units (SBUs) and their interactions.
2. Strategic posture and planning guidelines: corporate strategic thrusts, corporate performance objectives, and planning challenges.
3. The mission of the business: business scope, and identification of product-market segments.
4. Formulation of business strategy and broad action programs.
5. Formulation of functional strategy: Participation in business planning, concurrence or non-concurrence to business strategy proposals, broad action programs.
6. Consolidation of business and functional strategies.
7. Definition and evaluation of specific action programs at the business level.
8. Definition and evaluation of specific action programs at the functional level.
9. Resource allocation and definition of performance measurements for management control.
10. Budgeting at the business level.
11. Budgeting at the functional level.
12. Budgeting consolidations, and approval of strategic and operational funds.

Figure 2.1: The Formal Corporate Strategic Planning Process
(Source: Hax and Majluf [1984a, 1984b])

design.

With respect to cost objectives, frequently used measures include labor, materials, and capital productivities, inventory turnover, and unit costs. Quality measures include percent defective or rejected, field failure frequency, cost of quality, and mean time between failures. To measure delivery performance, percentage of on-time shipments, average delay, and expediting response time may be used. Flexibility may be measured with respect to product mix flexibility, volume flexibility, and lead time for new products. This task of matching performance measures with corporate and business objectives can be difficult because of the often uncertain effects of changed short-term operating policies on long-term measures (Kaplan [1983,1984]).

The business level managers respond to the corporate objectives, assuring that all the managerial functions, including manufacturing, have plans that are consistent with the corporate vision and move the business toward the desired competitive position. Since business unit strategies are primarily a collection of well-coordinated multifunctional programs aimed at developing the fullest potential of each business; functional strategies, including manufacturing strategies, are developed primarily at the business level.

Finally, the functional managers, who might have participated actively in the development of the various business strategies, have to formulate the corresponding functional strategic programs. The nature of those programs and the strategic categories that must be part of a manufacturing strategy are the subjects of Sections 3 and 4 of this paper.

It is important to emphasize once more that the central objective of manufacturing strategy is to achieve long-term competitive advantage. Obviously, this objective cannot be fulfilled unless the firm understands how to position its manufacturing skills vis a vis its competitors. Recently, it has become obvious that neglect by many American firms of the manufacturing function has

contributed to a decline in our industrial competitive strengths. For some excellent discussion on this issue we refer the reader to Buffa [1984], Hayes and Wheelwright [1984], and Kantrow [1983].

3. The Strategic Decision Categories in Manufacturing

A manufacturing strategy must be comprehensive in the sense that it should provide guidelines for addressing the many facets of manufacturing decision-making. At the same time, the complex web of decisions required in manufacturing management must be broken down into analyzable pieces. Nine strategic decision categories provide a comprehensive coverage of the broad set of issues that must be addressed by a manufacturing strategy while dividing the manufacturing decision-making task into small, easy-to-analyze pieces.

These nine strategic decision categories are facilities, capacity, vertical integration, processes/technologies, scope/new products, human resources, quality, infrastructure, and vendor relations. Figure 3.1 displays the nine decision categories and suggests which other functional departments in the firm have input into each set of decisions. Due to space limitations, we can only describe a small number of key issues in each category that must be addressed by the manufacturing strategy. Section 4 then describes how these categories are used in the manufacturing strategy design methodology.

3.1 Facilities

Facilities decisions are the classic example of long-term, "cast-in-concrete" manufacturing decisions. A key step in facilities policy-making for a multi-facility organization is choosing how to specialize or focus each facility (Skinner [1974], Hayes and Schmenner [1978]). Facilities may be focused by geography, product groups, process types, volumes, or stage in the product life cycle.

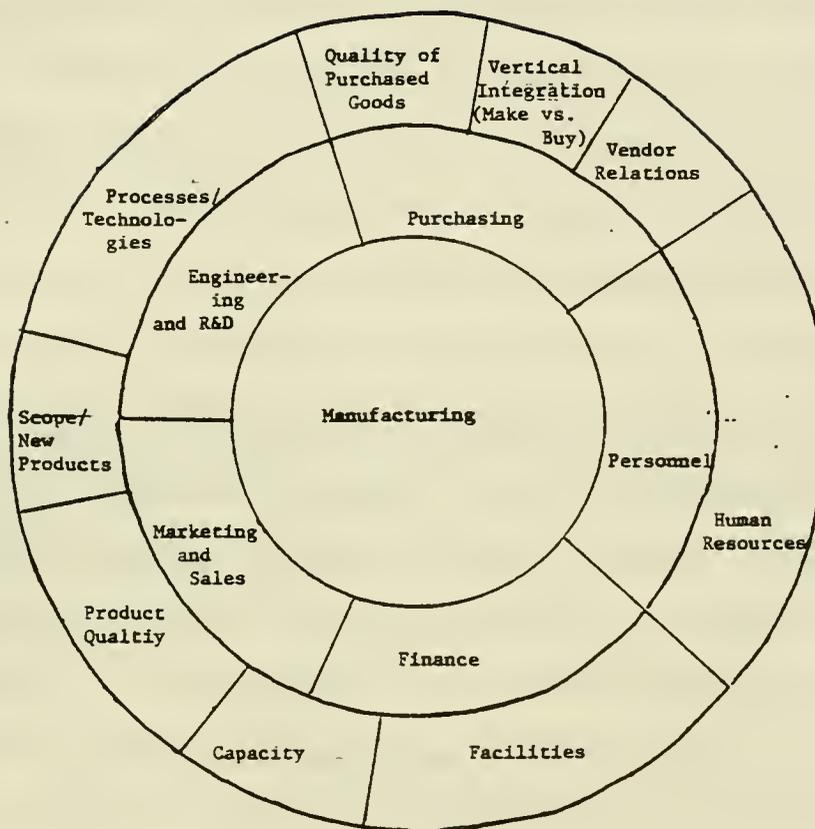


Figure 3.1: The Nine Strategic Manufacturing Decision Categories

In any given industry, such facilities-focus decisions usually depend on the economics of production and distribution for that industry. For example, due to the economies of scale in refining and the cost of transporting crude oil, oil companies tend to have process-focused plants that are located near crude oil sources (oil wells or ports). Consumer product companies have large, centralized plants when there are significant manufacturing economies of scale and non-critical delivery response requirements (e.g., non-perishable food manufacturers), and they have small, product- and location-focused plants if scale economies are not significant or closeness to the customers is important (e.g., furniture manufacturers). Firms in industries in rapidly changing environments, such as semiconductor firms, often focus plants by stages in the

product life cycle. One such configuration is to have low volume, high flexibility facilities for manufacturing prototypes; and high volume, dedicated plants for maturing products that are experiencing high demand.

Developing a well-thought-out facility focus strategy automatically provides guidance to the firm in other facilities decisions such as determining the size, location, and capabilities of each facility.

3.2 Capacity

Capacity decisions are highly interconnected with facility decisions. Capacity is determined by the plant, equipment, and human capital that is currently under management by the firm. Important capacity decisions include how to deal with cyclical demand (e.g. by holding "excess" capacity, by holding seasonal inventories, by peak-load pricing, by subcontracting, etc.), whether to add capacity in anticipation of future demand (aggressive, flexible approach) or in response to existing demand (conservative, low-cost approach), and how to use capacity decisions to affect the capacity decisions of one's competitors.

3.3 Vertical Integration

Operations managers are directly affected by vertical integration decisions because they are responsible for the task of coordinating the larger and more complex integrated system that usually results from vertical integration. The decision to vertically integrate involves the replacement of a market mechanism over which the operations managers have limited control by an internal, non-market mechanism that is the sole responsibility of the managers in the firm. Before making such a decision, a firm must assure itself that it has the capability of designing and controlling such a non-market mechanism that will be more efficient than the market it replaces.

Important issues related to vertical integration include the cost of the business to be acquired or entered, the degree of supplier reliability in the

important factors of production, whether the product or process to be brought in-house is proprietary to the firm, and the relative transaction costs (Williamson [1975]) related to contracting through market or non-market mechanisms. Other important issues are the impact of integration on the risk, product quality, cost structure, and degree of focus of the firm.

Legal ownership of the series of productive processes may not be the key element that determines the benefits of having integrated processes. Toyota Motor Company in Japan plays a very large role in directing the operations of its legally independent suppliers. Toyota gets the benefits of lower transaction costs (through what Porter [1980] calls a "quasi-integrated" market mechanism) because they coordinate the production of independently owned suppliers with the just-in-time system. The success of this system raises the question of whether the crucial element for success of integrated operations is ownership of the series of productive processes or management and coordination of the processes.

3.4 Processes/Technologies

The traditional approach to process choice has been to identify the principal generic process types (project, job shop, assembly line, continuous flow) and to choose among them for the production task at hand by matching product characteristics with process characteristics. (See, for example, Marshall et al. [1975] and Hayes and Wheelwright [1979].)

Although crude, this framework is quite useful for conceptualizing some important tradeoffs in process choice. Relative to assembly lines, job shops tend to use more general purpose machines and higher skilled labor, provide more product flexibility, and yield higher unit production costs.

Recent innovations in computer-aided design (CAD), computer-aided manufacturing (CAM), robotics, and flexible manufacturing systems have added more complexity to technology decision problems. New highly-automated factories

can be extremely expensive (e.g., see Bylinsky [1983] about Deere's \$500 million factory in Waterloo, Iowa and GE's \$300 million improvement in a factory in Erie, Pennsylvania). In many cases, these technologies can drastically change the manufacturing cost structure, capital intensity, unskilled labor usage, and ability to rapidly deliver high quality products at low cost.

Many firms decide to invest in these new technologies because they believe their survival depends on it. Traditional financial and accounting evaluation tools are often unable to capture all of the benefits that can be attributed to the installation of these systems. Because of these shortcomings, thorough strategic analysis is required to properly evaluate these investment choices.

3.5 Scope/New Products

The degree of difficulty of the manufacturing management task is influenced strongly by the scope or range of products and processes with which the manufacturing organization must be proficient (Skinner [1974]), as well as the rate of new product introductions into the manufacturing organization. In well-run manufacturing organizations, the manufacturing management must have significant input into product scope and new product decisions. Firms in environments that demand rapid and frequent product introductions or broad product lines must design flexible, responsive, efficient manufacturing organizations, must have product designers who have intimate knowledge of the effects of product design on the demands put on manufacturing, and must have good communication among design, marketing, and manufacturing.

3.6 Human Resources

Many students of management believe that the most important and the most difficult-to-manage assets of a firm are the human assets. (See, for example, Peters and Waterman [1983].) The principal issues in human resource management

are incentives and compensation, investment in human capital, labor union relations, hiring or screening policies, tenure policies, and job design. The principal challenge in human resource management is to design a set of policies that motivate and stimulate employees to work as a team to achieve the mission of the firm.

The design of such a set of policies can be quite complex. For example, with respect to incentives and compensation, a firm must decide whether to compensate its people as a function of hours worked, quantity or quality of output, seniority, skill levels, effort expended, loyalty, etc. Informational asymmetries (e.g. skill levels or effort levels are not costlessly observable by management) complicate the matter because the firm can only base compensation on observable measures. Aside from pecuniary compensation, employees often are rewarded with perquisites (such as cars or loans), training (human capital investments by the firm), employment guarantees, recognition for achievement, promotions to better jobs, etc. A well-thought-out incentive system will consist of a combination of these elements that promote quality, efficiency, and employee satisfaction.

3.7 Quality Management

Managing quality improvement is a crucial and extremely challenging task in most U.S. firms today. A quality improvement strategy requires zealous top management support and participation, a well articulated philosophy, and concrete goals and objectives. Such a strategy must specify how quality responsibilities are to be allocated among employees of the organization, what decision tools and measurement systems are to be used, and what training programs will be instituted for employees at various levels. To be successful, a quality improvement program must be viewed as a permanent, ongoing process whose philosophy is known and applied throughout the organization and whose

chief objective is the constant, never-ending quest for improvement. See Fine [1983] and Fine and Bridge [1984] for more detail on this subject.

Quality topics can be divided usefully into the categories of design quality and conformance quality. Although manufacturing managers should be involved in some degree with design quality (especially with respect to the design for manufacturability issue), conformance quality is the area where manufacturing managers play a most crucial role.

Three important issues related to managing for conformance quality are quality measurement, economic justification of quality improvements, and allocation of responsibility for quality. The two principal tools of quality measurement are statistical quality control (SQC) and cost of quality (COQ). Since both of these topics are well-covered elsewhere (SQC in Grant and Leavenworth [1980], and Burr [1976,1979]; COQ in Juran [1974], and Juran and Gryna [1980]), we will not elaborate on them here.

Economic justification of quality improvements is a difficult and controversial subject. Cost of quality accounting, the only economic tool that is widely used to evaluate quality projects or quality improvement programs, has two severe drawbacks. First, COQ ignores revenue effects of quality such as market share benefits and price premia for high quality products. Second, it emphasizes short-term cost effects without consideration of the long-term consequences of quality decisions. A system for measuring revenue effects of quality as well as cost effects is needed for sound economic decision making in the quality area. We know of no instances where measurement of the revenue effects of quality has been attempted.

Responsibility for product quality has traditionally resided in the quality assurance or quality control organization in the firm. (See, e.g. Juran [1974].) Recently (Deming [1983], Schonberger [1982]), this viewpoint has been challenged by the school of thought that each worker in the organization should be respon-

sible for the quality of his or her work. Implementing this proposal would require a significant change in many companies where hourly workers are not expected to exercise judgment on the job. Where implemented successfully, this corporate cultural regime has proven to be very efficient (Schonberger [1982]).

3.8 Manufacturing Infrastructure

To support decision making and implementation in the manufacturing function, it is essential to have a solid organizational infrastructure. As a part of this infrastructure, planning and control systems, operating policies, and lines of authority and responsibility must be in place. A corporate culture that reinforces the manufacturing strategy is also crucial as a cornerstone of the supporting structure. For a discussion of the integration among managerial processes, organizational structure, and corporate culture, see Hax and Majluf [1984b, Chapter 5].

We include decisions on materials management, production planning, scheduling, and control as a part of the manufacturing infrastructure decision set. With respect to materials management, firms should consider the relative merits of classical production and inventory systems, materials requirements planning (MRP), and just-in-time (JIT) in designing a system to fit their needs.

Production planning and scheduling decisions are typically thought of as tactical, rather than strategic decisions. However, in the areas of aggregate production planning and delivery system design, strategic considerations must be evaluated. In aggregate planning, the firm must decide how to match productive capacity to variable demand over the medium-term (12 to 18 months) planning horizon. The choices are usually to hire or lay off workers, schedule overtime or undertime, increase or reduce the number of work shifts, or build up or run down seasonal inventories.

With respect to design of the delivery system, the principal decision is whether the system should produce to stock or produce to order. In a make-to-

order shop, where flexibility is a crucial asset, the scheduling task is generally difficult, but the system responds readily to varying customer requirements. Make-to-stock shops are generally "under the gun" less often because they have finished goods inventories to buffer the production operation from customer demand. However, these operations tend to have significant finished goods holding costs. In many machine shops, where the number of possible products is extremely high, a make-to-stock system is not feasible.

3.9 Vendor Relations

There are two popular, but diametrically-opposed, views on purchasing and vendor relations strategy - the competitive (Porter [1980]) approach and the cooperative or Japanese (Schonberger [1982]) approach. The competitive approach recommends the development of multiple sources for most or all materials inputs. The idea is to have a number of firms that must compete among themselves to retain their supply contracts. Buyer-supplier relationships resemble spot contracting more than long-term contracting because suppliers can be dropped on short or no notice. Tapered integration is recommended as an additional threat to take business away from errant suppliers. All contracts are formal with many contingencies accounted for. Dependence on a supplier is to be avoided to as great a degree as possible.

The cooperative approach recommends developing long-term relationships based on mutual dependence and trust. Suppliers are given advice and training if their performance is unsatisfactory. Contracts are informal and contingencies are dealt with as they occur. Single sourcing is common.

The contrast between these two views is quite sharp. Each approach is practiced by successful firms. However, the recent trend in the U.S. seems to be toward trying the cooperative approach.

4. A Methodology for Structuring the Development of Manufacturing Strategy

The objective of this section is to describe and illustrate briefly the methodology we propose for the development of the manufacturing strategy of a firm. Although we recognize that any such methodology should be tailor-made to accomodate the idiosyncrasies of a given firm, we find that there are enough common issues in the formulation of a manufacturing strategy that it is possible to generate a useful, general-purpose process to guide managerial thinking in this area. Moreover, we desire to be as structured as possible in the specification of this methodology to allow managers to translate the basic concepts and principles of manufacturing strategy into pragmatic and concrete action programs.

The basic steps of the methodology we propose are summarixed in Figure 4.1. Each step will be reviewed, with occasional presentation of some of the forms we use to facilitate the reporting of the results of a given step. Obviously, strategic planning is not a form-filling exercise and there are significant dangers in over-specifying the planning process with detailed forms. We use those forms judiciously and we include them in here simply to allow for a more explicit understanding of the objectives of each step of our methodology.

Parallel to our description of the framework we will illustrate an abbreviated version of an application of the methodology on Packard Electric, a component division of General Motors. The study on which this illustration is based was conducted by a student of ours (Ortega [1985]). For pedagogical reasons, we have made some adaptations on his original work. We will concentrate our analysis on Packard's wire and cable SBU, which has four plants: three near division headquarters in Warren, Ohio and one in Clinton, Mississippi. A vast majority of Packard's sales are to General Motors, and Packard has been feeling significant pressure to reduce costs, improve quality, and improve product development.

1. Provide a framework for strategic decision making in manufacturing.
2. Assure linkage between business strategies and manufacturing strategy.
3. Conduct an initial manufacturing strategic audit:
 - (a) to detect strengths and weaknesses in the current manufacturing strategy by each decision category, and
 - (b) to assess the relative standing of each product line regarding the strategic performance measurements against the most relevant competitors.
4. Address the issue of product grouping:
 - (a) by positioning the product lines in the product/process life cycle, and
 - (b) by assessing commonality of performance objectives and product family missions.
5. Examine the degree of focus existing at each plant or manufacturing unit.
6. Develop manufacturing strategies and suggest allocation of product lines to plants or manufacturing units.

Figure 4.1: A Methodology for Structuring the Development of Manufacturing Strategy

4.1 A Framework for Strategic Decision Making in Manufacturing

A foundation of a manufacturing strategy is the conceptual framework that organizes the thought processes of the managers involved in the articulation of that strategy. The framework we use (which borrows heavily from Wheelwright [1984]) consists of defining the nine major categories of manufacturing strategic decision making (discussed in Section 3) and identifying the four manufacturing performance measures to address the objectives of the manufacturing strategy (discussed in the early part of Section 2.2). This framework is briefly summarized in Figure 4.2.

1. Major Types of Decisions Linked to the Manufacturing Function

- Facilities (number, size, location, focus)
- Capacity (amount, excess or tight capacity, expansion sequence, handling of peaks, competitive interactions)
- Vertical Integration (direction, extent, capacity balance among stages)
- Technologies and Processes (general or specific purpose, labor skills required, degree of automation, flexibility)
- Scope/New Products (product breadth, rate of new product introduction, length of product life cycle)
- Human Resources (incentives, skills, selection, training, security, unionization, participation)
- Quality Management (definition of quality, quality improvement programs, responsibility, training, quality control, prevention and testing)
- Manufacturing infrastructure (organization, planning and scheduling systems, control and information systems, inventory policies, forecasting, degree of centralization, lines of authority and responsibility)
- Vendor Relations (vendor strategies, selection, qualifications, degree of partnership, use of competitive bidding, controls)

2. Measuring Manufacturing Strategic Performance

- Cost (unit cost, total cost, life cycle cost)
- Delivery (percentage of on-time shipments, predictability of delivery dates, response time to demand changes)
- Quality (return rate, product reliability, cost and rate of field repairs, cost of quality)
- Flexibility (product substitutability, product options or variants, response to product or volume changes)

Figure 4.2: The Basic Elements of the Framework for Manufacturing Strategy

4.2 Linking Business Strategies to Manufacturing Strategy

The strategic planning process is hierarchical in nature. First, the corporate level articulates the vision of the firm and its strategic posture; next, the business managers develop business strategies in consonance with the corporate thrusts and challenges; and finally, the functional managers provide the necessary functional strategic support.

It is important, therefore, to assure the proper linkage between the business strategies and the resulting manufacturing strategy. To accomplish

this, we start by identifying the manufacturing requirements imposed by the set of broad action programs of each strategic business unit (SBU). Figure 4.3 displays a form for this purpose. The collection of manufacturing requirements represents the demands placed by the business managers on the manufacturing function. Occasionally, disagreements might occur between business and manufacturing managers as to the effectiveness or even feasibility of some of these manufacturing requirements. If concurrence cannot be reached by a direct process of negotiation, the nonconcurrence issues escalate to higher levels of the organization for resolution.

MANUFACTURING UNIT Wire and Cable

SBU	BROAD ACTION PROGRAMS	MANUFACTURING REQUIREMENTS
Wire and Cable	Identify GM requirements not being supplied. Study impact of silicon chips on cable substitution. Design packaging for new customers.	Assure capacity and technology for new demand. Plan for eventual electronics changeover. Develop new packaging capability.

Figure 4.3: Requirements Placed on Manufacturing by SBU's Broad Action Programs

4.3 Initial Manufacturing Strategic Audit

At this early stage of the manufacturing strategic planning process, it is desirable to perform a strategic audit on the current manufacturing strategy. Although analysis in subsequent stages of this methodology will contribute to the development of a more thorough diagnosis, we believe it is useful, at the outset, to extract from the participating managers their feelings about the status of their manufacturing function.

This initial audit has two objectives. The first is to assess the strengths and weaknesses of the existing manufacturing policies in each of the nine manufacturing strategic categories. Figure 4.4 presents a format for this evaluation. The second objective is to establish the competitive standing of each major product line according to the four measures of manufacturing performance. Figure 4.5 suggests how to conduct that evaluation. Notice that each product line compares itself against the leading competitors in each strategic dimension, and also establishes the relative importance of each dimension.

4.4 Addressing the Issue of Product Grouping

One of the most difficult problems in manufacturing planning revolves around the issue of product grouping. Even in relatively small firms, one encounters an extraordinary proliferation of manufactured items. Since it is impossible and undesirable to deal with each item in isolation, one has to find ways to aggregate individual items into product groups. This step in our manufacturing strategy methodology sheds light on the question of aggregation: how to group product lines into strategically sensible product groups that share common attributes?

We attack this question through two different analytical devices. The first is the product-process life cycle matrix, originally proposed by Hayes and Wheelwright [1979]. This matrix, depicted in Figure 4.6, positions each product line in a two-dimensional grid. The horizontal axis represents the

MANUFACTURING UNIT Wire and Cable

DECISION CATEGORY	DESCRIPTION OF PAST POLICY	STRENGTHS	WEAKNESSES
FACILITIES	Process Focus	Economies of Scale	Long physical supply distances
CAPACITY	Use overtime, third shift, and inventories to respond to cyclicalities	Flexibility	Layoffs and overtime are costly
VERTICAL INTEGRATION	Significant backward integration - all the way to wire rod	Good control over cost and quality	Less focus, transfer pricing complications
PROCESS TECHNOLOGIES	Cable & copper in automated, continuous processes. Printed circuits in job shop process	State-of-the-art in cable & copper	Automation in printed circuits could reduce costs
SCOPE/ NEW PRODUCTS	Respond to CM in principle lines	Low risk	Reactive rather than anticipatory Focus concept ignored
HUMAN RESOURCES	Strong quality of work life programs	Employee participation in decisions, good communications	Compensation system does not consider quality of output
QUALITY MANAGEMENT	Heavy use of Statistical Process Control and Cost of Quality tools	Integrated approach Top management support	Quality lags relative to Japanese competition
MANUFACTURING INFRASTRUCTURE	Control system with short-term, tactical orientation	Good control orientation	Short sighted system
VENDOR RELATION	Cost oriented competitive bidding Multiple sources	Keeps costs down	Hurts quality, cooperative ventures

Figure 4.4: Characterize Your Present Manufacturing Policies Regarding the Strategic Decision Categories

OPERATIONS UNIT Wire and Cable SBU

PRODUCT LINE	EXTERNAL PERFORMANCE MEASURES							
	COST		QUALITY		DELIVERY		FLEXIBILITY	
	IMPORT. *	PERFOR. **	IMPORT	PERFOR	IMPORT	PERFOR	IMPORT	PERFOR
1. Cable	30	++	40	-	20	E	10	-
2. Printed Circuits	20	--	50	E	20	+	10	+
3. Copper Rod	20	+	40	+	30	++	10	-

* IMPORT. = IMPORTANCE

** PERFOR. = PERFORMANCE RELATIVE TO LEADING COMPETITOR

ALLOCATE 100 POINTS ACROSS IMPORTANCE MEASURE. USE --, -, E, +, ++ FOR PERFORMANCE RANKING.

Figure 4.5: Assessment of Relative Importance and Performance of Each Product Line

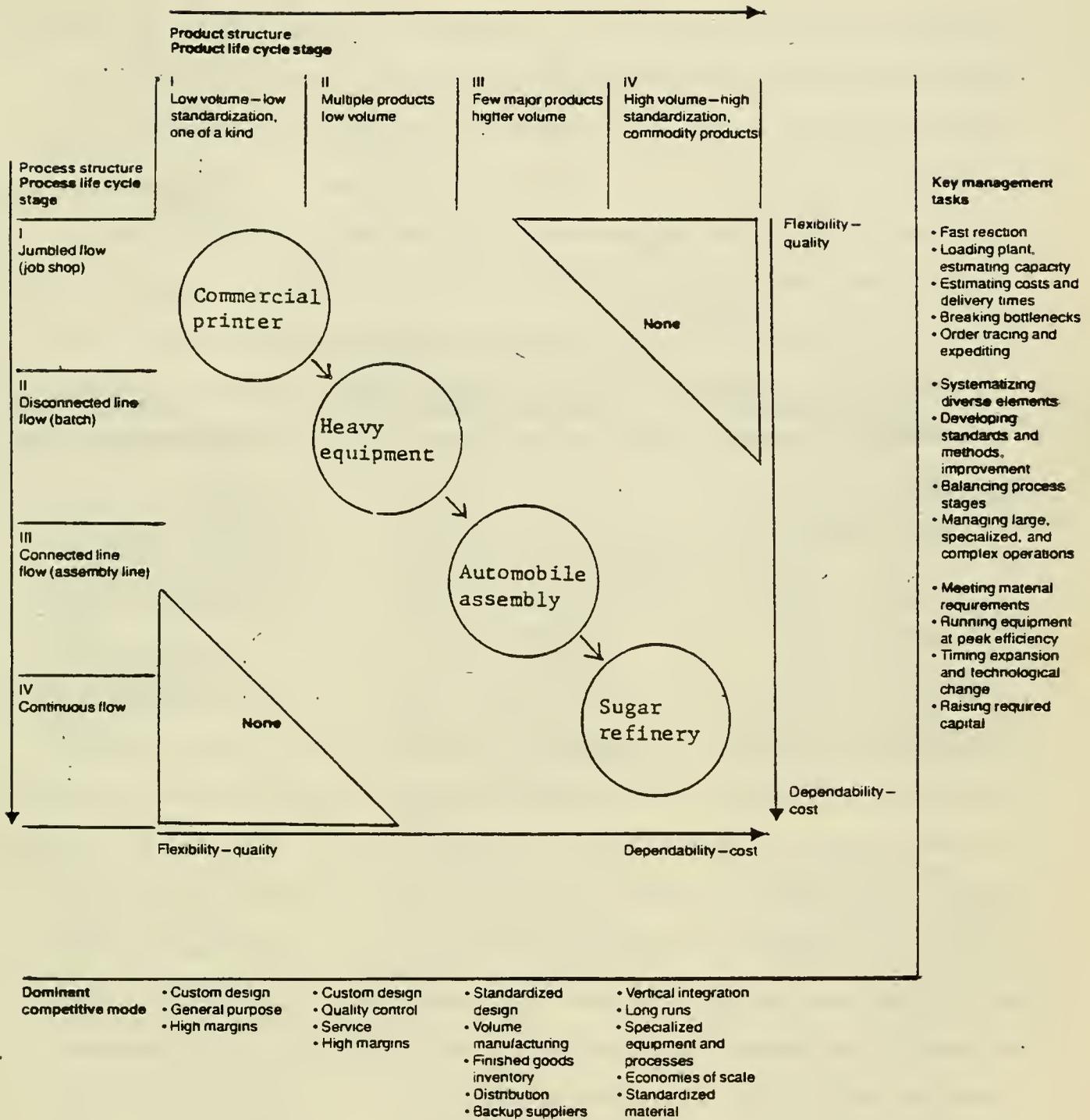
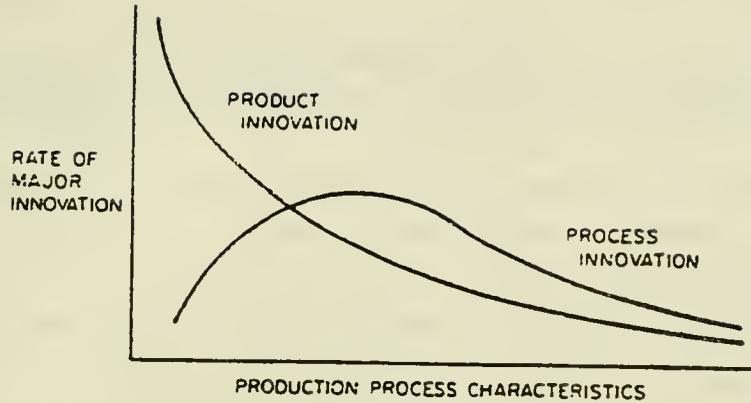


Figure 4.6: The Product-Process Life Cycle Matrix (Source: Hayes and Wheelwright [1979])

stages in the product-life cycle. The managerial implications of the product-life cycle have long been recognized as a valuable tool for analyzing the dynamic evolution of products and industries (Hax and Majluf [1984b], Chapter 9). As depicted in Figure 4.6, this evolution is displayed as a four-phase process initiated by low-volume, one-of-a-kind products, and culminating in highly standardized, commodity products. Similarly, the production processes used to manufacture these products travel through a corresponding evolution. The process evolution usually starts with highly flexible, but costly, job shop processes, and culminates with special purpose, highly automated manufacturing processes.

The matrix illustrated in Figure 4.6 captures the interaction between product and process life cycles. For the purpose of our analysis it provides two useful insights. First, it can show which of the firm's product lines are similarly positioned within their product-process cycles. This generates obvious candidates to be members of homogeneous strategic groups. Second, and more important, it is useful for detecting the degree of congruency existing between a product structure and its "natural" process structure. The natural congruency exists when product lines fall in the diagonal of the product-process matrix. A product line positioned outside the matrix diagonal could either be explained by inadequate managerial attention, or by concerted strategic actions seeking to depart from conventional competitive moves. (Utterback [1978] provides an excellent analysis of the matching characteristics of product and process as they evolve from a "fluid" to a more "specific" state. Figure 4.7 summarizes that analysis.)

We use Figures 4.8 and 4.9 to establish product line groupings by product and market characteristics and map these groupings onto the product-process life cycle matrix.



Fluid Pattern

INITIAL CONDITIONS

Product Innovation

- Emphasis on maximizing product performance
- Stimulated by information on user needs
- Novelty or radicalness high
- Frequency rapid
- Predominant type is product rather than process

Production Process

- Production process and organization is flexible and inefficient
- Size or scale is small
- General purpose equipment used
- Available materials used as inputs
- Product is frequently changed or custom designed

Transitional Pattern

Product Innovation

- Emphasis on product variation
- Increasingly stimulated by opportunities created through an expanding technical capability
- Predominant type is process required by rising volume
- Demands placed on suppliers for specialized components, materials, and equipment

Production Process

- Some sub-processes are automated creating "islands of automation"
- Production tasks and control become more specialized
- Process changes tend to be major and discontinuous involving new methods of organization and changed product design
- At least one product design is stable enough to have significant production volume

Specific Pattern

TERMINAL CONDITIONS

Product Innovation

- Emphasizes cost reduction
- Predominant mode is incremental for product and process
- Effect is cumulative
- Novel or radical innovations occur infrequently and originate outside productive unit
- Stimulation arises from disruptive external forces

Production Process

- Production process is efficient, system-like, capital-intensive
- Cost of change is high
- Scale and facility market share is large
- Special purpose process equipment used
- Specialized input materials used, or vertical integration is extensive
- Products are commodity-like and largely undifferentiated

Figure 4.7: The Relationship of Product Innovation and Production Process Characteristics
 (Source: Utterback [1978])

GROUP Wire and Cable

PRODUCT LINE	PRODUCT/MARKET CHARACTERISTICS				
	BREADTH OF PRODUCT LINE	MARKET VOLUME	MARKET GROWTH	PRODUCT STANDARDIZATION	PACE OF PRODUCT INTRODUCTION
1. Cable	high	high	medium	low	medium
2. Copper Rod	medium	medium	medium	high	low
3. Printed Circuits	medium	high	high	low	high

USE HIGH, MEDIUM, AND LOW (IF ACTUAL NUMBERS ARE NOT AVAILABLE).

Figure 4.8: Assessment of Product Grouping

PROCESS STRUCTURE PROCESS LIFE CYCLE STAGE	PRODUCT STRUCTURE PRODUCT LIFE CYCLE STAGE			
	I LOW VOLUME-LOW STANDARDIZATION ONE OF A KIND	II MULTIPLE PRODUCTS LOW VOLUME	III FEW MAJOR PRODUCTS HIGHER VOLUME	IV HIGH VOLUME-HIGH STANDARDIZATION COMMODITY PRODUCTS
JOB SHOP		Printed Circuits		
BATCH				
ASSEMBLY LINE				
CONTINUOUS FLOW	Copper Rod		Cable	

Figure 4.9: Position Each Product Line in the Product/Process Matrix

The location of copper rod manufacturing on the product-process matrix appears anomalous because low volume products are being produced on a continuous flow process. Historically, this came about because the copper rod is produced in the cable factory which is solely a continuous flow operation.

The second mechanism used to generate suggestions for product groupings is to identify families of product lines sharing similar competitor success requirements and product family missions. We recommend using a form similar to Figure 4.5, to search for product clusters with similar strategic performance characteristics and missions. Carrying out this task after the product-process life cycle matrix exercise tends to produce additional insights for grouping products.

4.5 Assessing the Degree of Focus at Each Plant

Ever since Wickham Skinner [1974] wrote his now classic paper on the focused factory, manufacturing managers in the U.S. have been giving significant attention to this important, but simple, concept. The central idea of focused manufacturing is that a plant cannot do a large variety of very different tasks exceptionally well. A factory that focuses on a narrow product mix for a well-defined market with a clear competitive objective, will outperform a conventional plant that attempts to do too many conflicting tasks with an inconsistent set of manufacturing policies.

To detect the degree of focus at each plant of a firm, we decided to use again the product-process matrix. This time we prepare one matrix for each plant, positioning within the matrix every product line manufactured at that plant. The resulting plot allows us not only to judge the degree of focus of the plants, but also to examine the degree of consistency between the products and the processes employed to manufacture them.

The final diagnosis can be summarized in a form like that exhibited in Figure 4.10.

OPERATING UNIT <u>Wire and Cable SBU</u>				
PLANT	EXISTING PRODUCT LINES MANUFACTURED IN EACH PLANT OR OPERATING UNIT	STRATEGY FOR PRODUCT LINE	STAGE OF PRODUCT LIFE CYCLE	PROCESS TECHNOLOGY CURRENTLY USED
10	Cable	Grow with industry	Mature	Continuous flow
	Copper Rod	Grow with industry	Mature	Continuous flow
22	Cable	Grow with industry	Mature	Continuous flow
	Metal Stamping	Hold position	Aging	Job shop
	Molding	Hold position	Aging	Job shop
3	Printed Circuits	Up or out	Embryonic	Job shop
	Plastic Molding	Hold position	Aging	Job shop
	Ignition Cable	Improve position	Mature	Assembly line
	Neoprene	Find niche & protect	Mature	Job shop

CONCLUSIONS: (COMMENT ON WHETHER THE PLANT OR OPERATING UNIT IS PRODUCT-FOCUSED, PROCESS-FOCUSED, OR HYBRID.)

Figure 4.10: Diagnosis of the Degree of Plant or Operating Unit Focus

4.6 Development of Manufacturing Strategies

The preceding analysis gives the necessary understanding of the basic issues involved in setting up a manufacturing strategy. The next step is to state strategic objectives, articulated through broad action programs, for each of the manufacturing strategic decision categories. Action programs may be targeted at one or more product groups. Figure 4.11 is helpful for performing this task. Each broad action program has to be supported by a set of specific action programs that can be monitored easily and whose contributions are measurable. Thus, for each manufacturing decision category, we suggest spell-

DECISION CATEGORY	OBJECTIVES		BROAD ACTION PROGRAMS
	LONG RANGE	SHORT RANGE	
FACILITIES	Rationalize plant focus	Study focus issue	Consider separating stamping and molding operations
CAPACITY	Respond better to fluctuations	Meet recent demand upturn	Design a model to simulate the impact of product substitution in cable capacity
VERTICAL INTEGRATION	Integrate only when strategically justified	Standardize make-or-buy decision process	Reduce backward integration for increased flexibility
PROCESS/ TECHNOLOGIES	Maintain state-of-the-art	Install more automation	Increase automation where possible
SCOPE/ NEW PRODUCTS	Anticipate customer needs	Upgrade customer contact	Become involved in GM decision process
HUMAN RESOURCES	Utilize fully employee resources	Upgrade personnel function	Improve compensation system
QUALITY MANAGEMENT	Institutionalize improvement	Improve training	Increase self inspection by operators
MANUFACTURING INFRASTRUCTURE	Develop central system to support new automated mft. technologies	Improve performance measurement system	Design new performance measures
VENDOR RELATION	Develop closer ties	Propose joint projects	Identify vendor candidates for joint projects

Figure 4.11: Define Broad Action Programs for Each Manufacturing Strategic Decision Category

ing out the information pertaining to its corresponding specific action programs, as indicated in Figure 4.12.

DECISION CATEGORY Quality Management

PROGRAM DESCRIPTION	PRIORITY	COST	MANPOWER REQUIREMENTS	SCHEDULED COMPLETION	RESPONSIBILITY
Improve quality training	A	\$150K	2 man-yrs	August 86	VP for Quality
Develop cost-of-quality system	B	\$700K	10 man-yrs	1987	Controller & Quality VP
Implement experimental design concepts	C	\$25K	½ man-yr	1986	SQC experts & design engineers
Fit quality into incentive scheme	B	\$75K	1 man-yr	1986	Personnel & Quality VP

CATEGORIZE AS FOLLOWS:

- A = ABSOLUTE 1ST PRIORITY - POSTPONEMENT WILL SIGNIFICANTLY HURT OUR POSITION.
- B = HIGHLY DESIRABLE - POSTPONEMENT WILL ADVERSELY AFFECT OUR POSITION IN THE MARKET.
- C = DESIRABLE - IF FUNDS WERE TO BE AVAILABLE TO ENHANCE OUR POSITION.

Figure 4.12: Define Specific Action Programs to Support the Broad Action Programs for each Manufacturing Strategic Decision Category

We recognize that different companies will pursue different paths to manufacturing strategy design. However, we have tried to capture in our framework and methodology the essential elements that must be considered by any firm attempting to design a manufacturing strategy.

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