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ABSTRACT

A SYSTEMATIC APPROACH TO DEFENSE DIVERSIFICATION

by
Sathappan Venkatachalam

The decline in defense spending has resulted in defense dependent companies seeking new markets through re-designing existing products, developing new products and restructuring their businesses. Defense diversification is defined as the process of transitioning a defense company's core capabilities (technologies, products, services) into commercial and non-Department of Defense government markets. A combination of site visits and review of the literature on defense diversification demonstrates the need for diversifying companies to adopt a systematic approach.

A concurrent new product development/product redevelopment model is proposed, based on the principles of concurrent engineering. The model consists of an eight phase development cycle and a set of enablers which are the key supporting processes and practices.

A phased sales cycle was formulated for a diversifying, defense dependent company. A survey of a sample of successful and unsuccessful companies in the different stages of diversification and a commercial company was performed using a questionnaire developed for this purpose. The survey responses were quantified using a scoring methodology devised as part of this thesis. The higher the score, the better the chances of success for a company in defense diversification. An analysis of the survey responses, together with company specific factors and changes, validated the fundamental applicability of the model.

**A SYSTEMATIC APPROACH
TO DEFENSE DIVERSIFICATION**

by
Sathappan Venkatachalam

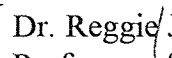
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Submitted to the Faculty of
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in Partial Fulfillment for the Degree of
Master of Science in Manufacturing Systems Engineering
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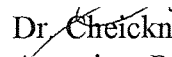
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TO DEFENSE DIVERSIFICATION**

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This Thesis is dedicated
to my parents

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CHAPTER 1

INTRODUCTION

1.1 Defense Diversification

The current and expected continued decline in the Department of Defense (DoD) spending places a high degree of urgency on most defense companies to quickly and deliberately take actions to improve business performance for the short term and begin the process of developing new products for new markets. For those companies which wished to remain exclusively in defense markets, they have faced continued industry-wide consolidation, increased competition and required improvement in their time-to-market performance from both a price and technology perspective. The decline in defense spending also has far reaching impacts on the preservation and advancement of defense related critical technologies.

Companies have responded to the defense spending cuts by pursuing one or more of the following strategies: closing plants and offices; selling off defense divisions; exporting arms abroad; seeking other government or commercial markets for existing products; internal diversification through development of new product lines, forming strategic partnerships with other firms or acquiring/merging with divisions of other firms which make related products; and external diversification through the acquisition and buy-outs of existing firms in unrelated fields (Markusen and Hill 1992).

Defense diversification is the process of transitioning a defense company's core technologies into commercial and non-DoD government markets. Companies, both prime

contractors who are the first-tier suppliers and their subcontractors who are the second - tier suppliers , have to:

- Implement a structured diversification approach and be prepared to significantly restructure business operations to be competitive in the new markets.
- Change from a Request-for-proposal (RFP) response oriented culture to a sales force prospecting mode of obtaining new business. It is important to realize that reconstructing sales and marketing channels without changing the approach to product development , manufacturing, quality and distribution will not produce desired results.

1.2 Impact of Defense Spending Cuts in New Jersey

New Jersey ranked tenth in 1991 and eleventh in 1992 amongst states receiving defense prime contract awards. (DoD Report 1993). New Jersey, with its heavy investment in military electronics, aerospace, and telecommunications has lost and will continue to lose substantial manufacturing employment as a result of defense budget cuts.

The spending cuts have impacted the critical high-value end of the manufacturing sector, particularly the electronics industry with its many small defense-dependent subcontractors. 97% of the companies have less than 500 employees and 85% of the companies have less than 100 employees. (Source: U.S.Department of Commerce, Bureau of Census, County Business Patterns - New Jersey, 1989 and Dun & Bradstreet Database). Major defense contractors like AT&T, GE Aerospace, ITT Avionics and Martin Marietta have been adversely affected. Thousands of small subcontractors who serve these major defense prime contractors have also been affected.

The general solution to the problems of defense-dependent firms is clear (Caudill 1993) : the sophisticated skills and equipment used in the production of military goods should be redeployed to serve the needs of growing commercial markets at home and abroad. Many large firms and most small New Jersey firms that have focused on defense contracts will need technical, managerial, and marketing assistance if they are to make the transition successfully. This is so because military goods markets have long been unique in terms of engineering standards, cost accounting methods, and sales and contracting procedures. In fact, few lessons learned in the defense environment are useful to firms that must now compete in volatile industrial and consumer markets. As a result, small defense-related firms are particularly ill-equipped to operate in commercial environments where survival requires:

- Cost minimization and competitive pricing;
- Flexible manufacturing processes that can produce limited production runs efficiently and respond quickly to changing market conditions;
- Value engineering and methods of quality assurance appropriate to producer and consumer markets;
- Rapid, internally-driven innovation in process and product design;
- Customer-oriented business cultures and worker involvement in the management of change;
- Competence in market research, marketing , promotion, distribution, sales, and after-sales service.

According to the New Jersey Department of Commerce, Office of Economic Research, 163,753 total New Jersey workers are dependent in some way on defense contracts. Of the 837 companies in ten industries in New Jersey which are heavily defense-dependent, 65% are electronics manufacturing companies. A reduction of 30% in total jobs is expected by 1997 due to defense spending cuts. (NJDOC Report 1992, 1993).

Of the 235 defense contractors who were surveyed by the New Jersey Department of Commerce in 1993, the following were the strategies which companies employ for reducing their current dependence on defense contracts.

- Develop new, non-defense products (41% have done, 25% would consider)
- Expand domestic sales force (31% have done, 33% would consider)
- Expand exporting program (33% have done, 28% would consider)
- Acquire another product line/firm (13% have done, 42% would consider)
- Merge with another firm (5% have done, 30% would consider)

1.3 Types of DoD Suppliers

There are two major categories of suppliers - Prime Contractors (PC) and Sub Contractors (SC). As the names imply, a PC's customer is the Defense Logistics Agency (DLA), the agency of the DoD responsible for logistics. The SCs are suppliers to the PCs and are functionally organized into tiers - first tier, second tier etc. Again, the lower tier SCs are suppliers to the upper tier SCs. The defense contracts are awarded and administered by the Defense Contract Management Area Offices (DCMAOs).

A company irrespective of its size - large, medium or small, can become a PC. Most of the time, the small and medium sized companies are SCs to the larger companies who are PCs. A company is a PC or a SC depending on the value of their individual supply in the total value chain of the contract.

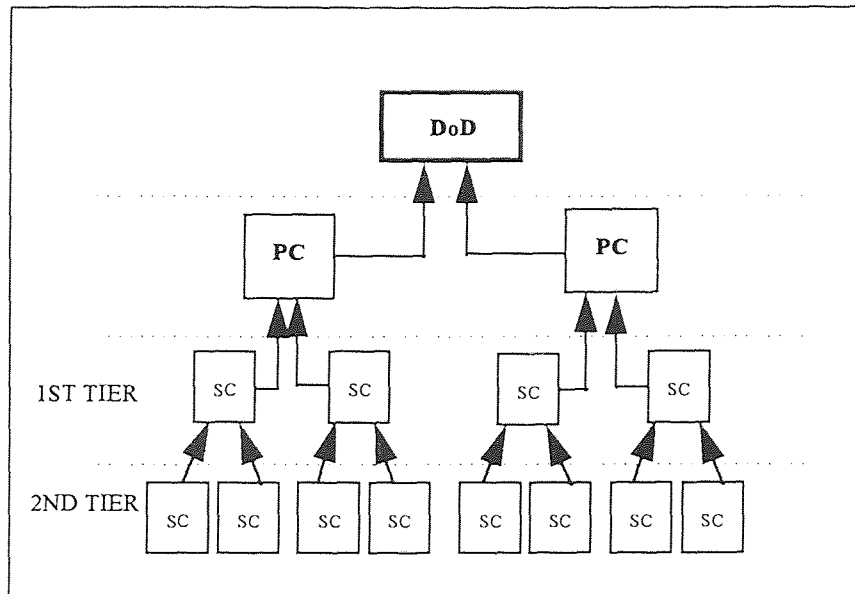


Figure 1.1 DoD Supplier Chain

PCs and SCs could be further classified into two categories depending on their dependence on DoD - Military (M) and Commercial-Military integrated (CM). A company in the former category depends on the DoD for all of its sales whereas the latter is partly dependent on DoD and partly on the commercial market for its sales. When a company is CM, by virtue of their knowledge of the commercial markets, they have an edge over the M companies in the diversification process. In the CM companies, the Sales

& Marketing function is represented either by a functional department or by an individual, usually the Chief Executive.

1.4 New Product Development / Product Re-development

Bischak et al. (1992); Oden et al. (1993, 1994); NYSDDED Report (1993); and other studies have found that two initiatives have been at the core of the efforts of defense diversifying companies - New Product Development (NPD) and Product Re-Development (PRD), for both known and new markets. 'Known' markets are the civilian markets which the companies currently serve and 'New', as implied, are those markets which the company wishes to penetrate with its new or existing products.

Figure 1.2 shows the typical product-market mapping efforts of companies. 'Existing' are those products which the company currently sells to the PCs, DoD or civilian customers. 'Re-Develop' are products which result from changes made to the design of existing products and developed to suit the market requirements. 'New' are those products, may or may not be of the same product type as the ones which the company presently sells, which are designed and developed.

		PRODUCT		
		EXISTING	RE-DEVELOP	NEW
MARKET	KNOWN	Low	Medium	High
	NEW	Medium	High	High

EFFORT

Figure 1.2 Product - Market - Effort Mapping

The degree of efforts of companies for the various Product-Market groups have been relatively termed Low, Medium and High. They can be explained as:

- **Low:** This type of effort involves sales solicitation for new customers, market research based on existing customer groups for selling more of the existing products.
- **Medium:** New markets are those which the company is not serving currently. To penetrate and compete in entirely new markets involves re-development of existing products to suit the needs of these markets, which only be accomplished by doing extensive market research on the new markets, product benchmarking with competitor's products and an effective redesign of the existing product. This type of effort also involves investment in terms of equipment purchase, retooling etc.

- High: A “high” effort involves the development of products based on a new technology or tapping the existing technology of the current products. Besides being an organization-wide effort and on a longer time frame compared to the earlier categories, this effort involves extensive market research, benchmarking of competitor’s products. Product differentiation by way of cost and quality holds the key to market success.

1.5 Concurrent Engineering

The process of NPD and PRD cannot be better realized than through the adoption of Concurrent Engineering (CE) practices. The Defense Advanced Research Projects Agency commissioned a five year pioneering study in concurrent engineering from 1982 to 1987. According to its Institute for Defense Analyses Report R-338, CE can be defined as, “ a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule, and user requirements.”

CE is other wise known as Simultaneous Engineering, Integrated Product and Process Development, Integrated Engineering, and Integrated Product Development. Regardless of the term used, it is a sound methodology to use during the product development cycle.

The key ingredient in CE is teamwork. People from many departments collaborate over the life of a product - from idea to obsolescence - to ensure that it reflects customer’s needs and desires. Marketing, engineering and manufacturing, for example, work together

from the outset to anticipate problems and bottlenecks and to eliminate them early on. In so doing, delays in bringing the product to market and costly failures in service can be avoided. Accounting and purchasing departments too are part of the team and they help to ensure low product cost and reliable supplies of part and materials.

In the traditional Serial Manufacturing, engineering department's design gets 'tossed over the wall' to manufacturing. CE is much more than teamwork. Computer aided-design (CAD), engineering and manufacturing tools play a big role. Systems for sharing and managing design information are vital in large projects (Floyd et al. 1993).

Defense industry contractors are used to another form of concurrency, which can be called Concurrent production. This is the practice whereby defense contractors literally 'squeeze' numerous steps of the production process into fewer processes. It is in fact, serial production, in a condensed form. In commercial firms, various steps involved in going from the research and development stage, to developing the product, to the testing of the prototype ordinarily occur before the product goes into production. But the DoD encourages defense contractors to condense steps, frequently even skipping the prototype stage. Because steps are condensed, with two or more performed at the same time, problems encountered in developing the product often are not corrected before the prototype has been fully scrutinized. Instead, problems are often confronted and addressed after they are produced and sometimes even delivered by the military-serving firm. It makes good engineering and business sense to employ CE practices, which have been successfully tested in the process of NPD and PRD in commercial companies.

1.6 Research Approach

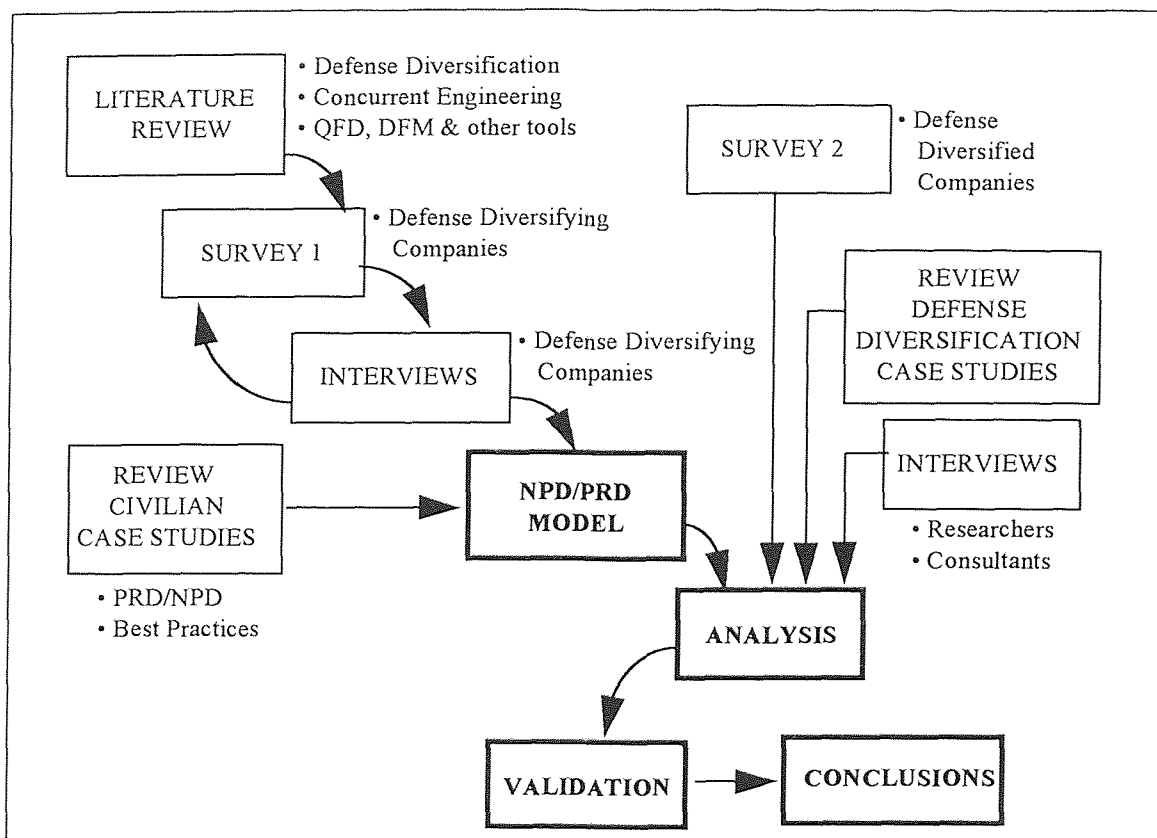


Figure 1.3 Research Approach

Figure 1.3 is a flow diagram of the research approach. A literature review was done on Concurrent Engineering (CE) including the following:

- Elements of CE;
- CE practices;
- Case studies on CE implementation;
- Tools for CE.

A literature review was also done on Defense diversification:

- The defense industry;
- Surveys of defense contractors;
- Characteristics of defense companies;
- The process of selling to the military;
- Past diversification efforts; and
- Barriers to diversification.

Case studies on new product development and product redesign in commercial companies were also reviewed.

A survey (survey 1, survey instrument in Appendix A) was done with a set of small subcontractors in New Jersey as part of the New Jersey defense diversification project. These companies were identified by the New Jersey / Pennsylvania chapter of the American Electronics Association as being in need of defense diversification assistance, and, are representative of the general mix of small subcontracting companies in New Jersey. Site visits and interviews with key personnel followed. Also case studies and new product development in commercial companies were reviewed.

The survey and studies demonstrated the need for companies to adopt a systematic defense diversification approach; and led to the formulation of the Concurrent New Product Development/ Product Re-development (CNPD/PRD) model. The model is based on commercially well-tested and practiced principles.

A survey (survey 2) on a sample of successful and unsuccessful companies in the different stages of diversification and a commercial company. This survey was performed

using a questionnaire developed specifically for this purpose (Appendix B). The questionnaire was designed to help identify the typical processes and practices employed by these companies in new product development and product redesign. The questions were based on the concurrent engineering model which was formulated. Companies were also asked to identify their critical success factors and organizational changes which have had significant impact on the overall performance of the company.

Classic and contemporary defense diversification case studies were reviewed and interviews were conducted with researchers and consultants who work with defense diversifying companies, and , the personnel in the respective companies.

A scoring methodology was devised and the survey responses were tabulated and quantified to obtain the total score for each company. Every company was analyzed on five dimensions - total employment, annual sales and defense dependence changes between 1992 and 1994, total score and the aggregate score for sales and costs. Two levels of value - 'ideal' and 'at least' were identified for each of the five dimensions. The assumption made here was that each dimension is indicative of the individual company's success in defense diversification. The total score, being one of the dimensions for analysis, helped identify the relationship between the use of the elements in the CNPD/PRD model and the success of each company in its diversification efforts. A high total score is thought to improve the chances of success for a company in defense diversification.

A phased sales cycle chart, showing the life cycle trend in terms of annual sales, in a defense company is formulated and explained. During the analysis, information on the

companies helped map the individual company to one of the phases in the sales cycle chart. Defense diversification case studies are presented to help reinforce the importance of company strategies , changes , practices and processes.

Conclusions were drawn from the analysis on the contributors to successful defense diversification, including the impact of the NPD/PRD model.

1.7 Organization of the Thesis

Chapter One contains the introduction to this thesis. Literature survey on defense diversification is the subject of Chapter Two. Chapter Three profiles the literature and examples on New Product Development and application of CE practices. Data on the defense diversifying companies in New Jersey which were part of the survey 1 together with the CNPD/PRD process model is the subject of Chapter Four . Data collection on defense diversifying companies, analysis, case studies, insights gathered from researchers and consultants is contained in Chapter Five. Chapter Six concludes this thesis along with recommendations for future work.

CHAPTER 2

DEFENSE DEPENDENT COMPANIES

2.1 The Defense Company Characteristics

There are great differences in company practice and culture between defense and commercial companies. Most large defense contractors (usually PCs) are accustomed to low-volume production of highly specialized, expensive equipment. In designing the equipment, the main emphasis is on technical performance and meeting DoD requirements. In contrast, many commercial products have to combine reliability and affordable cost with high-volume manufacture.

Technical performance of the product, as opposed to cost, drives the design and hence the manufacturing processes. Defense contracts may lock in technologies and applications that no one producing commercially is willing to build at reasonable cost. Another source of difficulty is the DoD practice of imposing rigid, detailed specifications and standards throughout procurement.

DoD contracts impose unique terms and conditions, requiring information that commercial companies do not routinely collect or cannot certify with assurance. Companies typically respond to such requirements either by establishing special data management or administrative systems, which adds cost and inefficiency.

The government's accounting requirements, sourcing preferences, or contractor responsibility provisions generally force sellers to set up government-unique administrative

procedures, data collection and management systems in order to comply. These laws and regulations have the following effects:

- require commercial companies to establish special accounting procedures and other information collection systems at their own cost simply in order to bid on government work;
- require changes in supplier networks, sources of supply, hiring and personnel practices; and
- require companies to provide proprietary process information for possible distribution among their competitors.

A 1991 survey results indicate that most companies that operate in both the commercial and federal markets (Dual-Use markets)either physically segregate some portion of their operations or set up a separate data management system to do business with the government. This is due to the requirements of federal contracting rather than unique technology needs. The survey respondents indicated that the segregation is required due to the following requirements:

- unique accounting requirements (cost and pricing data, cost accounting standards and principles);
- unique contracting requirements (socioeconomic and contractor responsibility provisions, sourcing preferences, certifications, etc.);
- government oversight and audit procedures;
- protection of proprietary data;
- penalties for certification errors; and

- quality control and technical requirements.

This results in

- Higher prices. Due to the segregation in production, and hence the associated costs, it leads to higher prices.
- Creation of special data management and administration procedures to comply with federal contract requirements drives up the cost of federal procurement.

This cost differential makes it relatively more difficult for defense companies to diversify their operations into commercial markets. The overheads associated with complying with federal contractual requirements carry a significant administrative cost burden - the ability of defense contractors to price competitively for a commercial market is severely impaired.

Still more pervasive are different management practices which are in part due to detailed government supervision. Defense contracting is probably the most heavily regulated business in the United States. In addition to the usual environmental, health and safety, and fair labor regulations that apply to all firms, defense companies must comply with DoD reporting requirements and undergo extensive reviews and audits. The reason for such detailed oversight was the government's concern that taxpayer's dollars not be wasted and that defense contracting not be prey to favoritism or fraud. This results in large overhead costs which are then passed along in higher prices to the government. A major reason why companies doing both defense and commercial work keep the two sides separate is not to burden the commercial business with overhead from the defense side (OTA Report 1992).

Because defense contractors are fully compliant with all of the administrative and technical requirements of military standards, which often specify organizational, management and reporting procedures, they carry a much larger overhead burden than a commercial operation. This is in addition to the sizable overhead incurred in complying with statutory and regulatory requirements of government contracting.

The subcontractors are not spared either. When a military specification or standard, or a government - unique contractual requirement is added to a prime contract, the prime contractor will often “flow down” that requirement to its subcontractors. Typically, the primes flow down the requirement to protect themselves, because ultimately, they are responsible for providing any required documentation to the system or item being purchased. This ensures that DoD receives a full milspec item.

2.2 Small Business and the Defense Industry

A small business is defined by Small Business Administration Federal Acquisition Regulations (SBA FAR 19.101) as one that is independently owned and operated, is not dominant in its field of operations, and with its affiliates does not employ more than a specified number of employees, usually not more than 500, 750 or 1000, depending on the type of product called for by the contract.

Small and medium-size firms - collectively, “small business” are important players in defense production, accounting for one-third of DoD purchases. These firms might range from a 10-person machine tool shop, to a semiconductor producer with nearly 500 employees, to a manufacture of missile engines with just under 1000 workers.

Some of the small defense firms are niche producers of sophisticated or specialized military goods and have little experience in commercial production and marketing. During the times of defense spending reductions, these firms are strongly motivated to survive by converting to commercial production. Other small companies that produce military goods, either as prime contractors or subcontractors, already sell some of their output to commercial customers; many of them continuously look to expand their sales. These are companies which can be called commercial-military integrated.

A 1989 survey of 97 small and medium-size prime DoD contractors and subcontractors in Ohio found that only 50% of their sales were to the military. A 1990 survey of small prime defense contractors in New England showed that 40% of sales were to DoD. In St.Louis, 152 small prime-defense contractors responding to a survey reported that only 30% of their sales were to DoD. Similar results were found from a survey in Pennsylvania (OTA Report 1992).

2.3 Sales to DoD

Military serving firms sell their products to only one customer when contracting with the DoD, a condition which economists call a monopsonistic market. DoD officials have a great deal of input into every facet of the business including the products contractors make, the quantity they manufacture and the technical specifications of the desired equipment, wages, insurance and worker benefits. This is also due to the fact that at least three-fourths of all defense contracts are distributed on a non-competitive basis. DoD

officials also influence which firms do the subcontracting work. DoD officials specify the criteria used by prime contractors to select subcontractors.

Sometimes the DoD guarantees a market to military contractors. In 1986, since no U.S. firm produced silicon that is pure enough to meet the needs of the DoD for missile guidance systems, it created a \$8 million market for American companies (BW Report 1986).

The military serving firm is not an economizing enterprise. Since, weapons systems with the latest technology rather than the systems of lowest costs is of interest to the DoD, the military serving firms are largely unconcerned with minimizing costs. Costs are typically driven up by one or more of the following :

- Cost overruns: After receiving a contract award from the DoD for a specified dollar amount, a military-serving firm renegotiates with government officials so that the DoD will underwrite additional costs.
- Highly paid personnel: High costs are common in military-serving firms also because of their very big and relatively higher paid technical and professional staffs.
- Concurrency: This is the practice of combining numerous steps of the production process into fewer ones, many times even skipping the prototype stage. Hence problems are often confronted and addressed after the products are produced and sometimes even delivered.
- Historical costing: Engineering costing attempts to minimize costs by seeking alternative ways to produce the desired material or weapons in the most price efficient way as possible. But historical costing examines past prices and projects the averages

of a given number of years into the future. Historical costing thus assumes that costs and prices will continue to increase over time (Melman 1983; Fitzgerald 1972).

- **Inefficiency and Waste:** This is due to inefficient company control over the production processes, poor decision making, the red tape and excessive administrative requirements related to doing Pentagon procurement work push up unit costs in military serving firms.

Profits as a percent of investments are significantly higher for the military serving firms because DoD supplies much of the production equipment and material. Hence, contractors invest little capital in production, enjoy very low risks, and high profits.

Also, to varying degrees, R&D expenditures are subsidized by the DoD. Waste, management inattention to costs and concentration on making high and fast profits, often adversely affect a firm's commercial business. Technical personnel have a "trained incapacity" to produce for civilian markets because of inefficient engineering and cost control practices which encourage high R&D overheads (DiFilippo 1991). Managers, engineers, and sales personnel with a long involvement in defense accumulate competencies and special skills which have high value in the defense arena - managers organize and complete large multi-year projects; engineers adeptly design and integrate high performance systems; sales personnel are skilled at negotiating with DoD and Congressional customers. Unfortunately, the knowledge and competencies associated with these activities are exceedingly difficult to leverage into different market areas.

2.4 Diversification in Small and Medium-Size Firms

Small companies making commercial and military sales are better equipped to increase their commercial sales. Though these firms must keep separate accounts for their defense work, there is no segregation in the workforce or in the production equipment. Sometimes the same products are sold to their military and commercial customers. Unlike major companies that are in both defense and commercial businesses, small companies rarely have separate defense divisions. They are inherently dual use, especially the small metalworking companies. The reason could be one of limited resources and lower defense dependency compared to the major businesses.

Though it is technically feasible for these companies to substitute commercial work for declining defense contracts, they face stiff competition in getting commercial customers. These companies have a high degree of sophistication with their production and testing equipment as a result of making products for the military. In a survey in Massachusetts, conducted by the Maryland's Department of Economic and Employment Development, companies felt that there is no loyalty in DoD contracting and little repeat business, which means there is a new learning curve on each order, which in turn lowers profits. DoD business also involves waste of time - in waiting for contracts, waiting for clarification of drawings, extra paperwork, and the incredible detail of military specifications. With commercial customers, the company can develop long-term relationships and trust; take orders or ask for clarifications over the phone; and get orders for many different parts or long runs of particular parts without going through new bids and new competition. The high-tech production and quality inspection equipment bought

for defense work makes these companies more versatile and competitive in commercial markets. Ohio firms reported that equipment and skills they acquired for precision machining of military goods could be applied to health care products, where close tolerances are also demanded.

The main worry of most small to medium-sized defense firms in shifting to more commercial business is in sales and marketing followed by availability of finance. These are the two main constraints identified in the survey of firms in New England and Ohio. It certainly is representative of all similar firms.

2.5 Challenges in Defense Diversification

There are a number of organizational and technical barriers to overcome which make it difficult for military serving firms to enter into commercial markets effectively (Markusen 1991; Melman 1971). A number of firm specific characteristics determine the commercialization strategy for each company. Yet there is a reasonable consensus among analysts about the main factors which determine a firm's vulnerability to defense cuts.

The principle factors which seem to influence a company's ability to diversify into commercial markets include: the degree of defense dependency, core technology and products, company size and structure and capacity for organizational change (Oden et al. 1993).

2.5.1 Defense Dependence

The degree to which a firm depends on defense sales obviously defines, in the short to medium term, a company's vulnerability to reduction in contracts. The organizational structure and culture which has evolved as a result of serving one unique market is a barrier for diversification.

Defense firms, nurtured in a RFP environment, know how to sell and market to their customers but the skills and capabilities are altogether different than those needed to prospect, promote, sell and distribute in most commercial markets. Sales staffs of "arms" manufacturing companies are likely to be top heavy with former uniformed officers, defense engineers and professional lobbyists who have little experience in commercial sales. Firms which have significant involvement in both commercial and military markets tend to retain commercial marketing skills.

Another rigidity results from the parts of the organization built to manage the legal, financial and production regulations that govern the military business. Cost of products is often not as important as satisfying performance standards, meeting deadlines and ensuring reliability. The regulatory framework through which performance and reliability are guaranteed is what makes most types of defense production so costly and what explains the uniquely high overheads of defense companies (CSIS Report 1991). High overheads for R&D, financial documentation, testing and meeting and documenting military contract specifications are a normal part of doing business with the DoD. In almost all cases, this regulatory framework adds unique labor costs and management inefficiencies.

The technical challenges and regulatory framework of major weapons systems together make product cycles long which is in contrast to the short time to market cycles in commercial markets. Defense firms obtain external financing from financial institutions by advertising their backlog of defense orders. They are not adept at selling investors and lenders on prospective product introductions and sales targets which must constantly be met in turbulent commercial markets.

Hence, the accumulated organizational disparities in marketing, finance, technology, and production practices explain why military-oriented firms cannot easily translate their expertise into commercial competitive advantage. What is an asset for a military firm is often a liability in commercial markets, which is why many highly defense dependent firms stay in declining defense markets.

2.5.2 Product or Technology

A company's product/technology specialization, if happens to be in the growing segments of the military market, may provide stable or growing sales opportunities, even in a declining military procurement market.

The "value chain" of military production moves from small machine shops or component makers at one end, intermediate-level suppliers, to specialized design and final assembly operations found in the largest defense contractors.

Firms at the beginning of the chain, whose technology is less specialized and the overhead burdens less severe, find it easier and necessary to diversify. This is due to the greater shift towards "insourcing" in the prime contractors who they currently serve.

Firms further along the chain and closer to DoD direct procurement usually find diversification more challenging and risky. Their technology and product mix are specialized for defense applications, they carry large defense-specific overheads, and enjoy healthy cash flow from military weapons purchases.

The Defense Conversion Commission defines Dual-Use as “having defense and commercial application, whether as a technology, process or product.” Firms who have dual-use technologies or products have greater flexibility to serve both military and commercial markets. Many firms that serve both military and civilian markets face the difficulty of setting up separate accounting, record keeping, sales and production systems for the commercial side (DCC Report 1992). This makes it difficult for these companies to achieve the overhead efficiencies and cost savings needed to achieve competitiveness.

Another issue is the ownership of the technology and product design. Having proprietary control over an innovation is central to achieving a competitive advantage in the commercial market. However, many defense firms who have obtained DoD support for R&D surrender proprietary rights to the technologies and products which they develop. The DoD can provide information, drawings and even prototypes to competitors without compensating the original developer. This closes off opportunities for some firms to leverage promising technologies and products into new commercial markets. Companies have to now design customer-enriching products instead of designing products only for extreme reliability and performance.

2.5.3 Firm Size and Structure

There are a number of tradeoffs associated with the size and structure of defense firms which influence their ability to adjust to defense cuts. Large contractors have the resources but often have a culture and organizational structure resistant to change. Small firms are often more open and can react faster, but may lack the resources to enter non-DoD markets.

The large prime contractors usually have a measure of security in the face of defense cutbacks by virtue of their important role in military markets. The Government's effort to ensure that the nation's capacity to make major weapons systems is retained is to the advantage of these large contractors. Also, large prime contractors generally possess the financial and technical assets to enter civilian markets through either internal development or the acquisition of commercial firms. A number of firms such as Lockheed, Martin Marietta, Westinghouse and Hughes have made strong moves into civilian government or commercial markets related to their core technologies and competencies.

Other factors make large contractors adopt strategies centered on downsizing, selling off defense divisions for maximizing profit in the face of stiff defense budget cuts. Within large defense companies or divisions, top corporate management typically has a limited interest in pursuing alternative product ideas from managers, engineers and workers. The acculturation of key managers to military production and markets often leads to conservative behavior (Melman 1983).

The pursuit of new opportunities often occurs only when individuals or teams take their ideas outside the corporate umbrella. Some small defense firms were started up for the purpose of selling to DoD, frequently by people who previously worked for large contractors and understand the intricacies of the defense business. Often these firms are niche producers of sophisticated or specialized military goods and have little experience in commercial production and marketing. During times of defense budget reductions, though some of them close shop, many are motivated to diversify into commercial businesses (OTA Report 1992).

Small to medium-sized firms are often pressured to pursue higher risk diversification efforts because they are more exposed to falling defense sales. They don't have as secure a place in the defense market, or the financial resources of their larger counterparts. Furthermore, they sometimes have the ability to respond to opportunities faster than big firms. What they lack in most cases are the resources, particularly the financial capability, to make the changes and new investments required to successfully expand into new areas.

2.5.4 Capacity for Organizational Change

One of the determinants of success is the existence of an entrepreneurial environment - the capacity of the organization to implement and manage change. The need to diversify into commercial markets could arise due to many diverse reasons including: loss of a major contract, existing management links to non DoD organizations, markets or

products, change in ownership/top management. A major shock to a military serving organization is often necessary to achieve the necessary changes (Oden et al. 1993).

A high degree of commitment and risk-taking are required to move into new markets. A company diversifying into commercial markets must either differentiate its product - match and exceed the quality and cost performance of established commercial firms; or develop a new product or service, carving out a market niche. Increasingly, to expand market share, or create a new market for a product requires that an enterprise meet extremely high performance standards in the areas of cost and quality.

Best (1990); Womack et al. (1990); Black (1991); Goldman et al. (1994) have called attention to the set of "Best Practices" that have allowed firms to drive down costs, improve quality, and respond to changing customer needs in order to compete effectively in domestic and overseas markets. These practices encompass all areas of activity including research and product development, product design, manufacturing processes, relations with suppliers, employee involvement and participation. Cooperation within and between firms, the functionality and manufacturability of products, defect prevention, speed of final product delivery to the customer and the ability to integrate customer specifications into the product design - these are some of the elements identified as the determinants of success.

Many defense companies are well positioned to compete. A number of companies have implemented quality control measures and have participated in extensive quality certification programs sponsored by the DoD or the major prime contractors. Many defense firms utilize modern process technology, computer aided design and

manufacturing, have collaborative links with customers and suppliers and participation of shop floor personnel in quality and cost improvement measures. The effectiveness of the efforts and the collaboration is what needs to be determined.

Studies of defense firms and research findings of organizations like the Project on Regional and Industrial Economics at Rutgers University, New Brunswick, New Jersey (Oden et al. 1993) suggest that the characteristics of defense companies are embedded in a distinct set of organizational practices related to unique requirements of the defense market. There are several areas where defense and commercial best practice look the same, but are in reality quite different.

- Collaboration with customers: In defense markets, designing and manufacturing the product around customer needs is a slow process of negotiating changes in performance requirements, specifications and allowable costs. In many commercial markets, it involves making rapid improvements and design changes based on customer demands while maintaining or lowering costs.
- Quality: Quality assurance is through extensive testing and inspection of individual materials, components and final products. In high performing civilian enterprises, quality is built into the design of the product and processes. It is maximized by tight process control and defect prevention.
- Collaboration with suppliers: Defense firms meet with their suppliers on a regular basis to get guarantees that agreed upon performance requirements and military specifications are met. Civilian firms collaborate not just to maintain quality, but to

drive down input costs, improve manufacturability, and establish just-in-time delivery procedures.

- **Labor-Management interaction:** Interaction with employees in defense firms is often more aimed at overcoming technical problems in manufacturing and to keep up the production schedule. In commercial firms, employees are empowered to make decisions, continuously involved in making constant improvements for improved cost and quality of the products. In defense firms, milspec requirements makes it very difficult to make any changes in design, materials, components and production.
- **Time to market:** Since product cycles are generally long, time to market is not a key measure of competitiveness as it is in many civilian firms. Getting military products from the drawing board to the field often takes more than ten years (Oden et al. 1994). Rapid movement of products from the design stage to the market stage is crucial in commercial markets, is not a common attribute of defense firms. Moreover, defense firms win large, long term contracts and receive a stream of revenue over a number of years; they are not used to prospecting businesses through sales personnel and closing sales on a routine basis. Out of habit, defense companies sometimes relax after initial commercial launch sales, not understanding that a sustained sales efforts and high volume production is crucial to successfully gaining market share in civilian markets.
- **Low Volume production:** Military producers typically produce lower volumes of the same product in plant layouts geared for batch production. They lack the flexibility of civilian firms which make products in high volume, more recently, a variety of products in any volume. Few defense companies have the experience making the rapid

product or design changes or rapid changeovers in manufacturing processes required to make batch production a source of competitive advantage.

Obviously, the differences between the defense and civilian best practices are associated with the type of markets being served. Some of the defense specific abilities - design and develop complex systems in a highly regulated environment, capacity to ensure exceptional standards of durability and reliability, are real assets in markets like public transport, civilian aviation and medical equipment.

In other markets, a fundamental change in the organization and its practices is required for competing successfully with leading civilian firms. Defense firms which have had past or continuing exposure to commercial markets are likely to have an edge over counterparts without exposure to civilian production culture.

2.6 Key Barriers to Diversification

The Project on Regional and Industrial Economics research team, in its study of defense companies in St.Louis, Missouri, found a number of common constraints in diversifying firms, inspite of their innovative efforts. The same constraints were identified by New Jersey companies responding to a 1993 survey of the New Jersey Department of Commerce, Office of Economic Development. Finance and Sales and Marketing were identified as the top two barriers to diversification.

- Finance: Most companies find extreme difficulty in obtaining finance for the necessary upgrading of equipment, tools and processes, building inventory and maintaining necessary cash flow through the transition period. Except for big companies, firms

lack cash reserves from profits to internally finance the required restructuring and investment. In addition, some defense firms lack the experience with collection and receivables management in non-government markets. These firms lack the know-how or resources to present an identified set of prospective financial sources and customers how sales targets will be achieved. They have to transform from times of having safe Blanket Purchasing Agreements (BPAs) to closing sales through active solicitation.

- Marketing: Defense firms, in spite of having real technology and product strengths, due to lack of marketing know-how embark on conservative strategies of liquidation or down-sizing. Though most companies are keen to diversify, they see no market, or no market where they can compete with established companies.
- Management orientation: Top management, which has been defense oriented for many years, lack the necessary understanding and commitment to re-orient the organization. They may be further constrained by shareholders more interested in preserving shorter-term share values and dividends, even it means reducing the scale and long-term growth prospects of the enterprise.
- Adoption of civilian best practices: Many defense companies have modern equipment, highly-trained, motivated workers, and firm-wide quality control systems. However, companies must overcome significant barriers to transform these core capabilities to meet the competitive standard of new commercial markets. Successful diversification involves much more than a search for new markets. It involves restructuring the organization to match the high standards of competitive commercial companies.

CHAPTER 3

PRODUCT DEVELOPMENT AND ITS ELEMENTS

3.1 Product Development Process

3.1.1 Serial Development

Traditional product development called serial development, is a “serial” process in which the design is “thrown over the wall” from one department to another at the completion of each phase of the development cycle. It has been known from experience of many companies and the numerous publications that this approach does not work well, it stretches out the development cycle due to which the company loses the opportunity of early-to-market advantage. This approach also introduces errors and involves many times, costly changes. Each of the functional departments waits until the “upstream” department completes its work before beginning its own task.

Product definition is frequently done by marketing with minimal involvement of the design, manufacturing and purchasing functions. The result is often a product specification that is incomplete, has requirements that are not technically feasible, or requires technologies that are difficult or expensive to manufacture, with components that aren't readily available. This leads to extensive changes during the product design and manufacturing process design cycles.

3.1.2 Concurrent Development

Concurrent development is based on concurrent engineering (CE) which is defined as the earliest possible integration of the overall company's knowledge, resources, and experience in design, development, marketing, manufacturing, and sales into creating successful new products, with high quality and low cost, while meeting customer expectations (Shina 1991).

Concurrent development consists of cross-functional teams with members from all the functional area working closely together, sharing details of their portion of the design as it progresses, and developing all aspects of the product simultaneously. This result in overlapping development phases which contributes significantly towards defects elimination, reduction in costs and faster development cycle.

The product development metrics typically fall into four broad categories (Floyd et al. 1993, 5-8):

1. Quality - of product and process.
2. Time - the cycle time for product development.
3. Financial - life cycle profits and Return on Investment (ROI).
4. Waste - Errors and changes, like the number of engineering change orders.

It has been widely understood and proved that CE based practices are the ideal way to achieve optimum values for the above metrics. Researchers, for ease of use and wide adaptability of CE practices have sought to automate the concurrent development process.

3.1.3 Automation in Concurrent Development

Traditionally, companies have invested heavily into automation for reducing labor costs, but it is only a one-shot deal. Companies have also started to invest in automation with the hope of shortening product cycle times.

According to Carter (1991), what needs to be done is a structured and organized approach to automating the concurrent engineering environment. The typical roadblocks to automation are:

1. Existing tools that can no longer perform the new requirements of design tasks.
2. The proliferation of different kinds of computers, networks, user interfaces, and operating systems throughout a company.
3. The lack of appropriate data management.
4. Downstream processes that get stuck downstream and never make it upstream - this deals with the lack of integration of data from all functional departments of the company.
5. The correct decisions are not made soon enough.

There are five enabling phases of automated concurrent engineering and they help resolve the above roadblocks - Interoperable tools and tasks, Interoperable computing environment, Data management, Process management and Decision support. Considerable research is also underway in the creation of knowledge-based systems and software to support the concurrent engineering environment and research into solving the information management issues (Prasad et.al 1993).

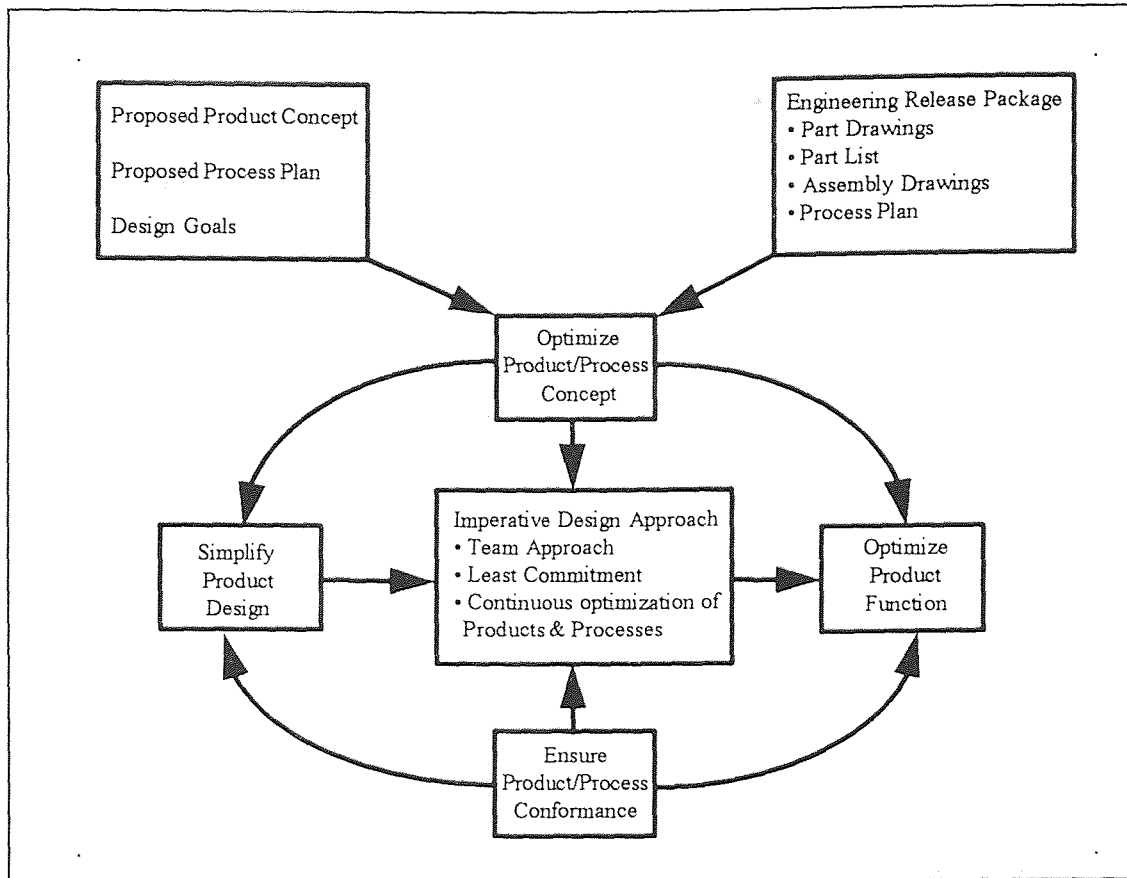


Figure 3.1 Typical DFM Process for Continuous Optimization of Product and Process

3.2 Product Quality and DFM Techniques

3.2.1 Product Quality

Continual product improvement and innovation are being widely practiced by successful manufacturers to stimulate consumption and to increase market share. The quality of a product undergoes a change at each value adding process in its manufacturing cycle. Quite frequently there is found on the market an inferior product or machine which owes its inferiority to the quality of the decisions made during the design. The attainment of high levels of product quality is a prerequisite for the success of a product.

Quality of any product can be broadly defined into two categories, namely: design quality and manufactured quality. Design quality is defined as the utility of a product as perceived by the customer. On the other hand, manufactured quality is defined as the extent to which a product deviates from its design specifications. Most of the available literature talks about either improving the design quality or the quality of the entire business process both inside and outside the manufacturing environment. Several approaches have stressed on building quality in the design, in the product, in the process, rather than develop it after the product has been produced.

3.2.2 DFM Techniques

There are several Design for Manufacture (DFM) techniques; the primary objective of all of them is to identify product concepts that are inherently easy to manufacture, to focus on flexibility and a superior product. A typical DFM process proposed by Stoll (1988) is shown in figure 3.1. The DFM process begins with a proposed product concept, a

proposed process concept, and a set of design goals (both manufacturing and product goals). Each of the activities within the DFM process addresses a particular aspect of the component design for ease of manufacture and assembly, and to integrate manufacturing process design and product design.

Numerous DFM methodologies are proposed by authors. The most commonly used is the Design for Assembly (DFA) method developed by Boothroyd and Dewhurst (1983). Details of this methodology are presented in their handbook on DFA. The DFA method developed by Boothroyd and Dewhurst minimizes the cost of assembly by first reducing the number of parts and then ensuring that the remaining parts are easy to assemble. The Axiomatic Approach proposed by Suh, Bell and Gossard (1978) is based upon a hypothesis that there exists a small set of global principles, or axioms, which can be applied to decisions made throughout the synthesis of a manufacturing system including evaluation of a design decisions leading to a good design. Other DFM methodologies include DFM guidelines Designers Toolkit, Computer-Aided DFM, Group Technology, Failure Mode and Effects Analysis, Value Analysis, and Hitachi Assemblability Evaluation Method (Stoll 1988, 23).

The major principles of design for manufacturing are:

- Minimum part types
- Standard components
- Parts fit/snap together
- No fasteners
- No assembly tools required

- Reduced assembly time and operator skills

Of all the DFM approaches, the most widely used are the DFA technique by Boothroyd and Dewhurst and the Axiomatic approach. DFA, in particular is more popular owing to its ease of use in the form of a software which is available from Boothroyd and Dewhurst, Inc. in Wakefield, Rhode Island. The success of this approach is widely documented and is used by all industries where the end result is a manufactured product.

The IBM Proprinter is considered a prime example of an electronic product that was designed for flexible automated assembly. IBM was able to use manufacturing as a strategic weapon to achieve and maintain a market share in the highly competitive personal printer market (Shina 1991, 62-65).

3.2.3 DFM and Quality

Most of the literature available on DFM talks about minimizing cost and integrating design and manufacturing. Taguchi Methods and concepts of Robust Design (Phadke 1989) provide a valuable insight into the role of design in determining the quality of a product or system i.e. they address the issue of design quality. The term Taguchi Methods (Sullivan 1987, 76) refers to the parameter design, tolerance design, the quality loss function, on-line quality control, design of experiments using orthogonal arrays, and methodology applied to evaluate measuring systems. These methods were developed by Genichi Taguchi, a noted Japanese engineering specialist, to simultaneously reduce cost and improve quality. Taguchi's method of parameter design has changed the meaning of

quality improvement from problem solving to reducing variability around target values, with the important point being how to measure quality improvement.

Total Quality Management (TQM) concepts promoted by Deming (1986) consider prevention rather than problem solving. These concepts advocate building quality into the design, as opposed to inspection of quality for quality assurance of the product. Daetz (1990) in his article on the effect of product design on product quality and cost has identified several factors of the design which contribute to defects. A set of guidelines for quality improvement are provided by Daetz (1990). Accordingly, from the quality standpoint, a design should be so simple that correct assembly and use of product are foolproof and should have as few options as possible.

The relationship between the design of a product and its manufactured quality is addressed by Das (1993), introducing a Design for Quality Manufacturability (DFQM) methodology, that focuses exclusively on evaluating a design from the “manufactured quality” perspective. This methodology identifies a set of defects at the assembly stage of manufacture of the product. A set of factors responsible for the occurrence of these defects are investigated. The relationships to bring about an effective link between the defects and the factors is also proposed. The proposed methodology provides a means of relating the activities of quality improvement, product design, and manufacturability analysis. The objective of this methodology is to enable the user to improve the design so as to reduce the likelihood of defective product being manufactured.

3.3 PDCA Cycle and Benchmarking

3.3.1 Benchmarking

Benchmarking can be defined as “ the continuous process of measuring a company’s products, services, and practices against its toughest competitors or those companies renowned as leaders.” Robert Camp who pioneered the practice of benchmarking in the Xerox corporation defines benchmarking as, “The search of industry best practices that lead to superior performance” (Camp 1991).

So as to say, benchmarking is a process of comparing a company’s current performance with that of organizations judged to be the “best in class”. It is a practice of being humble enough to admit that someone is better at something, and being wise enough to learn how to match and even surpass them at it. Benchmarking is of two types - Process Benchmarking and Product Benchmarking. In the former, the element benchmarked is the process and in the latter it is the product/s of competitors.

3.3.2 Process Benchmarking

Benchmarking’s primary objective is process quality improvement. Many progressive companies are now using benchmarking to assess their posture against competitors and learn from others for continuous improvements in business operations and processes. The most common benchmarking approach is a six-step process.

1. **Plan:** Determine what process or activity to benchmark. Form the necessary team and involve all interested parties, such as the manufacturing department, the marketing

department, suppliers and customers. Construct a process flow of how the work is currently being done.

2. **Research:** Check with in-house experts to find out what is currently known about the process or activity under study. Design sheets for checking the baseline data of the process. Train team members in listening and observing skills.
3. **Observe:** Use company visits, questionnaires, collection forms, and other sources to gather additional benchmarking information. Focus on the process, rather than the quantitative results, gleaned from these sources.
4. **Analyze:** Evaluate the findings. Determine the gap between the company's current performance and that of benchmarked firms. Use brainstorming to determine steps to close the gap.
5. **Adapt:** Decide how to use the information gathered. Make use of the data at the operational level while incorporating it into the firm's long-range strategic plan.
6. **Improve:** Institutionalize the changes and make them part of the ongoing operating process. Make benchmarking a key element of the overall TQM effort. Continue to get feedback from customers regarding their needs and desires, and use future benchmarking efforts to close any gap between current capabilities and customer demands. Begin the benchmarking process anew by returning to the planning step and starting again implied in the various definitions offered, benchmarking is a continuous process. It follows the PDCA cycle (Deming's Cycle or Plan-Do-Check-Act cycle). The six step process of benchmarking can be condensed into a PDCA cycle as shown in figure 3.2.

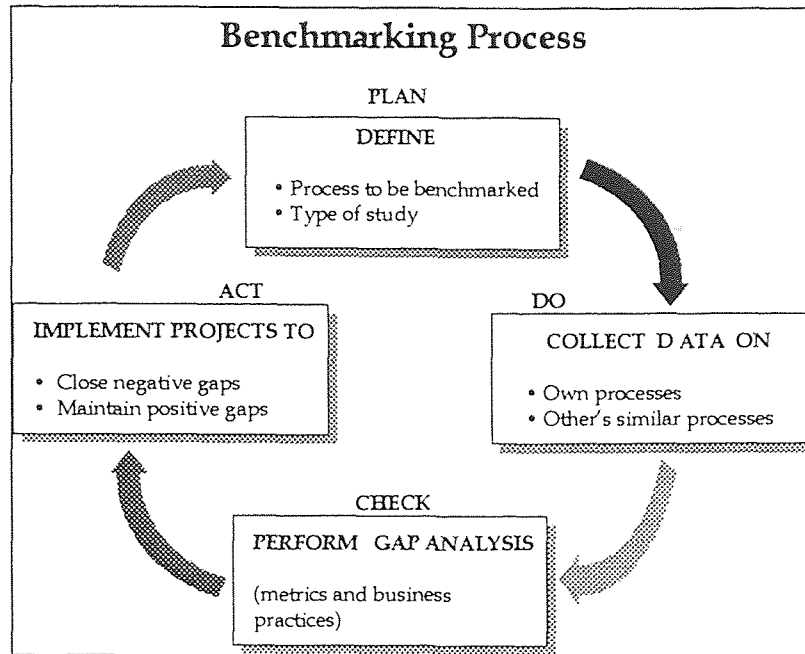


Figure 3.2 The Benchmarking Process

With an external focus, a company may enjoy meaningful and continuous improvements over the long-run through working with benchmarking partners. Why would any company share its sensitive information with others? There are several answers to this question.

- Some companies are expected to do so since they won the Malcolm Baldrige National Quality Award (MBQNA).
- Other companies may share information in one area for reciprocal information from the benchmarking partner in another.
- Do it as a service to industry or a community.
- Some companies see it as a part of professional relations with peers.

Whatever the reason is, experience shows that it works if the two parties are not involved in a competitive business. Thus, the benchmarking process, to be truly effective, needs to be ongoing. Benchmarking is the key to becoming the best of the best. Its a team effort. A small team of people help their organization to efficiently travel the journey of continuous improvement to become best of the best. They accomplish this by thoroughly understanding their own processes (or products/services); by finding the world class companies or organizations that do what they do; by learning how well those world class companies perform on key customer-driven measurements; by understanding how those companies accomplish their admirable levels of achievement; and by adapting appropriate ideas into their own processes.

3.4 Quality Function Deployment (QFD)

The founding philosophy of QFD is very simple - the voice of the customer will drive everything an organization does throughout the process of developing and delivering products or services (Eureka and Ryan 1988). The mechanics of QFD can be easily understood, yet it is not being adopted and practiced by a large number of companies. May be it is due to human “wisdom” to dismiss something simple as obvious and low-tech.

A set of planning and communication routines, QFD focuses and coordinates skills within an organization, first to design, then to manufacture and market goods that customers want to purchase and will continue to purchase (Hauser and Clausing 1988, 63). Shina (1991) says that QFD is an organized, disciplined process for determining the

product or service requirements necessary to meet the stated or implied customer wants and needs. QFD requires the horizontal integration of those organizational functions that must Plan, Do, Check and Act in order to successfully achieve customer-perceived expressed or unexpressed quality. Quality in this context is defined as the ability to meet or exceed customer expectations while maintaining a cost-competitive market position.

The key to success in QFD lies in ascertaining what the customer wants, the voice of the customer and this is fundamental to the QFD planning process. Dr. Noriaki Kano developed a model (Shina 1991,149) to look at the impact of differential levels of customer importance and the model defines three levels of customer importance - i) expected or taken for granted quality ii) one dimensional quality and iii) attractive or exciting quality. Garvin (1987) points out that there are eight dimensions to what a consumer means by quality and that it is a major challenge to design products that satisfy all these at once.

The International TechneGroup Inc., Milford, Ohio, which developed and markets the widely used QFD software, *QFD CAPTURE*™, describes QFD as a team-based approach for converting “The Voice of the Customer” into understandable terminology. Some of the major benefits obtained by companies which are successful at QFD include:

- Reduced development time due to the early identification and resolution of design problems. This reduces development costs and brings quicker market response time.
- Improved customer satisfaction with team resources focused on the issues which are important to their customers.

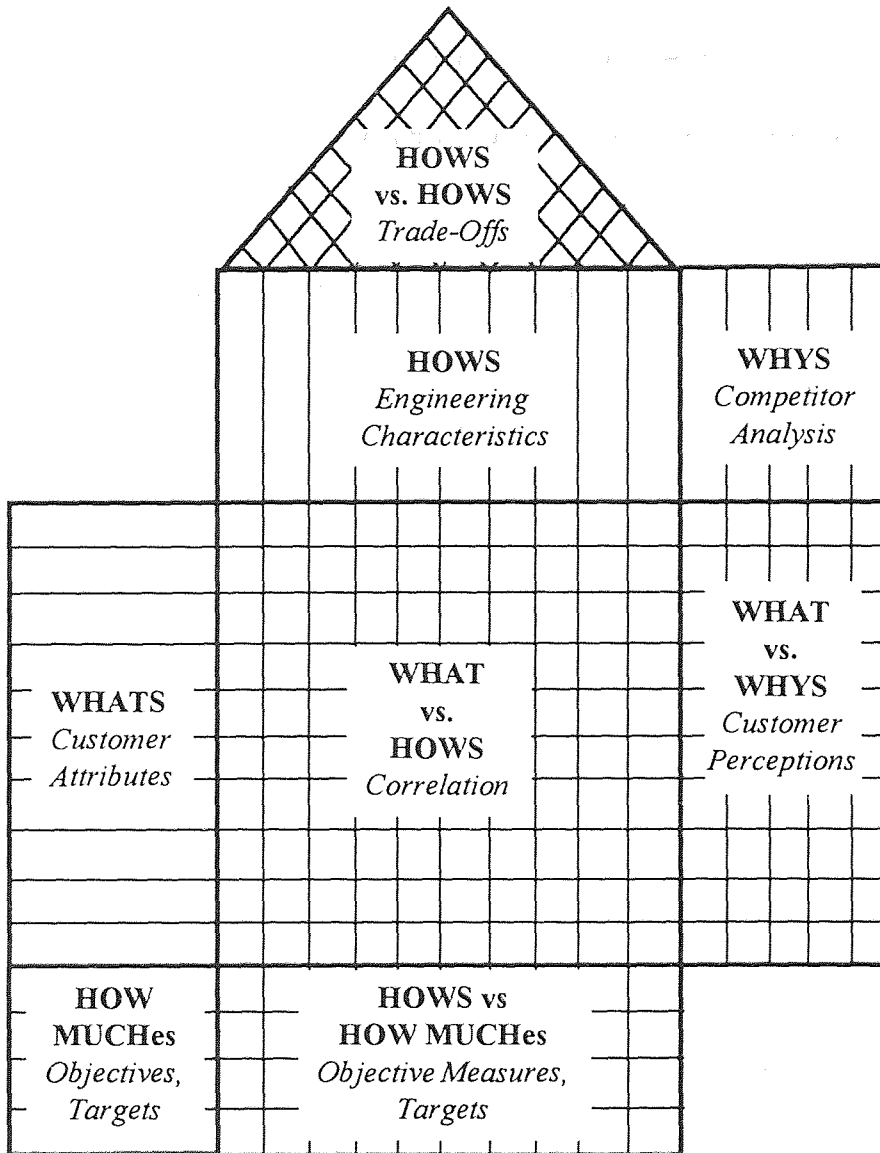


Figure 3.3 House of Quality

- Improved organizational alignment because all product, service or business direction judgments have been agreed to by the team.

Shina (1991, 148 - 152) details a four-phase approach - Organization, Descriptive, Breakthrough and Implementation for using QFD in design and development.

3.4.1 The QFD House of Quality (HoQ)

The tool for guiding an organization in the QFD process is commonly called the QFD House of Quality. The foundation of the HoQ is a kind of conceptual map that provides the means for interfunctional planning and communications. Hence, cross-functional teaming is at the core of the house of quality approach and undoubtedly, it is the most effective way to reap benefits from the house of quality.

The HoQ is a matrix-style chart (Figure 3. 3) and the different terms used are :

- **WHATS** or *Customer Attributes* - This is the Voice of the Customer. It is absolutely essential that the customer's own words and phrases be preserved and not prematurely translated. This is where market research can ensure that the team gets the Voice of the Customer. Customers can provide data about how these needs relate to one another and statistics can be used to combine the inputs from many different customers into a composite picture of how they think and what they want. The ultimate success of any QFD project hinges on the team's ability to clearly understand the wants of the customer.

- HOWS or *Engineering Characteristics* - These are product characteristics or features which can be measured to satisfy the WHATS. In other words, these are the design attributes determining customer satisfaction.
- WHYS or *Competitor Analysis* - This describes the market for the product or service. It also identifies other factors which affect the prioritization of the WHATS.
- HOW MUCHES or *Objectives, Targets* - This identifies target values, products to be benchmarked and technical importance values for each HOW.
- WHATS vs. WHYS or *Customer perceptions* - Determines the importance of each criteria.
- WHAT vs. HOWS or *Correlation* - Relationships between customer attributes (demands) and engineering characteristics (attributes).
- HOWS vs. HOWS or *Trade-offs* - Interrelationships between product attributes or engineering characteristics.
- HOWS vs. HOW MUCHES or *Objective measures, Targets* - These are target values of the attributes for customer satisfaction

Eventually the *HOWS* from one HoQ become the *WHATS* of another house as the details of the product design are fleshed out. This results in 'linked houses' or 'chain of HoQs'. Sullivan (1986) explains how QFD can be a system to assure that customer needs drive the production and design process. Hauser and Clausing (1988) explain in detail the process of constructing a house of quality and obtaining the desired customer-driven product definition. It also includes a description of 'linked houses' - the step-by-step process by which the voice of the customer gets conveyed to manufacturing to result in a

product which will delight the customer. Use of QFD for product redevelopment and how the concepts are integrated with the Design for Excellence and Total Quality Management efforts of a medium sized company is given in Almquist (1992). The effectiveness of the house of quality approach to resolve the impasse of a product development team over several product features, by making design trade-offs, is given in Hunter and Van Landingham (1994).

3.4.2 Other Uses of QFD

Customer enriching product definition is only one of the many uses of the house of quality. It is an effective tool for rational decision making. It can be used to define customer-supplier relationships to improve internal processes and quality (Gopalakrishnan et al. 1992). As the complexity of streams of processes increases, so does the probability that a company will lose control of the characteristics that are necessary to meet customer expectations, add value, and hold down costs. The solution is in working backward from customer expectations and using QFD to manage all processes accordingly (Conti 1989). A list of successful alternative applications of QFD by companies is given in Shina (1991,148).

The HoQ can also be used for Product benchmarking. This basically reverses the process in which the HoQ is formed. In this case, the WHATS are the features of the competitors' products. HOWS are the relevant engineering characteristics of the company's product to match the features of those of the competitor's products. WHYS would then be the reason/s why customers need these WHATS.

3.5 Value Analysis/Value Engineering

Value Analysis (VA) / Value Engineering (VE), in short VE, is a technique which relates the worth of the product to its cost. It is a way of thinking about productivity, the proper utilization of manpower and materials, and it can yield itself to improved profitability on a large or small scale. To succeed, it demands the backing and the cooperation of everyone in the organization. VE is effective because of the implied use of Heisenberg's principle of Indeterminacy - investigation can itself influence the destiny of whatever is under investigation (Oughton 1969).

In recent times, VE has evolved into a quality enhancing program and an efficient tool to realize results in the near term. Value management uses a "function analysis", which allows it to examine the function served by every aspect of a company's production process or service, and then asks a Value Team (VT), again a cross-functional team, to brainstorm and implement better ways of fulfilling any function. For example, if a company is using a 24-cent bolt to hold two parts together, the VT will define the function first - "Fasten parts"- and then will ask, how else can this function be served in this instance? In some cases, gravity alone, or a bonding process, can be used; or the VT may find ways to eliminate the two parts entirely, eliminating the bolt and subassembly cost.

As opposed to a TQM program whose results are in the long term - about four to five years, the turnaround time for results through VE in any organization has been found to be 6 months. Also, the typical return-on-investment of a VE study is twelve to one - that is, the company saves 12 times more than the study costs. In some cases, the returns are significantly higher (Hayes 1993).

3.6 Standards

Commercial standards are of the following types:

1. Quality management system standards like the ISO9000 series of standards;
2. Product technical-requirements standards like ANSI/ASME, ANSI/IEEE, ANSI/SAE, UL;
3. Product testing standards like ANSI/ASTM;
4. Environmental standards;
5. Occupational health and safety standards.

Standards are used by organizations voluntarily when they are driven by marketplace forces only or situations in which standards are mandatory, driven by regulations (Marash 1994, 27).

3.6.1 ISO 9000 Standards

The ISO9000 (International Standards Organization) standards define the requirements of a prevention-based quality assurance system. If the system is adhered to, the supplier will always produce and deliver a predictable product or service. As table 3.1 shows, ISO9000 is a set of five primary standards: three address specific quality systems (ISO9000, ISO9002, and ISO9003) and two are guidelines (ISO9000 and ISO9004). Additional guidelines have been published for software (ISO 9000-3) and services (ISO9004-2)

STANDARD	DESCRIPTION
ISO 9000	A guideline for the selection and use of quality management and quality assurance standards.
ISO 9001	A model for the assurance of quality systems for design and development, production, installation and servicing.
ISO 9002	A model for the assurance of quality systems for production and installation
ISO 9003	A model for the assurance of quality systems for final inspection and test
ISO 9004	Guidelines for quality management and quality system elements

Table 3.1 ISO 9000 Standards

These are system standards, not product standards. ISO9000 standards are essentially paper driven. All of the appropriate elements must be documented, the documentation must cover all of the requirements, and the company must do what it has documented. Adequacy of the system and the producer's adherence to it is measured by auditing against the standard. Therefore, ISO9000 standards measure neither the efficiency of the system nor how good the product or service is.

3.6.2 Military Standards

The DoD states its requirements, in a unique way, specifying its needs, and defining how those needs will be met (test procedures). Known as the "milspec" or equivalently military specifications and standards, it is used as a term to describe the form, fit and function of

the needed item (DoD Manual). The DoD, when it wants to buy an item, specifies what technical yardsticks the product must meet: size, weight, durability, reliability, and so forth. One of the purposes of such detailed description is standardization - to ensure that similar equipment in each service is interoperable and can be centrally supported.

Specifications and standards pose problems in two ways. First specifications for particular products may go well beyond a functional or performance description, defining the product in terms of how it's designed or manufactured. Second, some specifications (often called standards) spell out directly how to manage production of the item: how the quality assurance program is to be structured, how the product is to be manufactured, or how the company must manage the work.

Although some design parameters may be essential (e.g., form, fit or function), the DoD's product specifications too often describe design and fabrication requirements that limit the ability of contractors to use commercial items, components, materials and established process in performing government contract work.

3.6.3 Milspecs and Milstandards Reform

The Working Group on Military Specifications and Standards stated, “ If the Department of Defense is to control costs and sustain military readiness, it must shift to a more multipurpose production base. Without significant reform of the procurement process, however, this goal is virtually unreachable” (Saunders 1993).

The Department of Defense has, in February 1994, approved the use of commercial standards like ISO9000 and ANSI/ASQC Q90 (American National Standards

Institute / American Society for Quality Control) series standards in place of the current military unique standards MIL-I-45208A (Inspection System Requirements) and MIL-Q-9858A (Quality Program Requirements). DoD also emphasizes the purchase of Commercial Off-The-Shelf (COTS) products (Brecka 1994).

The reform in DoD acquisition practices, according to Undersecretary of Defense John Deutch, is intended to “improve process capability; process control and product quality, and lower cost by endorsing a single quality system in any contractor or facility..” The ultimate goal is to maximize the use of commercial specifications and standards in lieu of military-unique specifications and standards when practical.” Brecka (1994).

The reform provides a basis for defense suppliers to standardize and consolidate their procedures and systems based on a single set of quality requirements and this can be expected to result in lower costs and higher quality. The *Military Handbook - 9000* which is due for publication would provide guidance on the application of the commercial standards.

3.6.4 ISO9000 and Total Quality Management

Total Quality Management (TQM) is a management philosophy that builds customer-driven learning or organizations dedicated to total customer satisfaction with continuous improvement in the effectiveness and efficiency of the organization and its processes. In effect, it is providing total customer satisfaction through continuous improvement.

ISO 9000 might not be *the* path to TQM, but it could be *a* path to TQM, for ISO9000 as the path to TQM is incomplete. For example, ISO9000 doesn't have a

sufficient customer focus, doesn't address how good a product or service is, doesn't focus on continuous improvement, and doesn't call for an ongoing evaluation and improvement of the quality system elements. These aren't deficiencies of the ISO series of standards, because they serve a different purpose. They are designed to ensure the adequacy of a given quality system and to use audits to ensure its adherence to it.

TQM requires and assumes that an effective quality assurance system exists and is followed, though it is not a valid assumption. The first step for any organization starting a TQM effort is to assess the adequacy of its underlying quality system; what better way to do it than to use the ISO9000 standard for the assessment. This would prove an excellent measurement criteria and a structured approach to periodic evaluation of the quality system. Hence, the equation is a TQM system with ISO9000 as the underlying quality system (Corrigan 1994).

CHAPTER 4

THE CONCURRENT NEW PRODUCT DEVELOPMENT/ PRODUCT REDEVELOPMENT PROCESS

4.1 Survey on Defense Diversifying Companies

4.1.1 The New Jersey Defense Diversification Project

Acting for the state of New Jersey, the Center for Manufacturing Systems at the New Jersey Institute of Technology (NJIT-CMS) requested and received a federal Department of Commerce, Economic Development Administration (DOC-EDA) grant for establishing a Defense Conversion Center Program to assist primarily, the electronics companies who are severely impacted by the defense budget cuts . This is the New Jersey Defense Diversification Project (NJDDP).

The mission of NJDDP is to aid New Jersey manufacturing firms in making the transition from military to commercial markets. The project is designed to stimulate demand for conversion assistance by creating industry-led centers through which new technologies and management practices can flow efficiently into large numbers of small and medium-sized manufacturing firms. Core services include market research, proactive technology transfer, and comprehensive assistance to firms in developing and commercializing new products.

4.1.2 The Pilot Group

A set of five small subcontractors in New Jersey were surveyed, using the Defense Electronics Industry Questionnaire (Appendix A) as part of the New Jersey defense diversification project. These companies were identified by the New Jersey/Pennsylvania chapter of the American Electronics Association as being in need of defense diversification assistance ; and are representative of the general mix of small subcontracting companies in New Jersey. Site visits and a series of meetings to address strategic planning, market research, technology transfer and licensing agreements followed. These companies are well into the pilot phase of receiving assistance from the NJDDP.

The companies are electronics manufacturing companies who have been 1st tier and 2nd tier SCs in the defense business. Their major customers have been the PCs. Typical of any SC, part of their business is dependent on the commercial markets, where they have niches to sell products designed around defense product platforms.

The companies are representative of the types of suppliers in the New Jersey electronics industry - suppliers of materials, components, equipment, instruments and specialized systems and instruments builder. The companies have been in operation anywhere between 30-50 years. Employment, on an average, ranges between 100 -150 people, except one company which has 215 employees. Annual sales ranges from \$2 M to \$4 M for two companies and the other three are in the \$12M - \$15M range. Defense dependence has been from 50% to 90% of the businesses. Typically, companies estimated their defense dependence to come down by 20% in 1994.

The strengths of each of these companies is in the technology base. Some of them possess patent rights to their technologies. All these companies suffer from long product development time. Only one of the companies tried adopting CE practices and multi-functional teams in product development. The efforts did not bear fruit due to the downsizing of the company and many team members left the company. All the companies, by virtue of their commercial sales, have sales and marketing personnel and a small network of distributors. Two of the companies had overseas distributors. All of their products were certified to milspecs and standards and none of the companies had any commercial laboratory certification. Two of the companies were pursuing certification to the International Standards Organization series of standards, ISO9000, since it became some of their customers' requirements.

Typical of any SC, these companies too have been used to the defense industry system of 'Cost-Plus bidding' as opposed to "Value-based pricing". The products were rugged and had more emphasis on reliability under extreme conditions and functionality than aesthetics and ergonomics. This typically would make the products a hard sell in commercial markets. It was understood that no formal industrial engineering studies and analysis have been done of the production processes and the companies have never involved the services of an industrial designer in the product design.

Like all other companies in New Jersey and elsewhere, these companies' top two strategies for defense diversification were:

1. To find new customers for existing products
2. To develop new products based on core technologies and competencies.

All companies expressed their inability to shorten the design time and bring a product rapidly to the market. They were also constrained with the inflexibility in their manufacturing processes and equipment setup, whereby, they fear losing their early market advantage to their competitors.

Except for one company which entered into a strategic partnership for one of its products which has a low sales volume, all the companies wished to design and develop products around their core competencies and technologies only.

The discussion with these companies revealed certain characteristics and the reasons for their survival in the commercial markets:

1. All these companies have traditionally designed their products around the needs of the DoD, pertaining to milspecs and standards. They had to employ 'Concurrent Production' to rapidly bring the product to the customer and have incurred great overhead and losses in the first instance. But they had enjoyed the advantages of the 'Cost-plus bidding' system and also the research and development funds made available to them by DoD.
2. Their commercial market share has been in niche markets, where they had little or no competition. Now the halcyon days are gone and they not only have to survive with defense cutbacks but also show product differentiation in terms of quality, price and costs to survive in the commercial market.
3. It was realized that many of the problems and inability to gain early product advantage and the market share which would follow in commercial markets has been due to the haphazard way in organizing for new product development or product re-design.

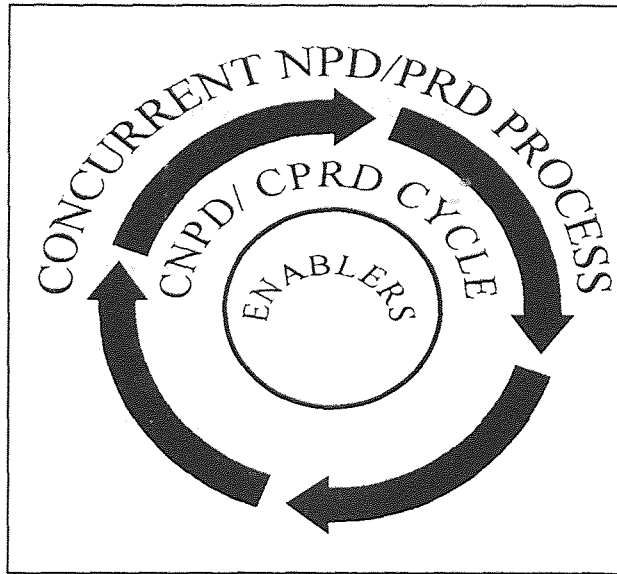


Figure 4.1 CNPD/CPRD Process Model

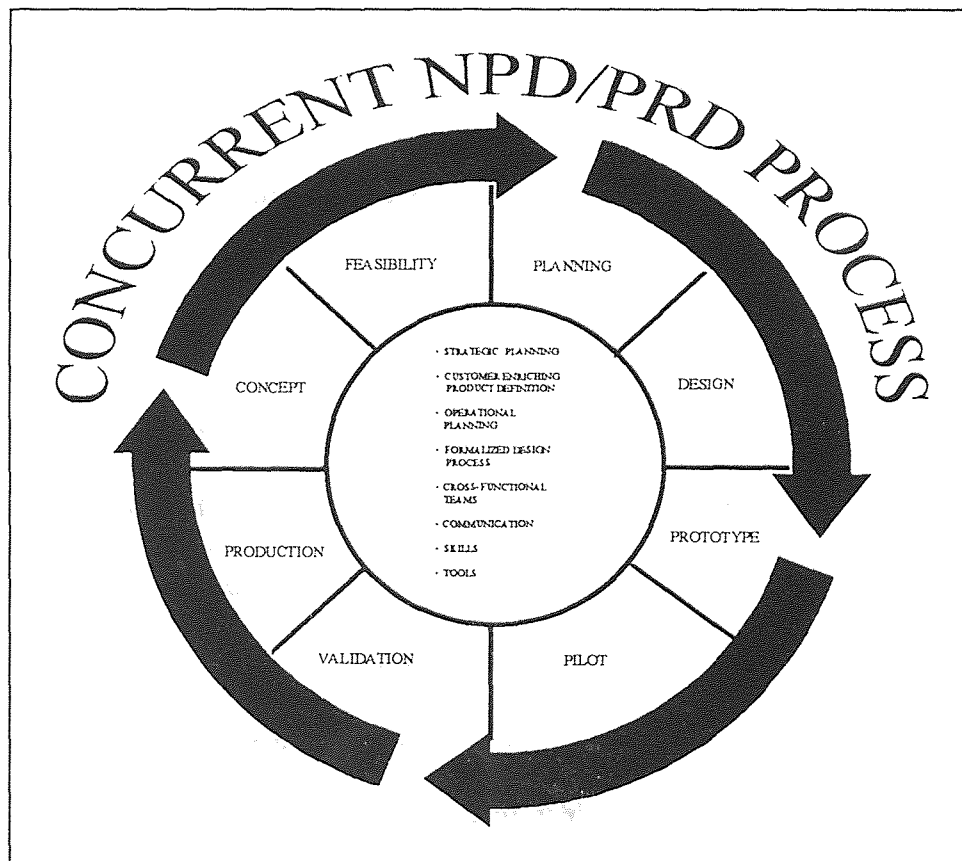


Figure 4.2 CNPD/CPRD Process

Instead of building quality into the design, it was inspected. Poor communications within departments and serial manufacturing, resulted in the delay in transformation of a design into customer ready products.

This led to the development of a NPD/PRD process model based on successfully tested and demonstrated practices, principles and processes. Besides incorporating Concurrent Engineering (CE) practices, it also identifies a set of Enablers which must go hand-in-hand with the different stages of the process . NPD/PRD is at the heart of a defense diversifying company and the process when done right results in a product which would turn out to be leading the company into commercial markets.

4.2 The Concurrent NPD/PRD Process Model

The Concurrent New Product Development (CNPD)/ Concurrent Product Re-Development (CPRD) process model is made of the CNPD/CPRD cycle and a set of enablers as shown in figure 4.1. The term ‘development’ is used instead of ‘design’ due to the wrong connotation of the latter as being unique to the functions of the Research and Development or Engineering department of the company. The term ‘process’ is used to indicate the ongoing nature of making continuous improvements to the products with the help of the enablers. Finally, the term ‘concurrent’ is used due to indicate the adoption of Concurrent Engineering (CE) practices in the NPD/PRD process.

4.2.1 CNPD/CPRD Cycle

From figure 4.2, the CNPD/CPRD cycle or alternatively the 'Concept-to-Cash' cycle has eight phases. In the discussion of the various phases, the term 'development' also refers to 're-development'. Also, a cross-functional team is involved in taking the product concept through the following eight phases:

1. Concept: During this phase, many potential product ideas are collected and, through a screening process, those ideas most likely to yield products which will significantly contribute to the company's goals and objectives are selected for more detailed consideration. After further analysis, one or more products that are consistent with the company's available resources will be selected for development. Customer needs and expectations for these products are then converted into specific product functions, features, specifications, requirements and embodied in a preliminary version of a product definition document, typically called the Marketing Requirements Document (MRD).
2. Feasibility: During the feasibility phase, the company verifies that it has the technology, know-how, and resources necessary to design, produce and market the product(s) defined in the concept phase. It reduces necessary inventions or new technology to practice and proves its feasibility either analytically or with feasibility models. Upon satisfactory completion of this phase, the product specification is agreed to by all the other functional departments and released to the engineering department for detailed design. The feasibility phase, if done well, avoids the occurrence of problems at the later stages in the design cycle.

3. Planning: This phase calls for a careful, thorough, and realistic planning before implementation. A product business plan is created for each product to be developed or re-developed. In addition to market forecasts, product definition, sales forecasts, cost projections, resource requirements, detailed implementation plans for the design, manufacturing ramp-up, and market introduction must be generated. During the planning phase, the team members create the plans necessary to design, produce and sell the product.
4. Design: The detailed designs are done in this phase. This would typically includes the design of the
 - product, along with the necessary documentation
 - manufacturing processes to produce the product, with associated procedures
 - quality system to insure excellent product quality
 - marketing approach and systems to maximize targeted market penetration
 - sales and distribution channels
 - service and support systems
5. Prototype: Upon completion of the design phase, one or more prototypes are manufactured according to the design documentation. Here, the product design is tested to verify that the product will fully meet the product specifications. Problems found during this phase are corrected, prototypes are updated and retested. The products go through the alpha-test stage.
6. Pilot: During the pilot phase, a limited number of early pre-production units are done to prove the correctness of the manufacturing processes and also to verify that the

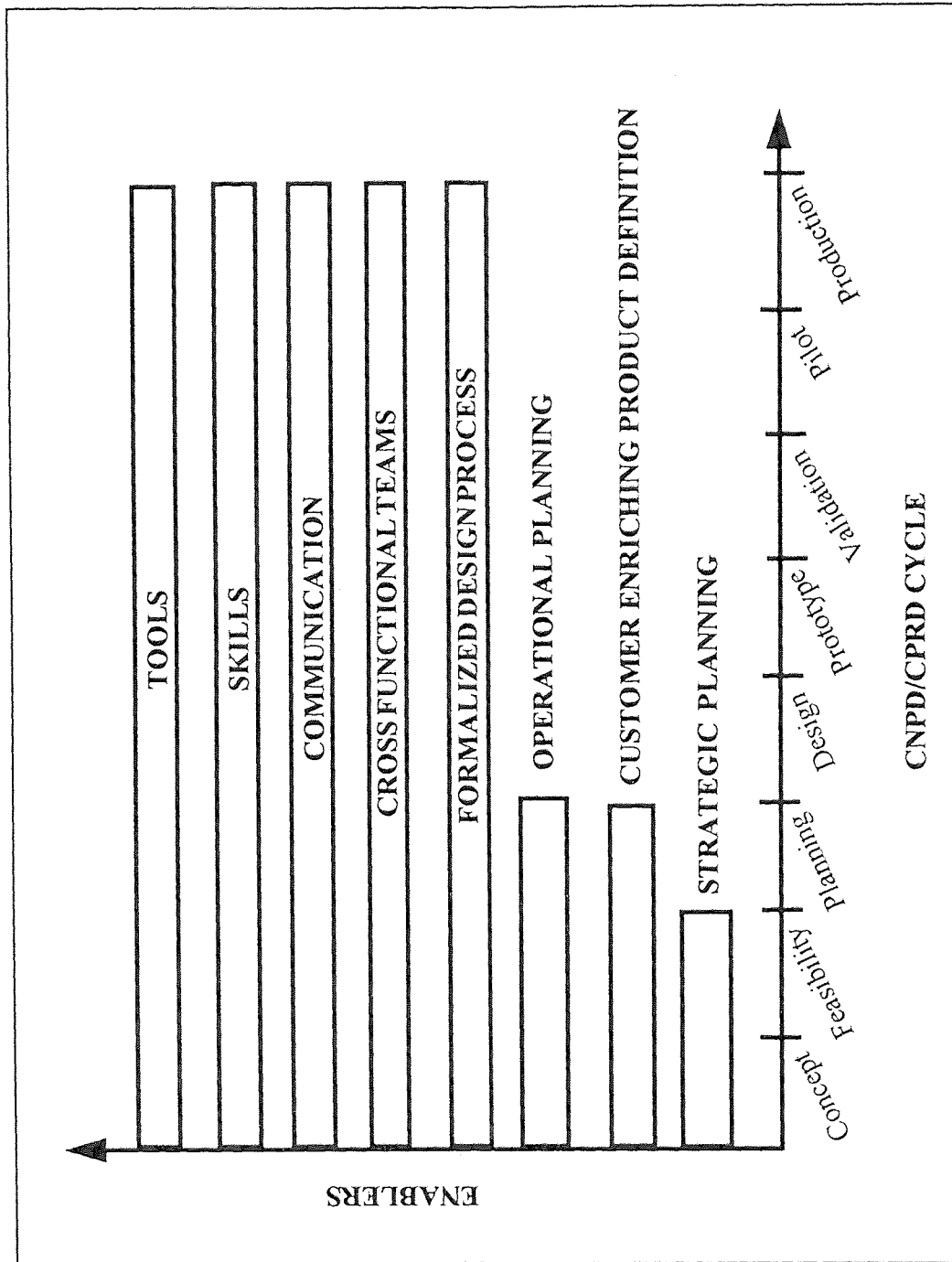


Figure 4.3 Enablers vs CNPD/CPRD Cycle

final product design is producible to targeted volumes, costs and quality. Beta testing of the product is done at this stage by using some of the pre-production units for test marketing, to ensure that the product meets current customer needs and expectations and has the potential to achieve targeted revenues.

7. Validation: This stage is an extension of the beta test where both product prototypes and pre-production units are tested and verified that the final released product will meet all of its requirements. Beta tests are done at external customer sites. An extended alpha test is also done on the pre-production units by the internal quality department or an independent testing group. The combination of the prototype verification testing, pre-production testing, regulatory compliance testing, and any test marketing activities form the core activities of this phase.
8. Production: This phase represents the formal completion of the product design cycle. In this phase, the company produces and sells the product.

4.2.2 The Enablers

The 'Concept-to-Cash' cycle probably may not result in cash if the cycle were traversed without the enablers. The enablers bring about more focus to each of the design phases. In short, the development cycle and the enablers are interrelated. Figure 4.3 depicts the relation of the enablers to the different phases of the development cycle. Following is a brief description of each of the enablers and their role in the development cycle.

4.2.2.1 Strategic Planning

A strategic planning session usually consists of members of the business team comprised of the chief executive officer, chief operating officer, functional heads of engineering, manufacturing, sales & marketing, materials, service and distribution and other members as deemed necessary by the core business team.

In the organizational sense, the central purpose of strategic planning is to sharply focus the limited time and resources of a company on those things that will truly maximize future profitability, survivability and growth. A correct strategic focus holds the key to success.

So as to say, Strategic planning is the process by which a company:

- establishes its mission
- specifies the desired business and financial objectives
- assesses the core competencies and weaknesses
- maps the core competencies to businesses, markets and products the company wishes to pursue
- determines resources required
- plans level of vertical integration which it expects to implement
- considers the sales and distribution channels which needs to be utilized

Creation of a comprehensive strategic plan requires a thorough and honest assessment of the company's strengths and weaknesses. The company must clearly evaluate how well its resources and assets fit with the markets of interest, determine the market segments it can best serve, and verify that these segments have the potential to allow the company to meet its desired objective. It must then select the products to be

developed. Finally, the company must document and communicate the strategic plan, its research and conclusions downward to the members of the company. It is implied that it is management's responsibility to conduct a strategic planning session and communicate the results.

4.2.2.2 Customer-Enriching Product Definition

Quality has come to be defined as meeting customer needs and expectations. The early and accurate determination of customer needs and expectations followed by the translation of these needs into an achievable product definition are critically important steps in the development process. Irrespective of the superior functional and technical aspects of the product, the desired sales will not be realized if the product does not meet the customer's expectations.

Furthermore changing a product's features or characteristics after development begins, to reflect revised perceptions of customer demands, is usually a very costly process. More often, late or inadequate product definition is a major cause of delays in the development cycle. To be profitable in today's world, companies need to adopt strategies for rapid productization and market introduction to capitalize on the early market advantage.

Product definition is not an activity for the marketing department but for the cross-functional team, as always. Customers wants, needs and expectations should be looked at from all perspectives. Internal sources of input could be - product designers, and personnel from manufacturing; quality; marketing and sales; customer service; service

and repair; patent attorneys and in-house users of company's products. External sources could be the likes of present customers, potential customers, focus groups, customer complaints, sales agents, vendors, distributors, business press, technical press, consultants. The key is to stay current and capture the needs of the customer.

A customer enriching product definition typically has five basic steps:

1. Use the inputs from internal and external sources concerning customer needs, wants and expectations.
2. Identify and capture these needs , preferably in the customer's actual words since interpretation could mislead many other people who work with this information.
3. Integrate and analyze the inputs.
4. Compare the customer needs with the company's ability to satisfy these needs.
5. Translate the needs into a product definition which has sufficient detail to guide the implementation of the development of the product. This is done effectively through the use of Quality Function Deployment (QFD) - the method by which the product requirements, design characteristics, and manufacturing processes are systematically derived in detail from the customer's needs and expectations. QFD was explained in greater detail in Chapter three.

Product definition, typically occurs during the concept and feasibility phases of the development cycle since any change in customer needs can be effortlessly captured into the design of the product during these initial stages.

Product feasibility again must be based on consensus from all the departments concerned - for example, manufacturing must verify that it is manufacturable and has a

reasonable know how and the required facilities. This is also the time for make/buy decisions. Finance must verify that the product's projected return-on-investment (ROI) is consistent with the company's overall business plan and that adequate program funding will be available.

4.2.2.3 Operational Planning

This is the planning stage for the implementation of the strategies which came out of the strategic planning session. In other words, the strategic direction provided by management is now transformed into tactical programs whose activities, resources and interactions are defined. It might not be surprising to know that inadequate planning is a major cause of failure to meet project objectives.

A good operational plan has the following characteristics:

- Serves as a roadmap for the project
- Identifies tasks, sequence of tasks, duration of each task, deliverables to internal customers, identifies needs - the deliverables from others.
- Identifies resources, equipment, people, facilities and finance which are needed
- Generates schedules
- Be flexible to modify itself to correct problems.

Successful planning is both a team and individual effort. Team members are responsible for preparing the plans for their functional product responsibilities. They are also responsible for ensuring that their needs and deliverables match those of other

members on the team. The resulting plans are, therefore, a team effort. The plans must be to a sufficient level of detail to facilitate rapid implementation.

4.2.2.4 Formalized Design Process

The primary purpose of having a formalized, systematic design process is to produce cost-effective, quality products in the least possible time. The process should be logical and lead the designers methodically through the design process. At each step, the emphasis should be on quality- meeting customer needs and expectations with reliable serviceable and stable products. Concurrent design is threaded through any successful design/development process.

Documentation is of utmost importance. Reasons for key decisions will soon be forgotten and hence a record is necessary in the event of personnel changes, to allow the original designers to review their previous logic when future changes are proposed, or to help in the search for solutions to problems.

The formalized design process standardizes product development/product re-development in companies by spelling out the specific phases of each stage of the product development and answers what is done, how it is done and how it is to be documented. Like, designing the product has the following steps - architectural, system design and detailed design, models and simulators and design reviews. It also details the complete list of product documentation starting with product master records, bills of materials up to patent applications. Detailed procedures have to be written for the testing of prototypes, validating the design and maturity testing.

A company once used to such documentation procedure is well poised to start working on obtaining certification to international quality management standards like ISO9000.

4.2.2.5 Cross-Functional Teams

The role of cross functional teams cannot be emphasized enough. It should be the basis for all activities in the company. Teams are very effective especially in the product development and redevelopment process due to the fact that collective decision making is a more productive process than individual decision making. The overall quality of decisions and the general success rate of an organization increase substantially when decisions are reached through collective or consensus processes.

Besides forming teams, team members must be empowered to make decisions thereby having the ownership and commitment to the decisions. There must also be an effective means of communication - all team members be in the same room; e-mail connection; periodic meetings etc. The idea is for every team member to be informed of the project status in real time.

4.2.2.6 Communication

Poor communications is a major contributing factor to ineffective product development. Individual contributors do not get the information they need to do their jobs well, and managers cannot make well informed decisions. Poor communications could be as a result of serial development of the product where the design gets ‘tossed over the wall’ to the

next department to work on. Clearly, the barriers to communication must be removed and a participative, communicative and open culture be made the norm. This again is the task for management to initiate and spear head.

4.2.2.7 Organizational and Technical Skills

The unique skills necessary to implement effective product development is of two types - Organizational and Technical skills. Generally they must be acquired through training and education. They do not come naturally. Companies must have ongoing training programs - either formalized or on-the-job. The following are the key organizational and technical skills required of team members for effective NPD/PRD.

Organizational: Team Management, Team building and dynamics, Continuous improvement, Vendor partnering.

Technical skills: QFD, Design for Manufacturability, Statistical Process Control etc.

4.2.2.8 Tools

The use of modern design tools will allow the NPD/PRD process to be completed quicker and with less effort and expense. The list of available tools is extensive and growing everyday. Generally, tools fall into two categories:

1. Productivity improvement tools - which help the implementors perform their current functions faster, or with improved quality.
2. Performance enhancement tools - which allow implementors to perform functions they are otherwise unable to do.

Some of the widely used productivity improvement tools are:

1. Computer - Aided Drafting (CAD);
2. Schematic capture - these are electrical CAD tools to create electrical schematics on a work station;
3. Personal computers/workstations - personal computers with appropriate software are an important productivity tool. Typical uses are for applications involving: word-processing, spreadsheets, databases, local area network, analysis, and information retrieval.

Some of the performance enhancement tools are:

1. Computer - Aided Engineering (CAE) - this refers to computer/workstation/software systems that provide designers with design capability beyond simple CAD. These systems essentially change the way designers work and the way they create new products. Training is essential, and the time needed to acquire intuitive skills may be significant. CAE tools can be further classified as:
 - Mechanical - solid modeling.
 - Electrical - logic simulators, analog modeling, printed circuit board layout and artwork generation.
 - Software - assemblers, compilers and development systems
 - Compute-Aided Software Engineering (CASE)
2. Test equipment - these tools refer to the likes of oscilloscopes, logic analyzers, storage oscilloscopes, programmable pattern generators and programmable waveform generators.

CHAPTER 5

DATA COLLECTION AND ANALYSIS

5.1 Sales Cycle

The sales growth of a defense diversifying firm, which has elements of both defense and commercial business, can be depicted as:

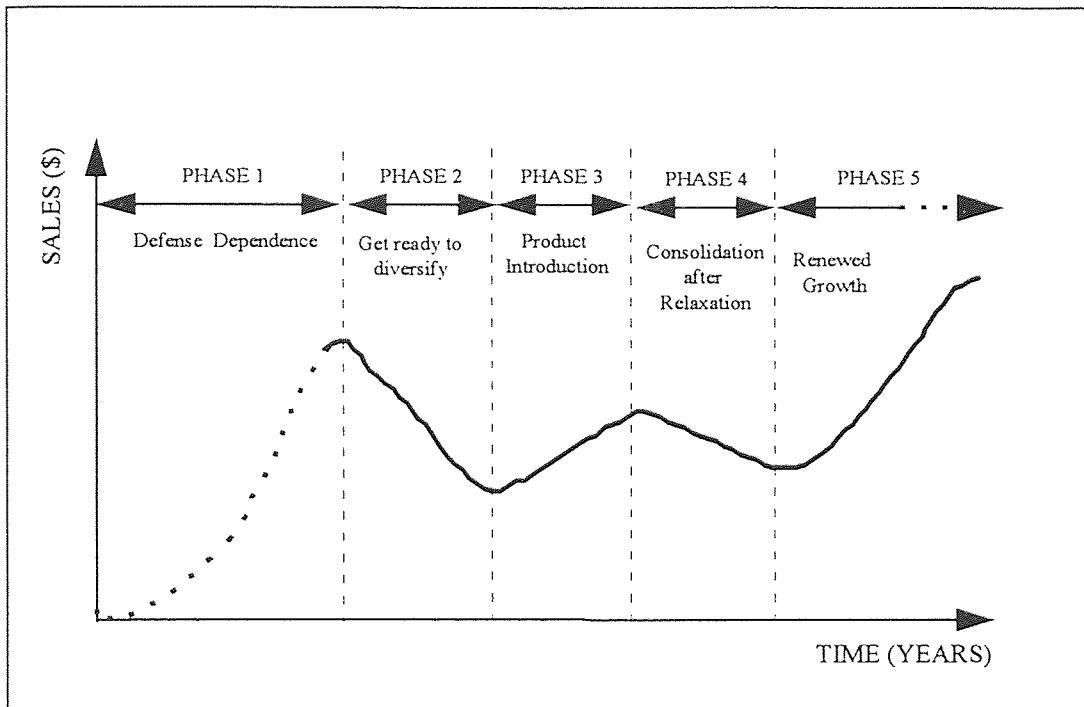


Figure 5.1 Sales cycle of a Defense Diversifying Firm. This figure was developed from the concept sketch of Dr. Michael Oden, Project on Regional and Industrial Economics at Rutgers University, published in Oden et al. 1994.

Phase 1: 'Defense Dependence'

Increasing sales are due to profitability in defense contracts. High profits as a percent of investment due to DoD supplying or financing production equipment and materials. This phase is a period of low risk and high profits.

Phase 2: 'Get Ready to Diversify'

Sales decline due to decrease in defense spending. Company realizes the need to increase commercial sales. This realization brings about the need for a "change agent" - management realization and commitment; new chief executive; new management due to buy-out or acquisition; any of these could bring about the change in the strategic focus of the company.

Strategic planning is done for mapping core competencies and products to potential market niches. Though trying in terms of internal and external resource allocation, the strategic planning process is better realized through the participation and involvement of all relevant employees and solicitation of external expert assistance. A 'plan for change' is created which for implementation. Typically, this plan centers on new product development/ product re-development for the commercial markets and reengineering current business practices.

The next challenge is in obtaining the necessary finance to implement the strategic plan. Obtaining finance has always been the greatest source of difficulty for a defense diversifying firm since the DoD usually funds the product development, capital investments and worker retraining programs. Companies usually typically resort to one of

the following: strategic partnerships, company mergers, acquisitions or buy-outs, solicitation of financial help from government resources.

A market research is done to know of the new markets and the customers and how the company can provide product differentiation in terms of cost, quality, availability and performance. Inherent dual-use nature of the current technologies which the company possesses would greatly enhance the rapid introduction of products into the markets. The company has to gear itself towards high volume production. The new paradigm which a company should subscribe to - "We are a high volume manufacturing company that happens to have good technology; not a technology company that happened to manufacture." The company solicits and closes initial sales by shipping desired quantities to the customer.

Phase 3: 'Product Introduction'

Initial sales in the commercial market during the introductory phase of the product results in an increase in cash flow. Few initial successes motivate the company to look for additional customers, until orders which bring about a noticeable increase in the cash-flow and profits are received. Typically, as a defense supplier used to the likes of Blanket Purchasing Agreements (BPAs) and multi-year contracts, the company tends to be satisfied with the initial orders and rests on its laurels. Oden et al. (1994) noticed in their survey that several companies relaxed their sales effort once they got initial launch customers. Many times, the company fails to realize that it has only reached the first milestone and that consolidation on the part of the company is needed to leverage on the initial market advantage.

Phase 4: 'Consolidation after Relaxation'

There tends to be a decline in sales as companies go through the learning curve in unfamiliar commercial markets. Sometimes, the company is not able to respond to large volume orders which makes customers unhappy. Also, the company is unable to find additional customers since it does not have the required sales & marketing personnel. The decline in sales, after the initial competitive position which the company enjoyed, spurs a flurry of activity in the company.

The company realizes that sales volume increases can be effectively realized only by organized sales solicitation and a permanent sales campaign through sales and marketing personnel. Also, the company faces up to meeting different price and quantity requirements of commercial customers. This results in the carrying of inventory, initially to meet the varying demands of the customers; thorough restructuring of the manufacturing operations of the company to meet fluctuating demands on a permanent basis.

A company which also is dependent on its defense related businesses, to seize the opportunity and penetrate into the commercial markets, typically has the following options to fall on immediately:

- outsource part or whole of the manufacturing of the product;
- form a strategic partnership with a commercial company, could be a competitor located in a different geographical region, who has the knowledge and distribution network in the target market;
- radically restructure the business to suit the commercial markets.

Phase 5: 'Renewed Growth'

Irrespective of the diversification efforts of the company either due to need or due to opportunity, the determined market penetration and expansion effort of the company leads to gradual increase in sales in the long term. The company has to build upon its market position by constantly improving its service to the customers and being innovative.

5.2 Data collection - Survey on Defense Diversified Companies

One of the modes in which the NPD/PRD model developed in this thesis can be verified for its adaptability in defense diversifying companies is to look at processes and enablers of NPD/PRD in a sample of other companies who have gone through the defense diversification process and:

- succeeded (Phase 3 or Phase 4) in the sales and marketing of a new product / re-developed product in the commercial market and realizing sales thereof;
- failed (Phase 2 - Phase 3) in their product introduction and sales realization in the commercial market - the product could not attract commercial customers due to varied reasons.

Also, similar data on a successful commercial company and a company going through the defense diversification process (Phase 2) was obtained.

5.2.1 Data Collection

A survey instrument - 'Defense Industry Questionnaire' (Appendix B) was prepared and faxed to companies which the author, from literature survey, discussion with researchers; consultants; and business press had identified as having gone through the defense diversification process. Except for three of the companies, the others requested to conceal their identity for business reasons. Since many companies wished not to respond, the author had to obtain data (only data, company identity was not revealed by source) from secondary sources - consultants, researchers and personnel from the State economic development authority and State economic conversion authority, who work with defense diversifying firms. When successful companies do not want to share information by responding to the survey, let alone those which failed. Hence, data on companies which failed, the processes employed by these companies and the reason/s for failure, were again obtained from such secondary sources.

Following is a brief description / source of data on each of the companies:

1. Merrimac: Merrimac Industries Inc. in Caldwell, New Jersey.
2. Arizona: A company in Tucson, Arizona whose details were obtained from the consultant at the Arizona Council for Economic Conversion (ACEC), which
3. NY1: A company in Long Island, New York State whose data were obtained from the New York State Department of Economic Development.
4. NY2: A company in Hauppauge, Long Island, New York whose data were obtained from the New York State Department of Economic Development, Long Island.
5. NY3: A Long Island, New York company who requested not to be identified.

6. Fail 1: Data obtained from the staff doing research in defense diversification at the Project on Regional and Industrial Economics at Rutgers University.
7. Fail 2: Data obtained from the staff doing research in defense diversification at the Project on Regional and Industrial Economics at Rutgers University.
8. Tecknit: Tecknit company, Cranford, New Jersey. This is a company going through the diversification process and a pilot member of the New Jersey Defense Diversification Project (NJDDP).
9. W&T: Wallace & Tiernan Inc., Belleville, NJ. This is a 100% commercial market dependent company which has successfully redesigned / developed product for the commercial markets.

Data was collected over the telephone and later quantified.. The responses to questions number 3 to number 7.1 were quantified as 0 or 1 or 2 as per the scheme shown in the table below. Responses to question number 1.0 to number 1.4 (Firm Data) and number 8.0 to number 9.0 (critical success factors, changes in the organization) were tabulated - the information contained in these responses were helpful in analysis and explanation. The rest of the responses, when available, were deemed supportive.

Based on the scoring scheme in table 5.1, a 'Score Chart' (Appendix C) was formulated and the minimum and maximum success scores were determined to be 23 and 38 respectively.

A maximum score is one where a company's response generates the maximum marks and a company has all the elements as asked for in the survey.

Response Type	Score
Yes or conformance	1
No or Non-conformance	0
Costs Underrun; Target sales Exceed	2
Costs Meet; Target sales Meet	1
Costs Overrun, Target sales Fall short	0

Table 5.1 Scoring Scheme

A minimum score is one where a company would respond to having the minimum elements, practices necessary for success. The reasoning is based on prioritization as to the criticality of the element. For instance, referring to the 'Score Chart' (Appendix C):

- the product could either be a product re-design or new product (number 2.0)
- Strategic partnerships or acquisitions or demand from market place could have contributed towards NPD/PRD. But, Strategic planning and Market research are the critical elements. (number 3.1)

Likewise, the responses on all of the companies were quantified and tabulated - ' Survey Results' (appendix D).

5.2.2 Summary of Results

The results of the company responses are summarized in table 5.2 - the elements of 'Firm data' in the survey instrument (Appendix B) which are the performance measures; the 'Total score' from the quantified results on the elements, processes and practices of

Company	Relative Employment '94	Relative Sales '94	Defense Dependence '94	Costs & Sales (max 6)	Total Score
Merrimac	Decline	Slight Decline	Decline	1	19
Arizona	Unchanged	Slight Increase	Decline	1	22
NY1	Increase	Slight Decline	Decline	2	26
NY2	Unchanged	Slight Decline	Decline	3	27
NY3	Increase	Increase	Decline	3	28
Fail 1	not available	not available	Decline	0	13
Fail2	not available	not available	Decline	1	16
Tecknit	Increase	Increase	Decline	4	32
W&T	Decrease	Unchanged	not available	4	31

Table 5.2 Summary of Results

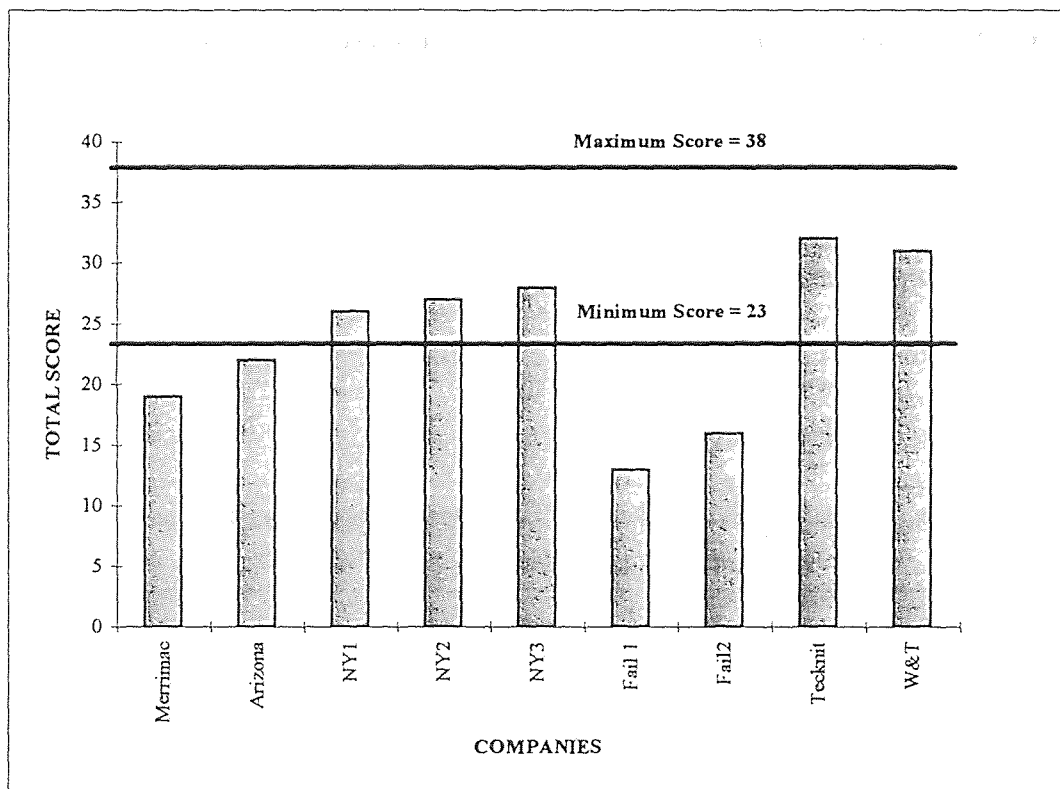


Figure 5.2 Total Score

NPD/PRD (represented graphically in figure 5.2). Responses to questions 8.0 and 9.0 of the survey instrument (Appendix B) - the critical success factors and organizational changes are shown in table 5.3.

5.3 Analysis of Results

With reference to table 5.2, the results can be analyzed on five dimensions namely,

1. Relative Employment in 1994
2. Relative Sales in 1994
3. Defense Dependence in 1994
4. Score for Actual vs. Target Costs and Sales
5. Total Score

Ideally, a company is said to be successful in its defense diversification efforts with respect to product introduction into the commercial market when each of the five indicators are as in the figure below. With reference to the sales cycle in figure 5.1, the company would be in transition from Phase 3 to Phase 4.

With reference to table 5.2, there has been a decline in defense dependence in all companies, though it is known that the factor by which it has changed varies from one company to another. This factor is neither calculated nor considered since it is reflected in the other indicators. All of these companies have the core functional departments - engineering, manufacturing and sales and marketing.

Company	Critical Success Factors	Changes in the organization
MERRIMAC	<ul style="list-style-type: none"> • Reputation • Product Quality • On-time delivery • Market awareness • Competitive Price 	<ul style="list-style-type: none"> • New CEO, hence new policies • Communications to employees • Cost consciousness • Practice of DFM,SPC • Efforts to pursue ISO9000
ARIZONA	<ul style="list-style-type: none"> • Strategic Partnership • Innovative product • Market awareness • Participative management 	<ul style="list-style-type: none"> • TQM Program • Employee training • Worker participation
NY1	<ul style="list-style-type: none"> • Open culture • Market awareness • Flexibility • Training 	<ul style="list-style-type: none"> • Management commitment and involvement • Worker participation and empowerment • Total Customer focus
NY2	<ul style="list-style-type: none"> • Management commitment • Open culture • Reputation • Innovative products 	<ul style="list-style-type: none"> • Total Customer Focus • Outsourcing • Inter-departmental communication • Employee empowerment
NY3	<ul style="list-style-type: none"> • Management Commitment • Business Process • Reengineering • New Product development 	<ul style="list-style-type: none"> • Acquisition of companies • Facility modernization • New Management • TQM Program
W&T	<ul style="list-style-type: none"> • QFD • Cross functional teams • Reputation • Effective distribution 	<ul style="list-style-type: none"> • Customer focused product definition • Inter-departmental communication • Focus on Quality • Worker participation • Outsourcing - subcontracting
TECKNIT	<ul style="list-style-type: none"> • Management commitment • Market analysis • Product design • Competitive price • Short Lead time 	<ul style="list-style-type: none"> • Flatter Organization • Increased R&D resources • Focused marketing department • Product teams • Improved communications

Table 5.3 CSF and Changes

Indicator	Ideal value	Atleast
Relative employment '94	Increase	Unchanged
Relative sales '94	Increase	Unchanged
Defense dependence	Decline	Decline
Score for Costs & Sales	6	≥ 3
Total Score	38	≥ 23

Table 5.4 Value of Dimensions

Amongst the successfully defense diversified companies, NY3, NY2 and NY1 in the order stated are the leaders. All indicators corroborate to the total score of each of these three companies which is well above the minimum total score (table 5.3). The slight decline in sales for NY2 and NY1 can be attributed to the learning curve these companies are going through in the commercial market. It is also related to the downside of general business conditions. NY3 has a slight edge over NY1 and NY2 in sales due to the contribution to its overall sales by the companies it acquired. With reference to figure 5.5, all of these companies have changed business practices, adopted participative management and total customer focus.

Despite the values for relative employment and relative sales coinciding with those mentioned in table 5.4, Arizona's overall score is slightly less than the minimum. It can be inferred that this is due to the low score for costs and sales. This company, though employs all the enablers and processes as per the NPD/PRD model, has quality problems

with its products due to the product being a new addition and that it is going through the maturation cycle. Also, this is an example of a company in transition from Phase 2 to Phase 3.

Merrimac's low score can be attributed to the fact that it does not employ most of the enablers for NPD/PRD at the front end of the design at present, though it uses Design for Manufacturability (DFM) analysis and Statistical Process Control (SPC). The company recently went through a change in top management and is transforming itself to being a customer focused company. Merrimac can also be thought of as a company in transition from Phase 2 to Phase 3. Its low overall score can also be attributed to the low score for costs and sales, which again is due to not employing efficient methods for product design and manufacture. It was understood that the product development for commercial markets was solely based on the perceived market place demand; no formal strategic planning or market research was done.

Both companies which failed in their first attempt, Fail 1 and Fail 2, are still highly defense dependent. Again the low score can be attributed to the non-existence of most of the enablers in the practices and processes of these companies. One of the main reasons for Fail 1's failure was the following: Fail 1 designed an electronic system with a commercial application (a dual-use product), but had produced only ten prototypes. The company was confident about the innovativeness of the product and that they will be able to ramp up to volume production, offered the prototypes at a large industry trade show. Several commercial customers were interested and asked if the firm could ship orders of

several hundred units, which Fail 1 obviously was unable to satisfy, since they were six months from production. Commercial customers quickly lost interest.

Fail 2 was a company which went into a strategic partnership with another firm. The firm's product development was done without a feel for the industry needs and the competition. There was no formal strategic planning and market research. When the product was about ready for the market, the companies realized the potential failure.

A defense diversifying company like Tecknit is certainly poised for success. Tecknit's strength lies, besides its organized diversification effort, in its technology base. It is one of the industry leaders in electromagnetic shielding materials, components and systems. This strong technology base combined with careful and meticulous planning and implementation of the diversification strategy has put the company on strong footing. This company can be said to be in the early stages of Phase 3. What is required is to keep up the momentum and defy Phase 4.

On the other hand, as expected a successful commercial company like Wallace and Tiernan Inc. measures up very close to the maximum score. Due to recent management changes and generally poor business conditions, there has been a decline in employment. Interestingly, worker participation and empowerment for continuous improvement of processes, products and facilities results in higher efficiency which results not in down sizing, but right-sizing.

5.4 Case Studies

These case studies explain some of the common business strategies and practices of companies responding to declining defense sales. These case studies were based on public company data, coverage in the press, interviews with researchers who had interviewed company officials and reports from these researchers which are in the public domain. In some cases, additional information was collected from the Dun and Bradstreet database and through telephone interviews with company personnel. Key characteristics of each company's diversification process is stated prior to the description.

Case study 1: Trans-Tech, Inc.

Key Characteristics: *Company foresight, Management vision and leadership, Business restructuring, Leveraging technology base.* Adopted from Shelsby (1994).

Trans-Tech, Inc. (TTI) is a small Maryland based, 38 year old company which is a subsidiary of Alpha Industries Inc. Its defense business has been in the supply of ceramic parts used in the Patriot and Hawk missiles and B1-B Bomber. TTI was not at all affected by the defense cut backs due to the foresight of its management.

In 1987, TTI was 90% defense dependent; annual sales of \$8.4 million; annual growth of 3%; and only had 10% of its sales from exports. That is when management made the decision to diversify - not only to find new commercial markets but also significantly restructure the company. A new chief executive officer (CEO), with the correct professional and business background, was hired by the parent company to restructure TTI and find new markets and make sales soar.

The CEO proved to be a strong leader and visionary and defied skeptics by finding new commercial applications for the ceramic insulators in cellular telephones, global positioning satellite systems, and wireless computer communication links.

TTI clearly understood the demands of the commercial market and what it takes to successfully penetrate into such unfamiliar markets. The company had to greatly reduce the time it took to design and manufacture new products, slash per-unit costs, and significantly increase the number of units produced on each product run. It realized that in the commercial market, parts are priced so competitively that making it right the first time is the only way not to incur losses. TTI had its challenges - strong Japanese competition, 30% drop in the price of its products annually and a skeptic workforce.

It took the vision, persistence, determination and leadership of the new CEO to turn the company around and every employee acknowledges this fact. TTI feels that changing the culture of the workforce was more difficult than bringing in new equipment and setting up new assembly processes.

TTI made a gradual and permanent change over a period of five years in its practices, culture, products and processes. Much of TTI's financial woes were taken care of by the Maryland Department of Economic and Employment Development by providing loans and grants. The results of TTI's untiring efforts in relation to its position in 1987:

- TTI's commercial business has increased from 10 to 85%
- Sales have jumped from \$8.4 million to \$22 million
- Export has increased from 10% to 40% of sales
- Employment has increased from 125 people to 170 people.

Case study 2: Microwave Power Devices, Inc.

Key Characteristics: *Strategic acquisitions; New management; Management commitment; Retention of defense business ; Dual-use technology base.* . Adopted from Oden. et.al. (1994), Dun and Bradstreet database, telephone interview with company personnel.

Microwave Power Devices, Inc. is a Long Island, New York, based company which designs and manufactures high power solid state microwave power amplifiers. It makes a variety of amplifier systems and subsystems for military and commercial applications.

MPD originally was a division of a large electronics company which, in 1991, was almost totally defense dependent and was undergoing sales and employment losses. Then, it was purchased by a large private investment group and new management team was installed to turn the company around.

The new management promptly implemented an aggressive strategy with the following main elements:

1. brought in new military and commercial work through strategic acquisitions of small companies;
2. implemented a major modernization of its facilities;
3. implemented a company-wide Total Quality Management (TQM) program;
4. invested in new product development;
5. reoriented its marketing to commercial areas.

MPD's strategic acquisitions in similar businesses brought in sales backlogs and reduced overheads. They also had new exciting products ready to go to the commercial market. The management focused on consolidating all operations in the same facility, restructuring business practices for the commercial markets; forming multi-functional teams for rapid product introduction; emphasizing manufacturability of its products; and pursuing ISO9000 certification. MPD revamped its sales and marketing department, and trained its personnel to actively solicit and close sales on regular basis. It also invested in the training of its personnel with financial assistance from State training grants.

The change in business practices and culture greatly enhanced the new product development effort based on inherent dual-use nature of its core defense technologies. Owing to its niche market in the defense industry, the company has turned out to be a commercial-military integrated facility by building a separate facility for its commercial operations so as not to carry the overhead resulting from accounting, testing and documentation requirements of the defense business.

MPD's efforts have resulted in sales increases of 10% last year and the addition of 50 new employees.

Case study 3: AES - IMCO

Key Characteristics: *Strategic partnership; Management foresight and initiative; Labor-management partnership; New markets through federal regulations.* Adopted from Evans-Klock (1994). Additional data gathered through telephone conversations with key company personnel.

Inter-continental Manufacturing Co. (IMCO) of Garland, Texas is a leading manufacturer of bomb casings and missile components. It is 75% defense dependent with metal forgings for the aerospace industry accounting for the rest. Though the company is not presently affected by the defense cut backs, to preserve the future of its 530 employees, including the 430 production workers represented by the International Association of Machinists and Aerospace Workers (IAM Local 526), decided to diversify into commercial markets. IMCO through strategic planning, given its core manufacturing competencies, identified specialty equipment as the business for diversification.

Advanced Enviro Tech Systems, Inc. of Dallas, a 15 month old company with 22 employees, is a start-up environmental engineering firm specializing in the design of waste disposal systems. AES had designed a thermal oxidizing system for eliminating hospital 'red bag' infectious waste without harmful emissions and was searching for a manufacturing partner.

The needs of IMCO and AES matched and they formed a strategic partnership between themselves. As a metal forging, machining and fabrication shop, IMCO's metalworking capability and technology met AES's requirements for a manufacturing facility. The AES-IMCO partnership, within one year through multi-functional teaming,

has successfully brought to market the AES modular on-site incinerator, called the Enviroclean 500, which efficiently disintegrates waste.

IMCO felt that “ breaking out of the mold required of government contractors - where all specifications, requirements, inspection procedure etc. are laid out; the overkill embedded in the specifications is ingrained in the way we think ” has been the most difficult aspect of their diversification effort (Evans Klock 1994).

The strategic partnership has given AES a manufacturing facility and for IMCO a starting point for internalizing requirements, for adopting aggressive cost containment measures and enhancing production to customer preferences. Also IMCO has benefited from leap-frogging the two barriers which a typical defense supplier faces - identifying alternative markets and becoming commercially viable.

The Environmental Protection Agency's (EPA) recommendation as incineration as the Best Available Compliance Technology (BACT) since it destroys, rather than treats and disposes, waste created a ‘market pull’ incentive for firms to develop better disposal technologies. AES had the scientific know-how and knowledge of the waste disposal industry to develop the Enviro Clean 500 in anticipation of the \$2 billion market growth for waste treatment by the year 2000.

By teaming with IMCO, AES has benefited by its staff becoming a part of IMCO's TQM program and worker training program. IMCO continues to remain a defense supplier.

Case study 4: National Manufacturing

Key Characteristics: *Take-over; Strategic Planning and execution; Emphasis on manufacturability, reliability and quality; Training for all employees; Participative management; Solicit external assistance.* Adopted from Oden et al. (1993).

National Manufacturing Company (NMC) is a medium-sized firm with over \$30M in sales and 90% defense dependent. Traditionally, it produced artillery shells for the army but has started the process of diversifying into commercial markets so as to be 25% defense dependent in the next two years, much credit goes to the entrepreneur who took over.

NMC went through a strategic planning process and mapped its core competencies - CNC turning and milling; electroplating; inspection and testing; engineering design and manufacturing; and injection and poured molding, to potential market opportunities and targeted three product/market areas:

1. A new design on a standard oil pump which will improve performance and pump life;
2. Various metal parts and components for automobile manufacturers;
3. Producing plastic cups and lids.

In order to establish credibility as a reliable supplier with commercial customers, NMC is undergoing top-down restructuring of its operations; improving manufacturability of parts, reducing defect rates, improving component quality and reliability. It systematically retrained workers, managers and engineers. There is increased worker-participation in the decision making and a profit-sharing system.

Market research and sales operations presented difficult hurdles as the company began to seriously pursue commercial market opportunities. NMC hired outside consultants to conduct market research and secured sales representatives with experience and contacts in the commercial product areas that it is pursuing.

CHAPTER 6

CONCLUSIONS AND FUTURE RESEARCH

6.1 Conclusions - NPD/PRD Model

The New Product Development / Product Re-Development process model was developed based on successfully tested and well demonstrated and documented principles, practices and processes in the commercial manufacturing industry. In addition, the model, as well as the modes of verification, was based on :

- literature survey, site visits to companies and data collected from the survey;
- the guidance and critique of the thesis committee members;
- discussions with manufacturing, engineering, sales & marketing executives of the companies whom the author worked with as part of the New Jersey Defense Diversification Project (NJDDP).
- author's first hand industry experience in having worked on NPD/PRD projects.
- data collected and analyzed through the survey done, as explained in chapter 5, section 5.2.1 and 5.3
- case studies reviewed, some of which are discussed in section 5.4

The model, though initially developed, as an application for small electronics companies, is very generic in its form and function so as to be adapted to NPD/PRD processes in companies belonging to any other industry.

Also, the model assumes that a company which adopts this approach for NPD/PRD has the basic elements of the three main functional departments - Engineering,

Manufacturing and Sales and Marketing; or will develop the necessary resources and personnel. As shown in the case studies, if the company lacks a specific functional expertise, it can be solicited from outside of the company through strategic partnerships, acquisitions, investment, consultants etc.

The results of the survey done with a representative set of companies successful and unsuccessful in their defense diversification efforts, and the analysis which followed show that:

1. The NPD/PRD process elements are practiced by all successful companies - those defense diversified, a company undergoing diversification and a successful commercial company, the NPD/PRD process can be said to be an integral part of a company's success in its diversification efforts.
2. Overall, it can be said that, NPD/PRD is one of the core activities of a company which is gearing itself to enter, penetrate and dominate commercial markets. An organized and systematic effort is fundamental to the success of the product in the commercial market place. It is also more important because success, especially the first time into the commercial market, is critical to providing the moral boost to the company and it results in organizational alignment and renewal.
3. Defense diversification is a long-term process and all companies go through the learning and maturation cycle. The companies which were surveyed were judged based on indicators for the years 1992 and 1994. As shown in the case studies, it could take anywhere between 4-8 years for a defense dependent company to completely mature in the commercial markets. Again, this time-frame is an estimate

based on the author's collective research, interviews, literature review and case studies presented in section 5.4.

4. Due to limitations in accurate and specific data collection from companies, especially the defense diversifying firms wanting to be secretive about their specific efforts, the responses were to a major part qualitative in nature which were later quantified. Hence, any form of statistical analysis is beyond the scope of this thesis.

6.2 Conclusions - Defense Diversification

Defense Diversification is a long term process and companies going through the process need to be committed and persistent. As is said, companies cannot dabble in the diversification process. The success of a company is dependent on many factors and elements, even though NPD/PRD is at the core of the efforts of all companies pursuing commercial markets.

Common elements in the efforts of companies going through the diversification process can be identified as follows:

1. A fundamental change in either management philosophy or ownership which results in management commitment to diversify. A basic long-term commitment, vision and leadership, is needed on the part of the decision-makers in the company;
2. Thorough restructuring of business operations to achieve the performance required to enter and compete in target markets;
3. A culture change which results in participative management, worker involvement and ownership, rapid productization goals and total customer focus.

Successful diversification requires a willingness to take risks and a commitment to restructure the operations from top-to-bottom. This shows that success in diversification takes much more than the core capabilities - modern equipment; highly trained and motivated workers; company wide quality control systems.

Companies go through a strategic planning process to link their core competencies to new market opportunities. Strategic planning helps companies identify the operational changes required to compete in the alternative markets selected. Learning to operate proactively in the rapidly changing and more unregulated conditions of the commercial market involves the creation of a new culture in the business. A whole new approach to quality and cost control for providing product differentiation and becoming competitive in commercial markets. A multi-functional teaming approach results in the close integration of and communication of research, marketing, design and manufacturing, which in turn necessitates the commitment of the entire work force.

The company must do what it takes to achieve excellence in product quality, price and customer service. Overheads linked to defense business must be eliminated, quality must be built into the products, establish cooperative participation with suppliers, customers and competitors. The latter is usually very helpful in resolving standardization issues in the commercial markets.

Companies which have niche markets in the defense business can continue to be commercial-military integrated. They might profit in the long run due to the recent DoD changes in acquisition practices and reform in milspecs, as explained in section 3.6.3.

6.3 Role of Technology Centers in Defense Diversification

In the core of a company's defense diversification efforts is the development of new products or re-development of existing products for the commercial markets. Some form of DoD funding was always made available to the firms for research and development work. Though all companies (a large number of them in New Jersey are small subcontractors) want to engage in either NPD or PRD to leverage their commercial market penetration efforts, more often than not, they lack the necessary financial resources.

As mentioned in Chapter 2, defense diversifying companies in all states have responded that availability of finance and sales and marketing are the top two challenges facing defense diversifying companies. If sufficient funds are available, sales and marketing expertise can be solicited and paid for from an outside expert or consultant.

The results of a 1993 survey on defense dependent companies in New Jersey by the Eagleton Institute of Politics at the Rutgers University for the New Jersey Department of Commerce and Economic Development show that seventy percent of the companies' leading strategy for reducing current defense dependence is the development of a new non-defense products.

The following technology areas, ranked by importance, were identified to be important to reducing dependence on DoD contracts:

- Mechanical design and manufacture
- Electronics design and manufacture
- Information technologies

Also, it was found that more than half of the companies were willing to actively cooperate with the universities in their efforts for defense diversification.

- Facilitating the rapid transfer of research results to the market place.

Undertaking collaborative research projects with industry, other academic institutions, and state-sponsored economic development and technology transfer programs to enhance manufacturing productivity and competitiveness in New Jersey and the region.

State funded Advanced Technology Centers (ATC) and their respective Manufacturing Extension Programs (MEP) can play a valuable role in the defense diversification process of companies through their technical and management resources, links to other federal and state agencies and research institutions, and collaboration with universities and federal labs.

1. **Business Incubators.** The technology centers could channel their efforts to actively promote the formation of business incubators. Incubators of this type would be a means of building on local defense technological expertise. Business incubators provide companies with low cost space and business services which would be of immense help to companies in the start-up period. Since this country is moving more and more towards a service oriented economy, incubators would attract the defense industry talents to set up turn-key consulting firms where the design is done and prototyping support provided by the ATCs.
2. **Turn-key projects.** The ATCs with their expertise in mechanical and electrical design and manufacture could be of assistance to defense diversifying firms in doing turn-key design and development projects. Typically, many small subcontractors lack expertise

in efficient manufacturing processes and practices. Typically, products could be designed, developed, prototyped and provided to the companies along with manufacturing process plans, calculations and other documentation.

3. **Training in CAD/CAE, CNC machines.** Practical, low cost, hands-on training programs could be developed to impart state-of-the-art skills to the design and process engineers of defense diversifying firms at a fraction of the cost charged by commercial training firms.
4. **Assistance in Research and development.** Besides product development and redevelopment, the companies have to make changes to the current manufacturing processes and equipment.. The engineering research centers in the ATCs can help these companies with specific technology development and rapid productization.

Besides providing technical assistance, the ATCs can provide management assistance to companies in the areas of Total Quality Management (TQM), certification to international quality management standards like ISO9000, benchmarking, reengineering business practices. All of these management elements which would make the companies totally customer-focused.

6.4 Future Research

Defense diversification has caught the attention many interest groups - researchers, consultants, lobbyists, universities, policy makers and State and Federal economic development authorities. The California State University at San Diego has recently started a graduate program in Defense Diversification.

A set of very detailed case studies on eight to ten companies of various sizes and industry classification which traces every company from its beginnings to the start of the diversification process and the maturity of the company five years from there on will shed more light on the inner workings of each successful or failure company. Statistical inferences could be possible if the sample size is adequately large. The author feels that it is a long-term undertaking and it takes a great deal of efforts, if at all companies agree to divulge scores of data on the history of their business and operating practices.

A computerized assessment tool could be developed on the type and intensity of CE practices which would suit a defense diversifying company . The Assessment Tool given in Carter 1992, Appendix B could be used as a benchmark. The tool will be intended to provide a road-map for adoption of CE practices.

APPENDIX A

DEFENSE ELECTRONICS INDUSTRY QUESTIONNAIRE

The purpose of the survey is to identify the products/services each firm is currently capable of delivering competitively to commercial markets, available resources and company practices, providing information needed to identify new customers and formulate a strategic marketing plan.

Name (of person):
Title:

Date:

4-D SIC code(s):
(8D, if known)

Firm Name:

Employees :

Address:

Contact/Title:
(if different from above)

Tel:

Fax:

1. FIRM DATA

1.1 Age: 1.2 Years at location:

Other locations?

1.3 Ownership form (partnership, corporation, subsidiary, etc.)

1.4 Sales (\$M) for Last Three Years:

1.5 Defense dependence (percent of sales): High year and %

1994 est.

1.6 Business Organization/Trade Association Memberships:

1.7 Please provide company brochures (by mail) and equipment lists (append).

1.8 Narrative history of firm 1985- (M&A, relocations/employment level changes/key technological changes/product lines, plans for defense conversion, etc.) Continue on back.

2. PRODUCTION CAPABILITIES

2.1 List major products/services and current capacity utilization:

APPENDIX A
(Continued)

2.2 Which steps in the production process are done here? (List in order of importance; note major pieces of production equipment)

2.3 What other manufacturing activities go on here?

2.4 Does firm work to print or develop proprietary products or both? What % of production is for both?

2.5 Subcontracting

2.5.1 Do you subcontract work to other firms? What? how much? how often?

2.5.2 How do you select the firms you subcontract to?

2.5.3 Where are most of your subcontractors located?

2.5.4 Are you looking for any specific types of suppliers at this time?

2.6 Which of the following do you intend to change in the next 2 years? Circle and describe.

Equipment

Space/layout

Product line(s)

Location

Quality assurance system

Workforce

Other

3.0 SUPPLIERS AND CUSTOMERS

3.1 Who are your *five most important suppliers* and what do you buy from each? (These may be catalog items.)

Supplier/location (address) purchased	Item	Estimate of annual quantity
--	------	-----------------------------

3.2 Who are your *five most important customers* and what are you shipping to each?

Customer/location(address) shipped	Type of goods/used in	quantity
---------------------------------------	-----------------------	----------

APPENDIX A
(Continued)

3.3 How is marketing currently handled? How many new customers will you approach this year? How many will be outside the defense sector?

Trade shows (which)

Independent reps (how many, where)

Marketing manager and staff in firm (describe functions in detail)

Advertising (obtain examples)

Other

3.4 Export record: have you exported?

Are you doing so now?

What?

How much in dollars?

Where?

How?

3.5 Do you have a strategic marketing plan?

Who is responsible for implementation?

Please describe the plan in some detail (target customer groups, product/service innovation, promotion and sales effort, etc.).

3.6 Do you have patents a/o copyrights that protect your products? How many?

4. QUALITY

4.1 To what Milspecs are you certified?

4.2 How are quality standards set in your *present* industry sector?

APPENDIX A
(Continued)

4.3 Do you experience problems with quality control? Describe reject rates, rework, sources of defects.

4.4 How do you currently control quality?(Y/N)

Individual workers are responsible

Special quality inspectors along line

Final inspection and testing only

Other (describe)

4.5 How do you service defective products in the field? What is the cost of doing this?

4.5 Are you working on or planning ISO 9000 implementation? Describe.

4.6 Would quality training or quality certification help you market your firm? How?

5. WORKFORCE

5.1 Please describe your manufacturing workforce at this time:

Machine operators (type and number)

Assembly (type and number)

Maintenance/repair (type and number)

Supervisory (shopfloor)

Testing/inspection

Other (type and number)

Total number of production-oriented workers

5.2 Is there a TQM/workforce empowerment/self-directed workteam program in place or planned?

5.3 Training to increase productivity. Discuss Customized training possibilities and note needs.

5.4 R&D capabilities: How many design engineers and/or scientists are employed here? List by specialty.

APPENDIX A
(Continued)

What R&D (field, dollar value) have you done recently?

What R&D plans have you? Do you use contract R&D labs? Federal or university partnerships?

5.5 What categories of workers do you have difficulty keeping or finding? How many of each could you use in the near future? At what starting pay?

Category	Number needed	Pay rate
----------	---------------	----------

6. FINANCING CONVERSION AND GROWTH

6.1 Many manufacturing firms have difficulty obtaining capital for innovation and expansion. Have you had this problem?

6.2 Has working capital been a problem?

Average amount needed

Reason (finance inventory, develop new products, clients slow pay,etc.)

6.3 Loans for equipment purchases?

Amount needed, equipment wanted.

6.4 What sources (state/federal loan sources, venture capital groups, banks) have you approached/what is key problem?

APPENDIX A
(Continued)

FINAL OPEN ENDED QUESTIONS

1. What is the *core competence* of your firm?

2. Your industry is going through a difficult period. What do you think are the strengths of the electronics industry in New Jersey?

3. What are the weaknesses of your industry here?

4. What do you think is the greatest challenge facing firms in your business?

5. What services--in a) technology selection, b) environmental compliance, c) management consulting, d) financial assistance, e) product innovation, f) marketing, g) workforce development, OR ANYTHING ELSE--do you think would help make your firm more competitive?

- 5a. Would value-engineering--help in redesigning products to fit the needs of commercial markets --be useful?

- 5b. Would you be interested in licensing product technology on a royalty basis if it gave you access to new markets?

6. Industry cooperation is frequently said to be the key to competitiveness in a global marketplace. How could electronics firms in the area work together to solve common problems?

Thank you. We will complete our preliminary market research and be back in touch.

APPENDIX B

DEFENSE INDUSTRY QUESTIONNAIRE.

Please fax the completed questionnaire to Sathy Chalam @ 201-596-6438, Tel: 201-596-6461

The purpose of the survey is to identify the the process of new product development / product re-design for commercial markets in defense sub-contractor companies engaged in the process of defense diversification

Date: _____ Firm Name: _____
 4-D SIC code(s): _____ Address: _____
 (8D, if known)
 Contact/Title: _____ Tel: _____ Fax: _____

1. FIRM DATA

1.1 Age: _____ 1.2 # Employees in: 1994 _____ in 1992: _____
 1.3 Annual Sales (\$M) for: 1994 (estimate) _____ 1992 _____
 1.3.1 Defense dependence (percent of sales): High year & % _____ 1994 est. _____
 1.4 The major functional departments are (like Engineering, Manufacturing..) *(Please state)*

2. PRODUCTS

2.1 Major products for the defense industry - their applications
 a) _____
 b) _____
 c) _____

2.2 Product/s for the commercial market and it/their application/s

This product was a *(Please ✓)*

Product	Product Re-design	New Product for Commercial use
a)		
b)		
c)		

3. THE PROCESS - of product development / product re-design for commercial markets. The emphasis is to find out the changes that the firm had to make in it's operational / business practices.

(Please ✓ all your choices for the following questions unless specified otherwise)

3.0 Changes in the product development/ re-design process

a) Formation of Cross functional teams b) Improvements in the manufacturing facility
 c) New, low cost manufacturing processes d) others *(please state)*

3.1 What were the key steps/processes which led to new product development/ redesign of product for the commercial market?

a) Strategic Planning b) Market Research
 c) Strategic partnership/alliance d) Demand from Market place

**APPENDIX B
(Continued)**

- e) Acquisition of companies f) others (*please state*)

3.2 How are products designed around customer needs and expectations ?

- a) Quality Function Deployment c) Product Benchmarking
b) Customer feedback d) Feedback from distributors

4.0 CROSS FUNCTIONAL TEAMS.

- a) Were such teams used in the product development process?
b) Was this an Enterprise team - Customers and Suppliers part of this team ? (*Please state*)
c) Were all members full time? or was there a core team of 2-3 people and others filled in when necessary? (*Please state*)
d) Did Team relocate to a common office space? (*Please state*)
e) Were there any other means of effective communication between the team members? (*Please state*)

4.1 EMPOWERMENT

- a) Were teams empowered to make design decisions? (*Y/N*)
b) Were individuals responsible for scheduling and completing their own tasks? (*Y/N*)
c) What was the level of empowerment; the level of authority they had? (*Please state*)

4.2 TRAINING

- a) Did the employees involved undergo training in the needed tools/skills? (*Y/N*)
b) Was this on-the-job training or formalized training? (*Please state*)

5.0 CAD(Computer Aided Design) /CAE (Computer Aided Engineering)Tools

- a) Were these tools available and used in the process? (*Y/N*)
b) Were these tools integrated with those of the suppliers? (*Y/N*)

5.1 DESIGN PROCESS (*Please state/ ✓ all your choices as applicable*)

- a) Which of the following do you use to evaluate the designs for cost, functionality, fitness for use, reliability?
Value Analysis/Engineering Design for Manufacturability Analysis
Failure Mode and Effects Analysis Statistical Process Control
Others (*please state*)

6.0 COSTS (*Please state*)

- a) Did your new product/s underrun, meet or overrun target costs?
b) Did your total product development costs underrun, meet or exceed budget?
c) Did the product sales exceed or fall-short of forecast ?

APPENDIX B
(Continued)

6.1 Are the products certified to commercial laboratory standards? *(Please state)*

6.2 Does there exist a systematic design and documentation procedure? *(Please state)*

OTHERS

7.0 Is there a Supplier qualification program to select third-party vendors for products and tools? *(Y/N)*

7.1 Is your company pursuing ISO 9000? *(Y/N)*

8.0 **CRITICAL SUCCESS FACTORS** - Please list what you think are the 5 most important factors/ enablers which contributed to your company's successful entry into the commercial market *(in the order of importance)*

1.

2.

3.

4.

5.

9.0 **WHAT ARE THE 5 MOST IMPORTANT CHANGES/ NEW PRACTICES IN YOUR ORGANIZATION** *(in the order of organizational impact)*

1.

2.

3.

4.

5.

APPENDIX C

SCORE CHART

Scoring Scheme:

Conformance = 1; Non-conformance = 0

U, E = 2; M=1; O, F = 0; n.a= not applicable

		TOTAL SCORE	
		Maximum	Minimum
1.0	Company Name	n.a	n.a
1.1	Age (years)	n.a	n.a
1.2	No. of employees in 1994/1992	n.a	n.a
1.3	Annual Sales (\$M) for 1994/1992	n.a	n.a
1.3.	%Defense - % Commercial (before 1993)	n.a	n.a
	%Defense - % Commercial (estimated 1994)	n.a	n.a
1.4	Functional Departments		
	Engineering	1	1
	Manufacturing	1	1
	Sales and Marketing	1	1
2.0	Product/s for commercial market		
	was a Re-design	1	1
	was a New Product	1	
3.0	Changes for effective NPD/PRD process		
	Formation of Cross functional teams	1	1
	Improvement in Manufacturing facility	1	1
	New Low cost manufacturing processes	1	
3.1	NPD/PRD was preceded by		
	Strategic Planning	1	1
	Market Research	1	1
	Strategic Partnerships	1	
	Acquisition of companies	1	
	Demand from Market Place/ others	1	1
3.2	Product definition		
	Quality Function Deployment	1	1
	Product Benchmarking	1	
	Customer feedback	1	1
	Feedback from distributors	1	
4.0	Cross functional teams		
	Customers part of the team	1	
	Suppliers part of the team	1	
	Core team + fill-in members	1	1
	Communication	1	1
4.1	Empowerment of team members	1	1
4.2	Training of employees	1	1
5.0	Use of CAD/CAE Tools	1	1
5.1	Tools for product optimization		
	Value Analysis / Value Engineering	1	1
	Design for Manufacturability Analysis	1	1
	Statistical Process Control	1	1
	Failure Mode and Effects Analysis	1	
6.0	Actual vs Target Costs & Sales		
	Product Costs (Underrun/ Meet//Overrun)	2	1
	Total Development Costs (Underrun/ Meet/Overrun)	2	
	Total Product sales (Fall short/Meet/Exceed)	2	1
6.1	Certification of products to commercial standards	1	
6.2	Procedure for Design and Documentation	1	1
7.0	Supplier Qualification Program	1	
7.1	Efforts in pursuing ISO 9000	1	1
TOTAL SCORE		38	23

APPENDIX D

SURVEY RESULTS

1.0	Company Name	Merrimac	Arizona	NY1
1.1	Age (years)	40	50	45
1.2	No. of employees in 1994/1992	125/170	140/140	155/135
1.3	Annual Sales (\$M) for 1994//1992	14/14.8	20/19.5	22/24
1.3.1	%Defense - % Commercial (before 1993)	70-30	75-25	70-30
	%Defense - % Commercial (estimated 1994)	50-50	60-40	60-40
1.4	Functional Departments			
	Engineering	1	1	1
	Manufacturing	1	1	1
	Sales and Marketing	1	1	1
2.0	Product/s for commercial market			
	was a Re-design	1	0	1
	was a New Product	1	1	1
3.0	Changes for effective NPD/PRD process			
	Formation of Cross functional teams	0	1	1
	Improvement in Manufacturing facility	1	0	1
	New Low cost manufacturing processes	1	1	1
3.1	NPD/PRD was preceded by			
	Strategic Planning	0	1	1
	Market Research	0	1	1
	Strategic Partnerships	0	1	0
	Acquisition of companies	0	0	0
	Demand from Market Place	1	0	1
3.2	Product definition			
	Quality Function Deployment	1	1	1
	Product Benchmarking	0	0	0
	Customer feedback	1	0	1
	Feedback from distributors	0	0	0
4.0	Cross functional teams			
	Customers part of the team	0	0	0
	Suppliers part of the team	0	0	0
	Core team + fill-in members	0	1	1
	Communication	0	1	1
4.1	Empowerment of team members	0	1	1
4.2	Training of employees	0	1	1
5.0	Use of CAD/CAE Tools	1	1	1
5.1	Tools for product optimization			
	Value Analysis / Value Engineering	0	1	0
	Design for Manufacturability Analysis	1	0	1
	Statistical Process Control	1	0	1
	Failure Mode and Effects Analysis	1	1	1
6.0	Actual vs Target Costs & Sales			
	Product Costs (Underrun/ Meet//Overrun)	0	0	1
	Total Development Costs (Underrun/ Meet/Overrun)	0	0	0
	Total Product sales (Fall short/Meet/Exceed)	1	1	1
6.1	Certification of products to commercial standards	1	1	0
6.2	Procedure for Design and Documentation	1	1	1
7.0	Supplier Qualification Program	1	1	1
7.1	Efforts in pursuing ISO 9000	1	1	1
	TOTAL SCORE	19	22	26

APPENDIX D
(Continued)

1.0	Company Name	NY2	NY3	Fall 1
1.1	Age (years)	60	10	20
1.2	No. of employees in 1994/1992	160/160	240/150	unknown
1.3	Annual Sales (\$M) for 1994//1992	28/29	26/24	unknown
1.3.1	%Defense - % Commercial (before 1993)	75-25	80-20	95-05
	%Defense - % Commercial (estimated 1994)	60-40	65-35	90-10
1.4	Functional Departments			
	Engineering	1	1	1
	Manufacturing	1	1	1
	Sales and Marketing	1	1	1
2.0	Product/s for commercial market			
	was a Re-design	0	1	1
	was a New Product	1	1	0
3.0	Changes for effective NPD/PRD process			
	Formation of Cross functional teams	1	1	0
	Improvement in Manufacturing facility	1	1	1
	New Low cost manufacturing processes	1		0
3.1	NPD/PRD was preceded by			
	Strategic Planning	1	1	0
	Market Research	1	1	1
	Strategic Partnerships	0	0	0
	Acquisition of companies	0	1	0
	Demand from Market Place	0	0	0
3.2	Product definition			
	Quality Function Deployment	1	1	0
	Product Benchmarking	0	1	0
	Customer feedback	1	0	1
	Feedback from distributors	0	0	0
4.0	Cross functional teams			
	Customers part of the team	1	1	0
	Suppliers part of the team	0	1	0
	Core team + fill-in members	1	1	0
	Communication	1	1	0
4.1	Empowerment of team members	1	1	0
4.2	Training of employees	1	1	1
5.0	Use of CAD/CAE Tools	1	1	1
5.1	Tools for product optimization			
	Value Analysis / Value Engineering	1	0	0
	Design for Manufacturability Analysis	1	1	0
	Statistical Process Control	0	1	1
	Failure Mode and Effects Analysis	1	1	0
6.0	Actual vs Target Costs & Sales			
	Product Costs (Underrun/ Meet//Overrun)	1	1	0
	Total Development Costs (Underrun/ Meet/Overrun)	1	1	0
	Total Product sales (Fall short/Meet/Exceed)	1	1	0
6.1	Certification of products to commercial standards	1	0	1
6.2	Procedure for Design and Documentation	1	1	1
7.0	Supplier Qualification Program	1	1	0
7.1	Efforts in pursuing ISO 9000	1	1	1
	TOTAL SCORE	27	28	13

APPENDIX D
(Continued)

1.0	Company Name	Fall2	Tecknit	W&T
1.1	Age (years)	30	36	70
1.2	No. of employees in 1994/1992	unknown	215/195	450/510
1.3	Annual Sales (\$M) for 1994//1992	unknown	15/14	70/70
1.3.1	%Defense - % Commercial (before 1993)	90-10	75-25	0-100
	%Defense - % Commercial (estimated 1994)	80-20	48-52	0-100
1.4	Functional Departments			
	Engineering	1	1	1
	Manufacturing	1	1	1
	Sales and Marketing	1	1	1
2.0	Product/s for commercial market			
	was a Re-design	1		1
	was a New Product	1	1	1
3.0	Changes for effective NPD/PRD process			
	Formation of Cross functional teams	0	1	1
	Improvement in Manufacturing facility	1	1	1
	New Low cost manufacturing processes	0	0	1
3.1	NPD/PRD was preceded by			
	Strategic Planning	0	1	1
	Market Research	0	1	1
	Strategic Partnerships	1	1	
	Acquisition of companies	0	0	
	Demand from Market Place	1	1	1
3.2	Product definition			
	Quality Function Deployment	0	1	1
	Product Benchmarking	0	1	
	Customer feedback	1	1	1
	Feedback from distributors	0	1	1
4.0	Cross functional teams			
	Customers part of the team	0	1	
	Suppliers part of the team	0	1	1
	Core team + fill-in members	0	1	1
	Communication	0	1	1
4.1	Empowerment of team members	0	1	1
4.2	Training of employees	1	1	1
5.0	Use of CAD/CAE Tools	1	1	1
5.1	Tools for product optimization			
	Value Analysis / Value Engineering	1	1	0
	Design for Manufacturability Analysis	0	1	1
	Statistical Process Control	1		1
	Failure Mode and Effects Analysis	1	1	1
6.0	Actual vs Target Costs & Sales			
	Product Costs (Underrun/ Meet//Overrun)	1	1	1
	Total Development Costs (Underrun/ Meet/Overrun)	0	1	1
	Total Product sales (Fall short/Meet/Exceed)	0	2	2
6.1	Certification of products to commercial standards	0	1	1
6.2	Procedure for Design and Documentation	1	1	1
7.0	Supplier Qualification Program	0	1	1
7.1	Efforts in pursuing ISO 9000	0	1	1
TOTAL SCORE		16	32	31

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