Critical Success Factor and Metrics for New Product Development Success

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ABSTRACT

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The literature emphasizes the great importance of new product development (NPD) for the continuing success of a business. Its contribution to the growth of companies, its influence on profit performance, and its role as a key factor in business planning have been well documented. The competitive environment in which new products are marketed is undergoing fundamental changes. These changes are the key factors driving the NPD activities in service and manufacturing industries. New product development has been an important managerial issue for many firms as the number of new products marketed has grown and product life cycles have shortened. Therefore, the study of NPD and the processes through which they emerge is important. In recent years, much research has been directed towards uncovering the secrets to new product success.

Organizations are looking for a steady stream of successful and profitable new products. The challenge is to successfully manage the development of the product from research and development to market launch. Despite the extensive research on how to achieve success in NPD, firms continue to deliver products that fail and therefore NPD ranks among the riskiest and most challenging tasks for most companies. As the number of dollars invested in NPD goes up, the pressure to maximize the return on those investments also goes up. It becomes worse as estimated 46 percent of all the resources allocated to NPD by firms are spent on products that are canceled or fail to yield an adequate financial return. This is a shocking statistic when one considers the magnitude of human and financial resources invested and wasted.

This thesis explores and analyzes the NPD process in detail. The focus is to develop a framework that identifies the critical success factors (CSF) of each phase in the NPD process, and proposes metrics to measure them. Furthermore, the tools and techniques that can be used to evaluate each metric forms an integral part of this framework.

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ACRONYMS

NPD	New Product Development
BAH	Booz, Allen and Hamilton Model
NPS	New Product Strategy
CSF	Critical Success Factor
QFD	Quality Function Deployment
ROI	Return-On-Investment
BSC	Balance Scorecard
ECV	Economic Commercial Value
PI	Profitability Index
BET	Break-Even-Time
NPV	Net Present Value
IRR	Internal Rate of Return
TTM	Time to Market

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1 INTRODUCTION

1.1 Background and Statement of the Problem

The new product development (NPD) literature emphasizes the great importance of developing new products for the continuing success of a business. Its contribution to the growth of the companies, its influence on profit performance, and its role as a key factor in business planning have been well documented by many academics and by business consultants alike (Booz, Allen and Hamilton, 1982; Crawford, 1987; Urban and Hauser, 1993; Cooper 1974, 1979, 1980, 1993, 1994, 1997, 2001). New product innovations are responsible for employment, economic growth, technological progress, and high standards of living. Therefore, the study of NPD and the processes through which they emerge is important. The competitive environment in which new products are marketed is undergoing fundamental changes. These changes are the key factors driving the NPD activities in service and manufacturing industries. Increased globalization; retail, channel, and manufacturing consolidates (mergers and acquisitions), the changing nature of consumer needs, changes in technology and forms of competition, and new management strategies all have an impact on NPD.

The development and introduction of new products on the market has been a challenging activity for many firms for many years. It requires financial and human resources and is very time sensitive. In the last two decades, the number of new product introductions increased dramatically. As the industry became more aware of the importance of new products to business, an upward trend in the number of new product introductions became more noticeable.

The hard realities are that the great majority of new products never make it to market and those that do face a failure rate somewhere in order of 25 to 45 percent (Crawford 1987, Cooper 20001). For every seven new product ideas, about four enter development, one and a half are launched, and only one succeeds (Booz, Allen and Hamilton, 1982). Despite the extensive research on how to achieve success in NPD, firms continue to deliver products that fail and therefore NPD ranks among the riskiest and most confusing tasks for most companies. As the number of dollars invested in NPD goes up, the pressure to maximize the return on those investments also goes up. It becomes worse as estimated 46 percent of all the resources allocated to NPD by firms are spent on products that are canceled or fail to yield an adequate financial return. This is a shocking statistic when one considers the magnitude of human and financial resources invested and wasted.

Organizations are looking for a steady stream of successful and profitable new products. The challenge is to successfully manage the development of the product from research and development (R&D) to the market launch, in other words, the NPD process.

1.2 Purpose of the Study

New product development has been an important managerial issue for many firms as the number of new products marketed has grown and product life cycles have shortened. In recent years, much research has been directed towards uncovering the secrets to new product success.

The purpose of this thesis is to explore and analyze the NPD process. By investigating the process in detail, ways in which firms can improve their performance

when developing new products are identified. A systematic NPD process helps reduce the challenge of managing the NPD effort and increase the likelihood of successfully launching new products. Metrics play an important role in helping companies to measure and enhance their NPD efforts.

The focus of this thesis is to develop a framework that identifies the critical success factors (CSF) of each phase in the NPD process, and proposes metrics to measure them. Furthermore, the tools and techniques that can be used to evaluate each metric forms an integral part of this framework. The research presented in this thesis has led to many prescriptions to heighten the chances of success.

1.3 Organization of the Thesis

The thesis is presented in seven chapters. Chapter I, Introduction, presents the background and objectives of the research. Chapter II, New Product Development Process, discusses the existing literature, describing models and processes used by firms to develop new products for industrial markets. In Chapter III, Stages of the New Product Development Process, a detailed study of the NPD process is presented and the significance and importance of each stage are discussed. Chapter IV, Cooper's Stage-Gate, details a well-known standard of the NPD process, known as the Stage-Gate process, in which a product innovation roadmap is introduced from beginning to end. Chapter V, Organizing for New Product Development, discusses the organizational aspects of NPD such as top management support and involvement, type of structure, team effort in NPD and how it affects NPD outcome. In Chapter VI, Critical Success Factors and Metrics for Stages of NPD, a detailed study of CSF and metrics, and tools and

techniques to measure progress, are discussed. The final Chapter VII, Discussion and Conclusions, summarizes the research and implications, and provides suggestions for future research.

2 NEW PRODUCT DEVELOPMENT PROCESS

2.1 Introduction

Companies today are facing intense competition from both domestic as well as international organizations. Because companies are often preempted by fast moving competitors, speed has become an economic necessity (Gupta and Wilemon, 1990). Competition, coupled with the rapid rate of technological change, has made speed to market a critical competency for successful new product development (NPD) (Gupta and Wilemon, 1990).

The NPD process consists of the activities carried out by firms when developing and launching new products. A new product that is introduced on the market evolves over a sequence of stages, beginning with an initial product concept or idea that is evaluated, developed, tested and launched on the market (Booz, Allen and Hamilton, 1982). This sequence of activities can also be viewed as a series of information gathering and evaluation stages. In effect, as the new product evolves, management becomes increasingly more knowledgeable (or less uncertain) about the product and can assess and reassess its initial decision to undertake development or launch. Following this process of information gathering and evaluation can lead to improved new product decisions on the part of firms by limiting the level of risk and minimizing the resources committed to products that eventually fail. The new product process differs from industry to industry and from firm to firm. Indeed it should be adapted to each firm in order to meet specific company resources and needs (Booz, Allen and Hamilton, 1982).

The performance, quality, and timing of new products are important to all firms involved in new product development. For companies that are leaders in their industries, new products enable them to create new markets and to revolutionize old markets. For followers, new products provide an opportunity to set new standards in cost and quality and to make minor enhancements which may later result in a considerable competitive advantage (Maidique and Zirger, 1984).

In this era of "faster, cheaper and better", companies are focusing on improving the product development process. New business strategies, new organizational approaches, new business processes, and new enabling technologies are being used by many forward-thinking companies to continually improve their product development process. How does a company keep up with these fast-paced changes? Some of the improvement opportunities are obvious to personnel within an organization. Other opportunities may not be obvious, or there are so many things to do that it becomes a question of where to start. Management will typically have a number of questions on their minds, for example, how does the company compare with the rest of industry, with the best in industry, what are its strengths and weaknesses, is the development process aligned with strategic objectives, what improvements need to be made, where to start, what are the priorities given available and limited resources, what benefits can be expected, and how can it all be figured out quickly so that the company can get started (Crow, 2003).

2.2 NPD Process Models

The NPD process accounts for a significant and unique portion of the variance in information implementation. For teams to implement the information they have acquired, an appropriate process is necessary. The NPD process may be able to provide a team with measurable milestones through mechanisms to track the project's progress and costs according to the plan and the ability to complete the process in a logical sequence (Englund and Graham, 1999).

A formal NPD process is a game plan that provides companies with conceptual and operational models by which to conceive, develop and introduce new products. The typical NPD process includes stages involving: idea generation, concept testing and evaluation, new product design, prototype and market testing, and launching activities. These activities can also be perceived as a means of gathering information and evaluating the product at various stages of the development, in an effort to successfully manage, direct and control product innovation efforts from idea to launch (Cooper and Kleinschmidt, 1991; Urban and Hauser, 1993).

Having a formal NPD process of superior quality has been found by researchers to be an important factor in bringing about new product success (Cooper and Kleinschmidt, 1995). By implementing a formal NPD process, firms are automatically forced to think out their NPD objectives and activities in detail and to seek better communication and coordination between the people who are involved in this process. This, in itself, has been shown to improve NPD outcomes. Furthermore, both the quality and timing of NPD activities, such as conducting effective evaluations throughout the project and carrying out parallel processing of activities, will motivate the adoption of a

formal NPD process, because it improves efficiency and effectiveness in delivering a new product (Cooper, 1993).

Many attempts have been made to develop a model that captures the relevant stages of the new product process (Wind, 2001; Cooper, 2001; Crawford, 1987; Scheuing, 1974; Flesher, 1984). A number of detailed NPD processes or models have been developed over the years, the best known of which is the Booz, Allen and Hamilton (1982) model, also known as the BAH model, which underlies most other NPD systems that have been put forward. Their sequential stage-based process uses seven stages as a base, as shown in Figure 2, which describes the activities that should be carried out in bringing new product ideas to the marketplace, with a number of evaluations and testing points in between. The "Stage-Gate™" system is a series of NPD process models developed by Cooper (1984, 1996, 1998), which also use the Booz, Allen and Hamilton model as a base, but goes further and adapts the model to more sophisticated NPD scenarios. Although the process is shown to have the various stages overlapping to a certain degree, in practice, the level of overlap may vary across the different stages, from high levels to none.

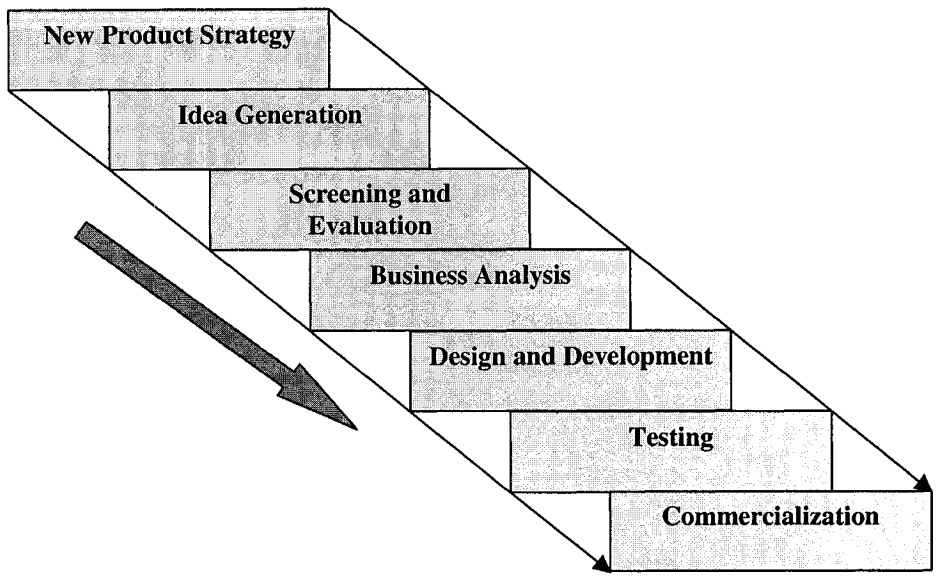


Figure 2.1: Stages of New Product Development (NPD) (Booz, Allen, and Hamilton, 1982).

The best companies are most likely to use some type of formal NPD process as compared to the rest (68 percent versus 44 percent). Griffin (2001) notes, however, that almost 60% of the companies surveyed use some form of Cooper's Stage-Gate™ process for NPD, and that these firms "are more likely to have moved from simpler Stage-Gate processes to more sophisticated facilitated or third generation processes and are more likely to have had processes in place for a longer period of time."

Cooper's Stage-Gate™ Model

The Stage-Gate™ system is a series of NPD process models developed by Cooper on the basis of the BAH model, as previously mentioned. The system was developed by Cooper because an earlier model was too strictly focused on the technical design and development of the product, lacking specifications about what actions should be taken during and between each stage (Cooper, 1994, 1996, 1998).

Cooper's Stage-Gate™ model shares similarities with the original model shown in Figure 2.1 in that it comprises some of its stages, but it goes further by including "gates", which are different points in the process where assessments regarding resource allocation are made by "gatekeepers". These gates are where the project is evaluated and decisions are made about whether to continue or kill the project (Cooper, 1993, 1994, 1998). Cooper (1998) defines gatekeepers as "a management team of decision makers and resource owners responsible for facilitating the rapid commercialization of selected projects", which will be explained in more detail later in Chapter 4.

The model which will be used as a guideline for discussion purposes in this thesis is that developed by Booz, Allen and Hamilton (1968, 1982). This widely recognized model appears to encompass all of the basic stages of models found in the literature. It is based on extensive surveys, in depth interviews, and case studies and, as such, appears to be a fairly good representation of prevailing practices in industry. Following is a brief description of the seven stages that comprise this model. A detailed discussion of each of these stages is provided later in the thesis.

- *New Product Strategy*: Links the new product process to company objectives and provides focus for idea/concept generation and guidelines for establishing screening criteria.

- *Idea generation*: Searches for product ideas that meet company objectives.

- *Screening*: Comprises of an initial analysis to determine which ideas are pertinent and merit more detailed study.

- *Business Analysis:* Further evaluates the ideas on the basis of quantitative factors, such as profits, Return-on-investment (ROI), and sales volume.

- *Development*: Turns an idea on paper into a product that is demonstrable and producible.

- *Testing*: Conducts commercial experiments necessary to verify earlier business judgments.

- *Commercialization*: Launches products and resources.

Booz, Allen and Hamilton (1982) found that companies that have successfully launched new products are more likely to have some kind of formal new product process and that they generally pass through all of the above stages. However, differences do exist among companies with respect to the emphasis placed on the various stages. For example, firms in industries with rapidly changing markets (e.g. information processing, instruments and controls, and consumer durables) place a greater emphasis on new product strategy. On the other hand, companies in industries with more stable markets, like chemicals and industrial machinery, focus more on business analysis. This is not surprising since firms that are in a mature, stable environment are generally more concerned with minimizing costs and maintaining their position and market share. In addition, products that are sold in this type of environment generally enjoy relatively long product life cycles. Innovations here are more likely to deal with minor modifications with respect to operations, e.g. process research and development (R&D), where lower costs are an overriding concern. On the other hand, for firms operating in a highly dynamic industry, where new products must be introduced at a much more rapid pace due

to shorter product life cycles, a greater emphasis is placed on strategy and early evaluation of new product ideas so that more promising products can begin to be developed and the obvious losers can be eliminated as early as possible.

2.3 New Product Successes

New products are critical to the success of modern corporations. Facing increasing competition at home and abroad, rapidly evolving technologies, changing customer needs, and shorter product life cycles, a steady steam of successful new products is fundamental to business success (Cooper, 1993; Montoya and Calantone, 1994). Researchers have undertaken many studies to help managers understand the process and success factors that are closely linked to the delivery of successful new products (Cooper, 1976, 1996; Cooper and Kleinschmidt, 1987, 1990).

Product development success factors can be divided roughly into two groups: process factors and selection factors (Cooper, 1993). Process factors capture the nature of the new product process and the projects that are undertaken; these factors are often controllable. Selection factors describe the new product project and its situation; these tend to be outside the control of the project leader, team, or management but are useful in project selection. The lists of new product success factors are presented below:

- *Critical Success Factors: Process-Related*
  - Developing a superior, differentiated product, with unique benefits and superior value to the customer or user
  - Having a strong market orientation throughout the process
  - Undertaking the predevelopment homework upfront

- Getting sharp, early product definition before development begins
- Quality execution - ensuring completeness, consistency, and proficiency of activities in the new product process.
- Having the correct organizational structure: multifunctional, empowered teams
- Providing for sharp project selection decisions, leading to focus
- Having a well-planned, well-resourced launch
- The correct role for top management: specifying new product strategy and providing the needed resources
- Achieving speed to market, but with quality of execution
- Having a multistage disciplined new product game plan

- *Critical Success Factors: Selection-Related*
  - Having a unique, superior product
  - The product-market environment:
    - Market attractiveness
    - Competitive situation (minor impact)
    - Stage of product life cycle
  - Synergy and familiarity.

Most important critical success factors are explained in detailed below:

1. Seek differentiated, superior products

The top success factor is delivering a differentiated product with unique customer benefits and superior value. Such superior products have five times the success rate, more than four times the market share and four times the profitability of products that lack this ingredient. Spare no effort in the search for product advantage. Build in a user

needs and wants study early in NPD process in order to identify the components of a truly superior product and unarticulated customer needs. And once a viable product concept is ready, test it constantly with the customer via concept test, rapid prototypes and finally, full product tests (Cooper, 2001).

2. Build in the voice of the Customer

The voice of the customer must be an integral part of NPD process. This begins with idea generation- focus group, customer panels, and working with lead users. Use market research and customers as input into the product's design, not just as a confirmation of it. Make the customer a part of the development process via constant rapid-prototype and test-iterations. Finally ensure that the launch is well planned, adequately resourced and based on solid market information (Cooper, 1993).

3. Getting sharp, early product definition before development begins

A failure to define the product before the development begins is a major cause of both new-product failure and serious delays in time-to-market. In spite of the fact that early and stable product definition is consistently cited as a key to success (Cooper, 1993).

4. Having a well-planned, well-resourced launch

A strong market launch underlines the success of any product. For example, new-product winners devote more than twice as many person-days and dollars to the launch as do those that fail. Similarly, the quality of execution of the market launch is significantly higher for winners. The need for a quality launch-well planned, properly resourced and well executed should be obvious.

5. Build tough Go/Kill decision points into the NPD process

Too many projects move too far into development without serious scrutiny. In fact, once a project begins, there is very little chance that it will ever be killed. The result is that many marginal projects are approved and scarce resources are allocated improperly. Indeed, having tough Go/kill decision points (or gates) is strongly correlated to the profitability of new-product efforts. But tough Go/Kill decision points are the weakest ingredient of all process factors.

6. Having the correct organizational structure: multifunctional, empowered teams

Numerous studies agree that good organizational design is strongly linked to success. Good organizational design means projects that are organized with cross-functional team, led by a strong project leader accountable for the entire project from beginning to end, dedicated and focused. Three approaches that appear to work well are the balanced matrix and the project team. All three emphasize the autonomy of the team and the independent authority of the project leader (Cooper and Kleinschmidt, 1995).

7. Synergy and familiarity.

The new product fares better when it leverages the business's core competencies. Leveraging core competencies means having a strong fit between the needs of the new product projects and the resources, strengths and experience of the company in terms of marketing, distribution, selling, technology and operations (Cooper and Kleinschmidt, 1995).

8. The role of top management is central to success

Management must make the long-term commitment to product development as a source of growth; it must develop a vision, objectives and strategy for product

innovation. It must make available the necessary resources and ensure that they aren't diverted to more immediate needs in times of shortage. It must empower project teams and support committed champions by acting as mentors, facilitators or sponsors of project leaders and teams. Senior management's role is not to get involved in projects on a day-to-day basis, nor to be constantly meddling and interfering in the project, or to micromanage projects from afar (Cooper and Kleinschmidt, 1995).

9. Achieving speed to market, but with quality of execution

Speed to market often appears as being critical to NPD. Karagozoglu and Brown (1993) state: "Earlier product introduction improves profitability by extending a product's sales life, creating an opportunity to charge a premium price, and allowing development and manufacturing cost advantages". Developing and launching a product quickly can have considerable impact on the success of the development effort. There will be a positive correlation between speed to market and new product success.

2.4 Causes of New Product Failure

The consistently high failure rate among commercialized new products has prompted much research into finding causes of new product failure (Urban and Hauser, 1980). The failure of new products is high, although estimates of failure rates vary considerably. Crawford found that failure rates could range from 15 % to 90 %, although the more accepted estimate of new product failure among products that have been fully commercialized is about 30 % to 35 % (Booz, Allen and Hamilton, 1982).

The large discrepancy that exists in the literature with respect to failure rates can be traced to a number of factors. First, one must look at how new products come into

existence. If one attempts to measure new product failure by studying only new products that have been commercialized or launched, a different failure rate will be obtained than if one were to study the failure rate of all products that have been introduced in the product development pipeline. The latter is actually the mortality rate, which of course is significantly higher than the rate of products that fail after being launched. Another reason for the discrepancy is that some studies measure new product failure at the point of test marketing instead of commercialization.

A study by Cooper (1993) shows the main reasons for failure in Figure 2.2. According to Cooper (1993) comprehensive analysis of new product failure, the failure reasons remain fairly constant over the years and they are as follows:

- Technical problems
- Higher than expected costs
- Competitive strength or reaction
- Inadequate market analysis
- Lack of effective marketing effort
- Poor timing of introduction
- Poor quality of execution
- A lack of product value for the customer
- The lack of a systematic new product process with discipline.
- Moving too quickly

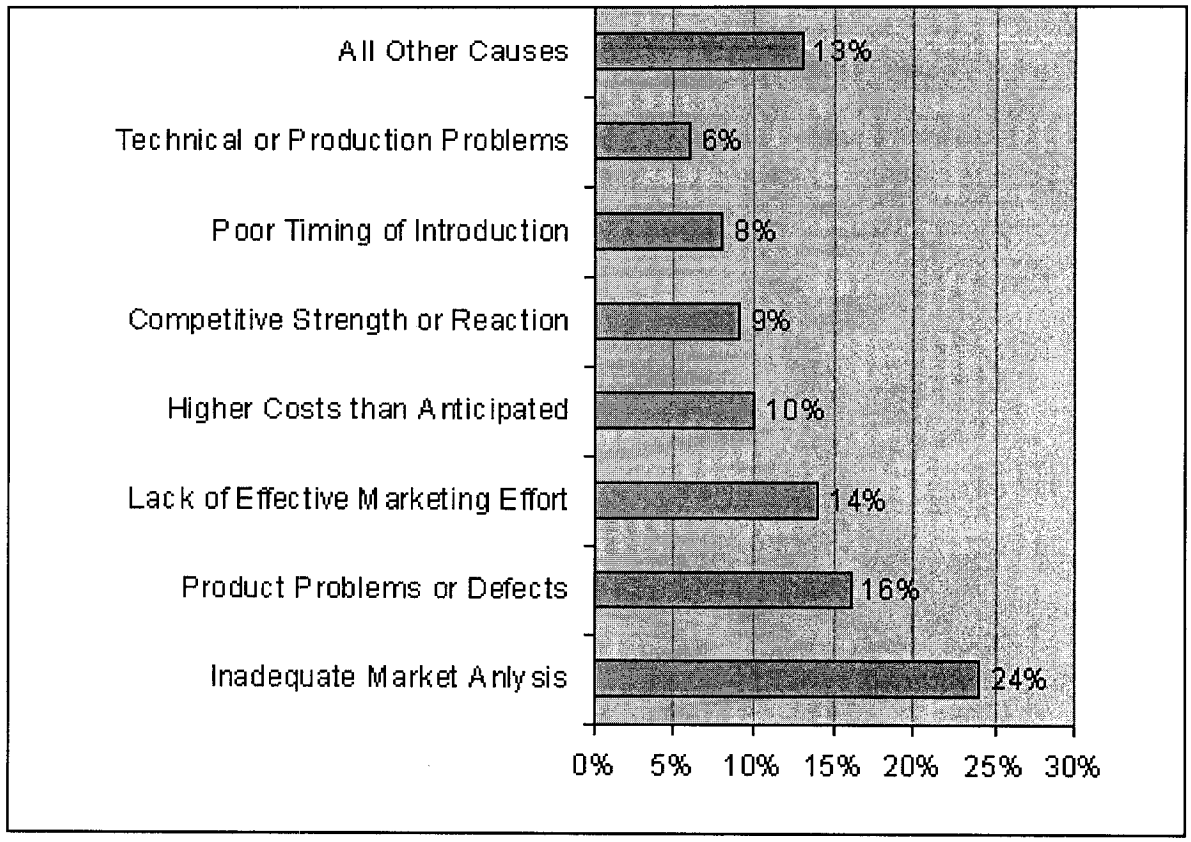


Figure 2.2: Main Causes of New Product Failure (Cooper, 2001).

Despite the many different reasons cited for new product failure, the last five reasons shown in Figure 2.2 appear to be directly or indirectly market-related rather than of technical origin (Crawford, 1983; Urban and Hauser, 1980; Cooper, 1975). A lack of marketing orientation is an overriding factor for new product failure.

2.5 Risk and Uncertainty

Any new product undertaking involves a certain amount of risk, which a firm attempts to minimize. Risk can be viewed as a function of the amounts at stake in a product venture (i.e. the amount of investment the firm incurs throughout the NPD process) and the uncertainty of the new product's outcome, i.e. the uncertainty

surrounding the eventual success of the new product in the marketplace, (e.g. uncertainty of information) (Cooper, 1974). Figure 2.3 shows this concept of risk. As can be seen in this figure, the cumulative, or amounts at stake, constantly rise throughout the NPD process. Throughout the process, however, uncertainties should be decreasing as more and more information becomes available with respect to how the product will perform and how it will be accepted in the marketplace. The information will also help management reduce the amounts at stake by indicating which projects merit further investment and which should be dropped. The total amount of risk, which is the combination of uncertainties and expenditures, decreases to a point where it tends to level off (Ding and Eliashberg, 2002).

While it is important that a firm minimize the risk due to the amounts at stake, management often has only limited discretion over a level of investment required for a given project. However, as cumulative development costs rise, causing total risk to increase, management can undertake activities that reduce the uncertainty surrounding the project, enough to maintain an overall level of risk that is tolerable to the firm. Therefore, in order to maintain an acceptable level of risk throughout the development process, each stage should produce enough information that will not only reduce management uncertainty but that will lead to decisions to invest in those products that show the most promise. Three types of uncertainty pertain to the new product process:

- *Technical Uncertainty:* uncertainty about whether the product can be made to the required specifications and perform as expected (Loch and Terwiesch, 1995).
- *Market Uncertainty:* uncertainty about whether or not the product will be accepted in the marketplace.

- *Economic Uncertainty:* uncertainty about whether the product can achieve the target level of profitability.

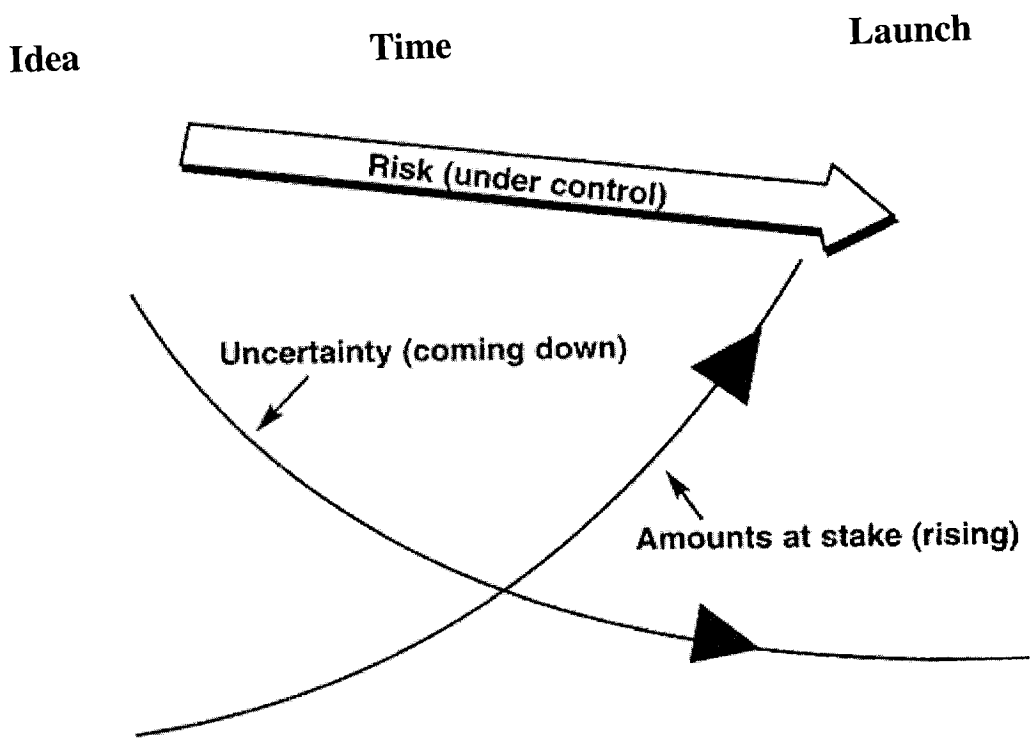


Figure 2.3: Relationship between Uncertainties and Amounts at Stake (Cooper, 1993).

In order to reduce the NPD risk, management must look at each of these uncertainties and decide how it will go about reducing total risk. For example, if market acceptance is highly uncertain but technical design is reasonably certain, there should be a greater emphasis placed on determining the needs of customers. Alternatively, if market acceptance is relatively certain but technical design is very uncertain; a greater technology push approach is needed.

Managers can reduce uncertainties, and thus total risk, by moving in an incremental fashion throughout the NPD process (Cooper, 1996). By phasing the NPD process, the overall level of risk can be minimized because each stage can provide

information that will reduce the level of uncertainty and that will demonstrate more clearly to management which products are potential failures and which are potential successes.

2.6 Summary

The main objective of a new product process is to ensure that profitable products are brought to the market place. Nevertheless, the failure rate among new products that are commercialized has remained consistently high over the years and the causes for this are not entirely clear. The new product process can be viewed as a series of information gathering steps by which managers can lower the overall level of risk surrounding the new product venture. Information can help managers to reduce the uncertainty surrounding a new product's feasibility and probable performance in the marketplace. Also, companies can continually reassess their investment decisions so that resources are allocated to those ventures which show the most promise.

3 THE STAGES OF THE NEW PRODUCT PROCESS

3.1 Introduction

In order for firms to develop and introduce successful new products, an effective and efficient NPD process is required. While the specific process differs from firm to firm, some basic stages are common to all firms and industries. Booz, Allen and Hamilton (1982) suggest that seven phases are basic to all new product processes as was shown in Figure 2.1. It is useful to examine each of these stages in some depth in order to obtain a clear understanding of the NPD process. Recall from Chapter 1 that the seven stages of the NPD process, as described by Booz, Allen, and Hamilton are: New Product Strategy, Idea Generation, Screening, Business Analysis, Development, Testing, and Commercialization. Each of these stages will now be described in detail.

3.2 New Product Strategy

3.2.1 Introduction

According to Booz, Allen and Hamilton (1982), the first stage in a firm's new product process should be an overall guiding strategy that directs and integrates the new product effort. In a business context, strategy has been defined as "the schemes whereby a firm's resources and advantages are managed (deployed) in order to surprise and surpass competitors or to exploit opportunities" (Luck and Prell, 1986). More specifically, strategic change is defined as "a realignment of a firm's product/market environment" (Ansoff, 1998). Strategy is closely tied to product and market specification.

The new product strategy (NPS) should reflect and stem from the overall corporate objectives and strategy of the firm. In a major study conducted on current new product practices, it was concluded that industries that had successfully launched new products were more likely to have identified a new product strategy (Booz, Allen and Hamilton, 1982).

With the increasing importance of new product warfare comes the desire to more effectively manage innovation, hence the wish to develop effective product strategies. Developing a product strategy for a business is not easy. Nevertheless, a product strategy is a must for all businesses that are serious about building new products in their long-range plans. Many businesses operate without such a strategy, and the senior management knows the problems associated with doing so all too well (Cooper, 1993).

3.2.2 Importance of a New Product Strategy

The purpose of the NPS and the importance to the firm in having such a strategy is twofold. First, the NPS sets the strategic roles new products will play to fulfill corporate objective (Booz, Allen and Hamilton, 1982). Second, a well-defined NPS impacts on and helps direct other areas of a firm's new product development process.

While these strategic roles "help identify markets for which new products will be developed" (Booz, Allen and Hamilton, 1982, p.22), they also help managers to identify areas that the firm should not pursue (Crawford, 1972). This latter point is essentially important to firms since, as suggested by Crawford (1987), the root cause of many new product failures may lie at the general management level, specifically that firms have improper new product strategies. Thus, a well-defined NPS can help a firm not only in

directing its efforts, but also in avoiding the development and marketing of products that are essentially wrong for the firm and its resources (Crawford, 1987).

A business with a defined NPS - one that specifies goals and the role of new products, defines arenas of strategic thrust, and has a longer-term orientation - achieves better new product results. These businesses more often meet their new product sales and profit objectives; they boast new product efforts with a much greater positive impact on the business; and they achieve higher success rates at launch. A business's product innovation and technology strategy includes the following:

- Objectives: the goals for business's total product development efforts
- The role of product development: how new business ties into the business's overall goals.
- Arenas of strategic focus: market, technologies, and product categories, including priorities.
- Deployment: spending allocations across these arenas (R&D funds or people, possibly marketing and capital resources for developments)
- Action plan: how to attack each arena in order to win.

A new product strategy links the new product process to company objectives and provides focus for idea/concept generation and guidelines for establishing appropriate screening criteria. The outcome of new product strategic planning is a set of strategic roles used to generate specific new product ideas but to help identify markets for which new products will be developed.

3.2.3 Strategy Types

One way of looking at strategy is through a typology based upon the speed that an organization uses to respond to a changing market and external conditions by altering its product and markets. There are four strategy types, according to Miles and Snow (1999) and Griffin and Page (1996).

- *Prospectors:* These businesses are the industry innovators. They value being "first in" with new products and are first to adopt new technologies, even though there are risks and not all such efforts are profitable.

- *Analyzers:* These businesses are fast followers. By carefully monitoring the actions of major competitors, and by moving quickly, they often are able to bring a superior product to market- one that is more cost-efficient or that has better features and benefits than the prospector's product.

- *Defenders:* Defenders attempt to locate and maintain a secure position or niche in relatively stable product or market area. They protect their domain by offering higher quality, superior service, or lower prices.

- *Reactors:* These firms are not as aggressive in maintaining established products and markets as competitors. They respond only when forced to by strong external or market pressures.

It is important that a firm have a clear statement of strategy in place that will help guide the firm's new product process. This NPS should be company-specific and should integrate both R&D and marketing. As per a study conducted by Kwaku and Felicitas

(2000), it is clear that if new products are to be successful, marketing and R&D play influential roles in the NPD and it is critically important for both research and practice. Such a strategy appears to provide the optimal direction for a firm's new product effort. With a well-defined NPS, the firm is ready to generate ideas that are expected to fulfill the goals of the organization.

3.3 Idea Generation

3.3.1 Introduction

The idea generation stage refers to a formal search for ideas that will hopefully be developed into products that meet the firm's objectives. Since, as stated in the previous section, a new product strategy generally provides a focus for new product ideas, the idea generation stage can be viewed as a starting point when a firm is determining its new product strategy. Along with R&D and technology considerations, priority markets are defined and target consumers are selected in the new product strategy and it is in this stage that ideas are generated such that the potential of these markets are tapped.

Idea generation is a vital stage in the new product process since the ideas generated here form the pool of possibilities from which products are eventually developed and marketed. It is important, therefore, that a firm generate quality ideas. The better the pool of ideas, the greater the probability that a commercially successful product will be produced (Lilien, Morrison, Searls, Sonnack, Hippel, 2002). A firm typically has to generate many ideas in order to find a few good ones. According to Griffin (1997), an average of 100 ideas must be generated in order to yield 15.2 successes: put otherwise, one success comes out of every 6.6 ideas. This number is not

different from Booz, Allen and Hamilton found (1982), when they determined that it took seven ideas to generate one success, as shown in Figure 3.1.

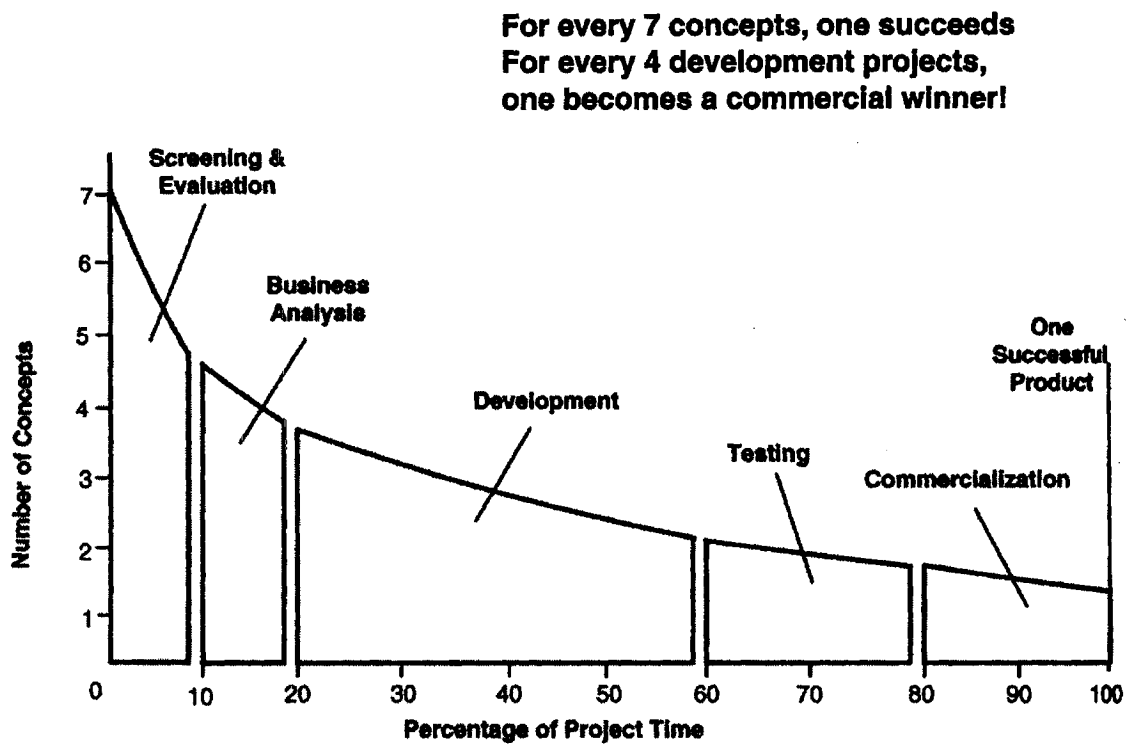


Figure 3.1: The Attrition Rate of New Product Projects (Cooper, 2001)

3.3.2 Bottom–Up or Top-Down

An important point is that idea generation can be top-down and purposeful, as well as bottom-up and serendipitous:

- *Bottom-up*, serendipitous idea generation is where a scientist uncovers a technological possibility, does a few experiments, and then realizes that a new product might be the outcome. Or perhaps a salesperson, walking through a customer facility notices a problem, and after some thought, sees a potential solution. Even better, both ideas are

in arenas deemed strategic by senior management, so the scientist and the salesperson submit their ideas, and two new product projects are born.

- *Top-down* is usually more directed. An example is where a strategy defines a particular market segment as a key area of focus. Market research reveals that there are some significant customer problems waiting to be solved in this arena, and these problems ultimately result in a product road map or in envisioning a set of new products to be developed over the next few years.

The point is that both approaches are important and have their own place in idea generation stage according to Cooper (2001).

3.3.3 Methods of Generating New Product Ideas

Another approach to studying idea generation is to look at the methods actually used when generating new product proposals. Following are some of the more commonly used methods (Urban and Hauser, 1980) (Crawford, 1987).

- *Brainstorming:* this is a group activity consisting of creative panelists who may or may not be employees of the firm. The panelists are required to discuss such things as the ways in which a particular need can be met. Negative responses to suggestions are not permitted during the session but suggestions are evaluated afterwards.

- *Suggestion Box:* employees are encouraged to submit their ideas. Incentives are normally awarded to people whose ideas are used. Suggestion boxes can also be available to members of the firm's distribution system and advertising agency.

- *Focus Group:* this is perhaps the most widely used method, particularly among consumer goods firms. It is a group activity where panelists discuss and elaborate on their personal feelings, needs, and attitudes. Panelists in a focus group typically comprise of users/consumers of the particular product or good under study. A free flowing atmosphere encourages discussions on problems with existing products and latent desires and needs, and on new ideas. Reactions to new ideas can be observed- e.g. excitement or silence and embarrassment- and insights into consumer's needs and motivations can be obtained.

- *Gap Analysis:* this is a structured method of analyzing consumers' perceptions of a product market. Perceived differences between products within a given market are identified and measured along a number of attribute dimensions. A perceptual map is drawn up and then contrasted with consumers' ideal product perceptions. New product ideas can then be identified since the ideal product is evident and because gaps in the perceptual map may represent unmet needs.

The trigger for the product development process is a new product idea, when technological possibilities are matched with market needs and expected market demand. A good new product idea can make or break the project: ideas are the feedstock of the new product process. But a well-oiled new product process cannot be expected to make up for a shortage of quality ideas. If the idea is uninteresting to begin with, the process will not turn it into a success.

Once a set of product ideas has been identified in the idea generation stage, the next step is to screen out those product ideas that are unsuitable for the firm.

3.4 Screening

3.4.1 Introduction

A firm generally does not have sufficient resources with which to develop all ideas. Furthermore, not all ideas are worth consideration. Therefore, it must employ a method of identifying which product ideas merit further resource allocation. Typically, the outcome of the screening stage is a ranking of proposals such that resources can be allocated to the best projects first. Thus, each product idea will result in either a GO or NO GO decision to proceed to the next stage of the new product process, based on whether or not it passed the screening phase.

3.4.2 Two Potential Errors

Two potential errors exist in this stage, as shown in Figure 3.2:

- Accepting the ideas that will fail at a later stage (BA).
- Rejecting product ideas that would have been commercially successful (AB).

In the first case, accepting a poor idea will result in a firm incurring unnecessary costs in further researching, developing and possibly launching the product. As well, resources spent on poor ideas may result in foregoing development of more promising ideas. The second type of error, that of rejecting a good idea, may represent an opportunity cost to the firm since it could have been profitable for the firm if commercialized.

Decision is to: / If the Product were marketed	A Abort the New Project	B Continue to next evaluation
A It would fail	AA	BA
B It would succeed	AB	BB

Comment: Cells AA and BB are correct decisions. Cells BA and AB are errors.

Figure 3.2: Matrix of Risk/Payoff at Each Evaluation (Crawford, 2003).

An effective screening method, therefore, should help to minimize the two potential errors shown in Figure 3.2 that can occur at this stage, i.e. it should minimize both the acceptance of poor new product ideas (BA) and the rejection of promising new product ideas (AB). It is important that an effective screening decision is made so that scarce resources are employed on the development and commercialization of the most promising new product ideas (Wind, 1982; Cooper, 1993).

3.4.3 Criteria

Choosing the criteria used to screen new product proposals is the responsibility of top management. The criteria on which proposals are judged should reflect the firm's markets, strategies, market position, and financial resources. The criteria chosen should, of course, be guided by the firm's new product strategy. Table 3.1 shows sample screening criteria.

Table 3.1: Sample Screening Criteria (Rosenau, Griffin, Castellion, and Anschuetz, 1996).

Strategic Screens	• Fit with corporate mission and strategy • Familiarity to company • Market Competitiveness • Market size and expected growth
Consumer Screens	• Importance of consumer need addressed • Consumer benefit delivered • Product Superiority • Perceived value for the money
Product Development Screen	• Fit with corporate technical capabilities • Degree benefit delivered • Time to Market • Competitors' ability to follow • Estimated development costs
Regulatory and Legal Screens	• Ability to protect from quick competitive response • Estimated timing for regulatory approval

Various studies have identified a basic set of dimensions applicable to firms when screening new product ideas. These dimensions include product characteristics and potential, market characteristics and potential, and resource compatibility, are described below.

- *Product Characteristics and Potential:* This set of dimensions includes such considerations as:

  - Product newness: is the new product idea significantly different from competitors' products? How are these differences perceived by consumers?

  - Proprietary position: can the firm expect to maintain a protected position for the new product? Can the firm expect the product to remain unchanged?

  - Technical feasibility: is the development and design of this new product idea feasible given the time and investment constraints of the firm? Can raw materials

and other components required in the production of the product be guaranteed with respect to quality and availability?

- *Market Characteristics and Potential:* Examples of criteria in this dimension include:
  - Market size and market share: how large is the market for the new product? How much of this market can the firm expect to capture?
  - Competitive situation: what existing products and firms on the market would the new product compete with? What are the firm's strengths and weaknesses with respect to potential competition?
- *Resource Compatibility or Product/Company Fit:* Factors that are considered here include:
  - Corporate synergy: does the new product fit with the company's overall strategy and objectives? Would the new product share existing resources such as distribution, sales force, etc.?
  - Production synergy: would the new product be able to use existing production technologies?

This may suggest that managers rely on oversimplified evaluative criteria to screen ideas seeing as how they do not assess any market criteria. An effective screening, however, should cover all aspects considering the impact it can have on the overall performance of a firm's NPD program (Cooper and de Brentani, 1984).

3.4.4 Formal vs. Informal Approach to Screening

A firm's approach to screening can be formal or informal. A formal approach involves the use of written and/or established procedures for evaluating product ideas. An informal method on the other hand uses personal judgment and intuition on the part of product planners, who essentially rely on "gut feeling" about each project. At the initial screening stage, many firms still tend to employ an informal approach. At this early stage, little information has been gathered by the firm with respect to the various criteria. Furthermore, such information would tend not to be very precise (Wind, 1982).

3.4.5 Screening Methods

Many different methods for screening new products ideas have been proposed. According to Booz, Allen and Hamilton (1982), companies should employ a custom-designed screening method in which the set of criteria reflects the firm's new product strategy, resources, competition, and industry. Some methods that have been proposed are described below:

- *Checklist:* the use of a checklist involves a subjective evaluation of each project on criteria that management believes are important factors in determining the eventual success or failure of a new product idea. This is the least complex R&D project evaluation method involving simple yes/no responses on the part of evaluators, and is reportedly widely used. Checklists can vary from an outline of key elements in a screener's mind (informal) to an elaborate manual with detailed instruction (formal). Advantages of using a checklist include making sure all significant factors are considered when evaluating different projects as well as keeping the evaluation

consistent. The use of a checklist lends itself to early screening since it involves a relatively simple list of criteria and does not require information that is unavailable at this early stage in the development process. The disadvantages are that because of its simplicity, complex problems may be overlooked, and the interactions and interdependency of projects are not easily accommodated for. Also it is difficult to rank projects.

- *Scoring Models:* scoring models are similar to checklists in that they ensure that relevant criteria are considered for each proposal. However, they are somewhat more complex because importance weights are assigned to the criteria and projects are numerically rated (i.e., from low to high rather than a simple yes/no) on each criterion. A final single score is then obtained for the full screen of new products concepts. Table 3.2 shows an example of a scoring model.

Scoring models can be easily modified with checklist when conditions have changed, and are relatively simple to use and helpful at early stages when evaluating relative merits of new product proposals. However, as opposed to checklists, a scoring model permits more realistic assessment of projects due to the rating of criteria. It also takes into account company priorities via the weighting scheme, and using the formal "score" allows for a ranking of proposals.

Product ideas that have successfully passed the screening stage are subject to what is generally referred to as a business analysis. This is an evaluation that will indicate the likely contributions the new product will make to the firm.

Table 3.2: Sample Scoring Model (Crawford, 2003)

Category	Factor	Scale 1 2 3 4 5	Score	Weight	Weighted Score
Technical Accomplishments	Technical task difficulty	Very Difficult ... Easy	4	4	16
	Research Skills required	Have none required ... Perfect fit	5	3	15
	Development skills required	Have none required ... Perfect fit	2	5	10
	Technical equipment/processes	Have none required ... Have them			
	Rate of technological change	High/erratic ... Stable			
	Design superiority assurance	None ... Very high			
	Security of design (patent)	None ... Have patent			
	Technical service required	Have none required ... Have it all			
	Manufacturing equipment/processes	Have none required ... Have them			
	Vendor cooperation available	Nine in sight ... Current relationship			
	Likelihood of quality product	Below current level ... Leadership			
	Likelihood of competitive cost	Well above Competition ... Over 20% less			
	Likelihood of speed to market	2yrs or more ... Under six months			
	Team people available	None right now ... All key ones			
	Dollar investment required	Over 20 million ... Under 1 million			
	Legal issues	Major ones ... None in sight			
					Total 210
Commercial Accomplishments	Market Volatility	High/erratic ... Very Stable	2	3	6
	Probable market share	Fourth at best ... Number one	5	5	25
	Probable product life	Less than a year ... Over 10 years	.	.	.
	Similarity of product life	No relationship ... Very close	.	.	.
	Sales force requirements	Have no experience ... Very familiar	.	.	.
	Promotion requirements	Have no experience ... Very familiar	.	.	.
	Target customer	Perfect stranger ... Close/current	.	.	.
	Distributors	No relationship ... Close/current	.	.	.
	Retailers/dealers	Trivial ... Critical	.	.	.
	Importance of task to user	No relationship ... Current/strong	.	.	.
	Degree of unmet need	None/satisfied ... Totally unmet	.	.	.
	Likelihood of filing need	Very low ... Very High	.	.	.
	Competition to be faced	Tough/aggressive ... Weak	.	.	.
	Field service requirements	No current capability ... Ready now	.	.	.
	Environmental effects	Only negative ... Only positive ones	.	.	.
	Market Diffusions	No other users ... Many other users	.	.	.
	Customer Integration	Very unlikely ... Customer seeks it	.	.	.
	Probable profit	Break even at best ... ROI>40%	.	.	.
					Total 240
					Grand Total 450

Concept: _____
Date of Screen: _____
Action: _____

3.5 Business Analysis

3.5.1 Introduction

The business analysis stage represents the first time a new product idea is fully evaluated using quantitative performance criteria. These criteria indicate the contributions the new product will provide, including potential profitability, expected market share, and growth rates of the product and market. Nearly two-thirds of the companies surveyed by Booz, Allen and Hamilton (1982) formally measure new product financial performance, and use more than one performance criterion. Financial evaluation methods used in evaluating new product proposals are those commonly found in capital budgeting and investment decisions in the area of finance. Based on the outcome of this stage, a decision will be made to either drop or start development.

3.5.2 Components of financial evaluation

The components of a business analysis conducted on new product ideas include cost, revenue, profit, tax considerations, and synergistic and cannibalization effects (Wind, 1982). Following is a brief discussion of each of these components.

1. Costs

Cost estimates should include such factors as expected development costs, expected set-up costs for production facilities, operating costs, marketing costs, and management costs. Difficulties in estimating costs arise from uncertainties about expected demand, economies of scale, effects of the learning curve, and uncontrollable factors such as competitive activities.

2. Revenues

Expected revenues come from both the sale of the product and from the sale or license of technology. The difficulties involved in estimating revenues again stem from management uncertainty about expected demand as well as about the effect of marketing efforts. Many factors must be considered when attempting to estimate revenues. These include forecast of market size and share, expected selling price and price elasticity, and an analysis of the product life cycle, including how the price, market size/share, and profitability will change over the product's life.

3. Profits

Expected profits can be determined once the costs and revenues have been estimated. Break-even analysis is usually used (Wind, 1982). Here, the minimum number of units that must be sold at a given price in order for the firm to break even is determined. Other profitability measures such as return on investment (ROI), net present value, and payback period can now be determined.

4. Tax Considerations

Not all new product ideas are subject to the same tax considerations. Such factors as depreciation rules, income tax and investment tax credits, and tax incentives may significantly affect the return on a new product.

5. Synergistic and Cannibalization effects

Management must consider how the introduction of a new product will affect the rest of the firm's existing product lines as well as how it will affect other potential new products. Synergy, a positive effect, can be obtained through interdependencies resulting

from shared technology, production, marketing, and management. However, a new product can steal sales away from firm's existing products, thereby cannibalizing products.

3.5.3 Alternative Evaluation Methods

Many alternative approaches to evaluate new products have been developed; including some relatively sophisticated new product evaluation models (Booz, Allen and Hamilton, 1982, Copper, 1975).

Cost/ Benefit ratio is a typical example of a new product evaluation method that is relatively simple to use. Here, costs are total resource costs of supporting the research, while benefits are net earnings from future sales. The present values of these cash flows are calculated using an appropriate discount rate. If this rate is less than or equal to one, the project should be rejected. The ratio can be expanded to accommodate risk factors, such as market uncertainty which would reduce the expected project benefit. As well, non-economic considerations, such as social, environmental, political costs or benefits of the product can be added into calculations if these can be expressed in dollars.

Risk analysis is an example of a more sophisticated approach to evaluating new products. Risk analysis, as proposed by Wind (1982), incorporates statistical probabilities to key variables such as market size, selling price, market growth rate, etc. in a formal model for forecasting earnings and cash flow.

3.5.4 Need for Ongoing Financial Evaluation

Economic or financial evaluation should take place at each stage in the NPD process. Profitability information is what management ideally requires when evaluating

proposals and determining the continued feasibility of projects. However, quantitative information such as sales, profit margins, and costs are very difficult to estimate, and in the early stages of the development process this information is often not known. Therefore, estimates of financial information will tend to be very rough at the beginning of the new product process but will become successively more refined and accurate over the development process. At the final stage of development, and particularly during the testing phase, reasonable forecasts of sales, profits, and market share of the life of the product should be available.

If the results of the business analysis of the new product conform to company objectives, the new product team can move to the next stage, i.e., the development stage, where it is ready to be developed or designed into a tangible product (Crawford, 1987).

3.6 Development

3.6.1 Introduction

The development stage represents the first attempt to design and develop the product in its physical form. It is an iterative process and requires a substantial investment. Booz, Allen and Hamilton (1982) found that among industrial goods companies, the development stage comprises 47% of total new product development time. For consumer nondurable firms, this figure is 30%, while for consumer durable firms it is 36%. On average, one third of total new product development expenditures are committed during this stage (Booz, Allen, and Hamilton, 1982). Tasks undertaken in this stage include design of the product, testing the prototype product at every step of the development phase, and developing plans for the launch (Cooper, 1993).

Translating an idea into a physical entity can be difficult (Cooper, 1993). For example, this difficult conversion may occur because when designing the actual product, the new product team may have disregarded customer needs. Technical problems may also arise, which may result in the exclusion of features requested by customers. A changing environment, with different needs and more competition can also impede the development of a successful new product (Cooper, 1993).

Throughout the process, however, uncertainties should be decreasing as more and more information becomes available with respect to how the product will perform and how it will be accepted in the marketplace. The information available after upfront homework and all the pre stages studies helps management to increase the amounts at stake by indicating which projects merit further by investing in and which should be dropped. Most product development problems are a result of unexpected events. Technical risk is a measure of the level of uncertainty for all of the technical aspects of the development process. Technical risk management identifies and tries to control this uncertainty found in product development. It is essential for identifying and resolving potential problems to ensure that the proposed system will work as intended and be reliable when it reaches the user.

3.6.2 Protocol

Before development work can be started, there must be a clear understanding between the various functional areas in a firm with regards to exactly what is to be developed. This can be obtained through the use of specification sheets or a product description. Crawford (1987) introduced the idea of "protocol", which is a written agreement between marketing, technical, and general management describing exactly

what R&D is to achieve. The protocol is a statement of product benefits, usages, and applications rather than a list of physical product attributes, as in a specification sheet. It guides each developer or researcher so that desired creative deviations are avoided, and it provides a model against which to compare prototypes (Crawford, 1993). An obvious advantage is that, if marketing has accurately identified user needs, R&D has a free rein to determine and develop which best delivers the required product benefits. Crawford (2003) implores managers to include a product definition step just prior to the development phase, where the requirements of the product are clearly spelled out and agreed to by all parties involved in the project. This definition includes the following shown in Table 3.3.

Table 3.3: Ingredients of Protocol or Product Definition.

Definition	Check point
Project Scope	What are the bounds of the development effort? Is it a single new product? A family of products or series of release? Or a platform development
Target Market	Who precisely is the product aimed for?
Product Concept	What will the product be and do?
Benefits to be Delivered	What is the value proposition for the customer?
Positioning strategy	How will be the product be perceived by potential customers? What is the price point?
Product Attributes	What function, features and detailed specification are needed?

This definition serves as a communication tool and guide. This protocol/definition must be fact based: it is developed with inputs and agreement from the functional areas involved (marketing, R&D, engineering, and production) and it must be agreed by the entire project team, and senior management should also commit to the definition. This protocol also provides a clear set of objectives for the development phase of the project and for the development team members. With clear product objectives, development typically proceeds more efficiently and quickly. At this time, the NPD team is ready to charge into the development activity.

3.6.3 Design and Development Process

For the purposes of discussion, the design and development process is divided into four linked and often overlapping phases:

1. Requirement Definition

The first phase of the design process is to identify the overall needs of the user and define the business and design objectives for the product. Requirement definition is the process of identifying, defining, and documenting specific needs for the development of a new product. The major objective for this step is to identify, consolidate, and document all the features that the system could have unto a feasible, realistic, and complete specification of product requirements. Product requirements or specifications are the final output of this phase of development.

2. Conceptual Design

The conceptual design process is the identification of the several design approaches that could meet the defined requirements, performance of trade-off analyses to identify the best design approach to be used, and to then develop design requirements

based on selected approach. Design goals and requirements are allocated to the lowest levels needed for each member of the design team and then finalized during this process. Trade-off studies, mathematical models, simulations, and cost estimates are used to choose an optimum design approach and technology. Products of the conceptual design phase include guidelines, design requirements, program plans, and other documentation that will provide a baseline for detailed design effort. During this phase that the initial producibility, quality, and reliability design requirements are documented.

3. Detailed Design

Detailed design is the process of finalizing a product's design which meets the requirements and design approach defined in the early phases. Critical feedback takes place as the design team develops an initial design, conducts analyses, and uses feedback from the design analyses to improve the design. Design analysis uses scientific methods to examine design parameters and their interaction with the environment. This is a continuous process until the various analyses are performed, such as stress analysis, failure modes, producibility, reliability, safety, etc. These require the support of the other personnel having specialized knowledge of various disciplines. During this stage, the product development team constructs prototype or laboratory working models of the design for testing and evaluation to verify analytic results (Crawford, 2003).

The detailed design stage therefore requires the most interaction of the many disciplines and design professionals. Communication and coordination becomes critical during the evaluation and analysis of all possible design parameters.

4. Prototype

One of the major activities in the development stage involves developing a prototype, which is "an inexpensively constructed model of the ultimate production unit" (Crawford, 1987, p. 385). While basic research may have made the product development feasible, this stage involves engineering tasks and skills "to use that capability, solve specific problems, and produce the product that delivers the (required product) benefits" (Urban and Hauser, 1980). At the same time that the prototype is being developed, other activities are being conducted in parallel. For example, the prototype is used for the purpose of carrying out a manufacturing feasibility analysis. Here, cost projections at different volume levels, tests for compatibility and stability of raw material availability, components, certainty of supply need to be determined. Also, the production process may need to be developed, using the prototype as a basis. Equipment facilities may require designing. In order to speed up the development work, the marketing plan will also be developed at the same time as the prototype (Crawford, 1983).

During the development many other activities are concurrently being undertaken by other members of the project team. Members continue to monitor and research market and the competitive situation to confirm product acceptance and a positive market situation. After bringing a new product from the original idea to a physical entity, the next stage consists of testing and validation of the entire viability of the project: the product itself, the production process, customer acceptance, and the economics of the project.

3.7 Testing

3.7.1 Introduction

Design and testing go and in hand, with testing being conducted throughout the development stage and afterwards. Information obtained from testing is used in developing the product and continues even after the prototype is completed and production is started. The purpose of the testing phase is to experiment and improve upon the new product, so that customers at least derive the minimum expected benefit (Urban and Hauser, 1993). During this stage, final and total validation of the entire project is carried out. The following three types of testing are the most important: concept testing, prototype/development testing, and test marketing (Cooper, 1993).

3.7.2 Concept Testing

Concept testing involves testing the new product idea or concept among potential users in order to gain information on consumers' attitudes, and to help guide the marketing and technical effort at the end of the screening stage or prior to the development phase. This is expected to yield useful information such as intent to purchase and suggestions for improvements, which will eventually guide the marketing effort. However, it can also be used as an approach to idea generation particularly in consumer goods firms. Industrial firms, on the other hand tend to omit the concept testing stage, in some cases with disastrous results (Cooper, 1983).

3.7.3 Product-Use Testing

The purpose of product-use testing is to ascertain whether or not the prototype is meeting objectives regarding its physical attributes and perceived benefits and to use the knowledge gained to make the product more suitable to the desired market. Figure 3.3 shows the key pieces of knowledge provided by product-use tests.

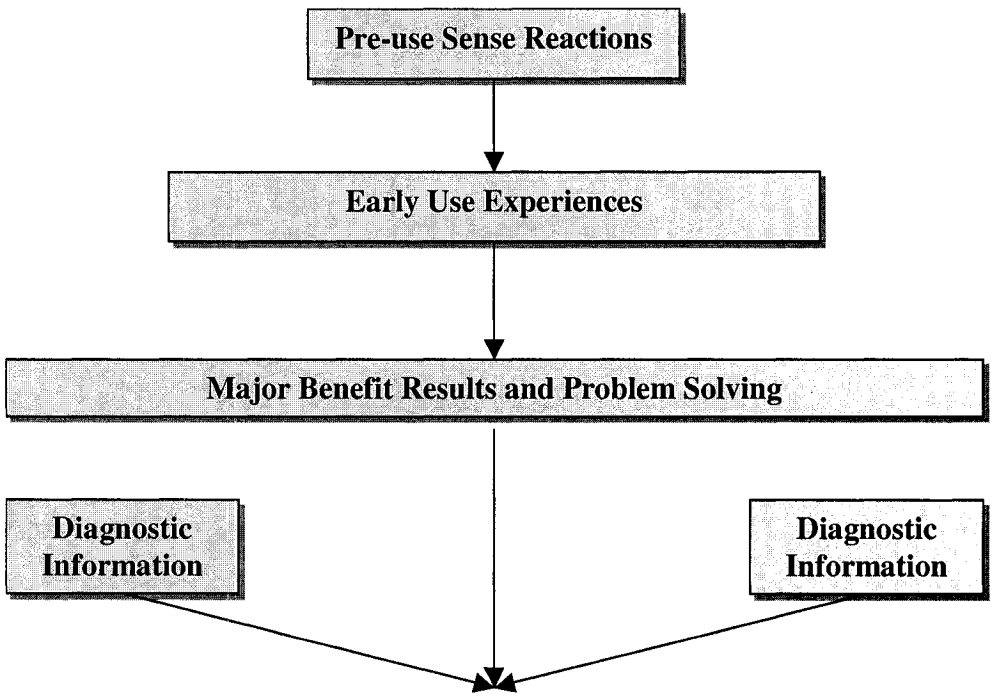


Figure 3.3: Knowledge Gained from Product Use Testing (Crawford, 2003)

During product-use testing, the product is being evaluated to be as similar as possible to the final product that will be launched. The purpose of this type of testing is to indicate how the product will perform under actual consumer use situations (Wind, 1982; Cooper, 1993). Product-use testing can be done using laboratory tests, expert evaluation, and consumer tests, or a combination of these (Urban and Hauser, 1980). Industrial products tested at a customer site would be assessed by various people, often using a number of different testing criteria, such as functionality, safety, and long-term

actual costs (Crawford, 1997).

Through product-use testing, new product managers are looking for how items are used, and what mistakes are made, and tests often suggest ways to improve performance or to reduce costs. They also seek specific pieces of information to back up claims, and marketing personnel want conformance to target markets and product positioning. Thus by prototype and product-use testing, developers try to determine if user had problems understanding the new item or were slow to accept the results they did get.

3.7.4 Test Marketing

This is the stage where, once the new product has passed the functional tests, the product and marketing program (i.e. positioning strategy, advertising, distribution, pricing, branding, and budget levels) are tested in more realistic market settings (Urban and Hauser, 1993). This allows the firm to gain some experience with marketing the new product prior to going through the expense of a full launch. In other words, test marketing can reduce significantly the risk of failure.

There are numerous advantages as well as disadvantages to test marketing. In addition to providing needed information as noted above, test market results can indicate that the new product should be dropped (e.g. due to cannibalization or lower than expected sales), thus avoiding a costly and unsuccessful commercialization. A critical disadvantage of test marketing is its high cost and its time consuming nature. In some cases, it may not be worthwhile to test market given these costs, the level of risk and marketing research's ability to adequately reduce the overall risk. Moreover, competition will become aware of the new product, observe and monitor the test results, and possibly introduce their new version of the new product before or at the same time as the firm's

expected national launching of the product, thereby destroying any competitive advantage.

Once a product has been developed and tested and if results indicate that the new product is likely to be successful, management will most likely decide to go ahead with the last phase of the new product process, the commercialization stage.

3.8 Commercialization

It is at the commercialization stage where large-scale production is started. The new product has been tested and refined and is finally ready to be launched nationally. In addition, a complete promotion and advertising program has been arranged. Considerable time and costs are incurred at this stage to equip the firm's plant and to inform customers. Typically, commercialization costs represent, on average, one third of total development costs (Booz, Allen, and Hamilton, 1982; Griffin, 1997). Time spent on this stage (as a percentage of total development time) is approximately 18% for industrial goods companies, and 29% for consumer nondurable goods (Booz, Allen and Hamilton, 1982).

The initial step in this stage is for the company to decide on the market-entry timing and where to launch the new product. Most companies do not have the means to launch the new product (i.e. capital and capacity). The decision as to which market the new product will be introduced in first also depends on criteria such as market potential, the company's local reputation, cost of communication media, influence of the area on other areas, and competitive penetration (Urban and Hauser, 1993).

Companies approach the market by focusing the design of their new product to sell mainly in their domestic market. If the product attains success in the market and is profitable for the company, it will consider introducing it to other countries by making adjustments to the product where deemed necessary. According to Cooper and Kleinschmidt (1991), however, this can prove to be detrimental for the company. Their study revealed that industrial companies that design the product from the beginning with an international focus are much more profitable in both their domestic and international markets compared to those companies that initially develop a product only for domestic markets.

While this stage represents an important area of concern and study, this thesis deals primarily with the pre-commercialization stages of the new product process.

3.9 Summary

A systematic NPD process provides a framework to help new product teams achieve their goals. The BAH model proposes a multistep new product process, where the product moves from idea to physical product, to launch stage, with the number of evaluations and testing points (gates) in between. The model is described in detail above. Those firms that have adopted a formal NPD process have a greater likelihood of successfully launching the new products. Moreover companies whose management places greater emphasis on the early steps of the NPD process improve their chances of success. This is because by undertaking evaluations and analyses on the process, they ensure that new products have a good fit with market requirements and with the firm's strategic objectives and resources.

Many organizations have adopted some variation of the basic model developed by Booz, Allen and Hamilton (1982) by incorporating parallel processing and multiple functional teams in product development process. Companies undertaking NPD have, to an extent, accepted the idea of using formal NPD process. Griffin (1997), in her study of NPD practices, shows that approximately 60 % of companies do use some form of NPD process. Moreover, of the firms that have adopted some form of NPD process, more than half have moved from a basic BAH model process to a more sophisticated Cooper Stage-Gate system (Cooper, 1994, 1998).

4 COOPER'S STAGE -GATE™ PROCESS

4.1 Introduction

The Stage-Gate™ system in shown Figure 4.1 is a series of NPD process models developed by Cooper (1984), which uses the BAH model as a base, but which goes further and adapts the model to a more sophisticated NPD scenario. Numerous global firms have implemented this process. Ironically, Stage-Gate methods were first developed in Canada but they are now, for the most part, applied outside the country.

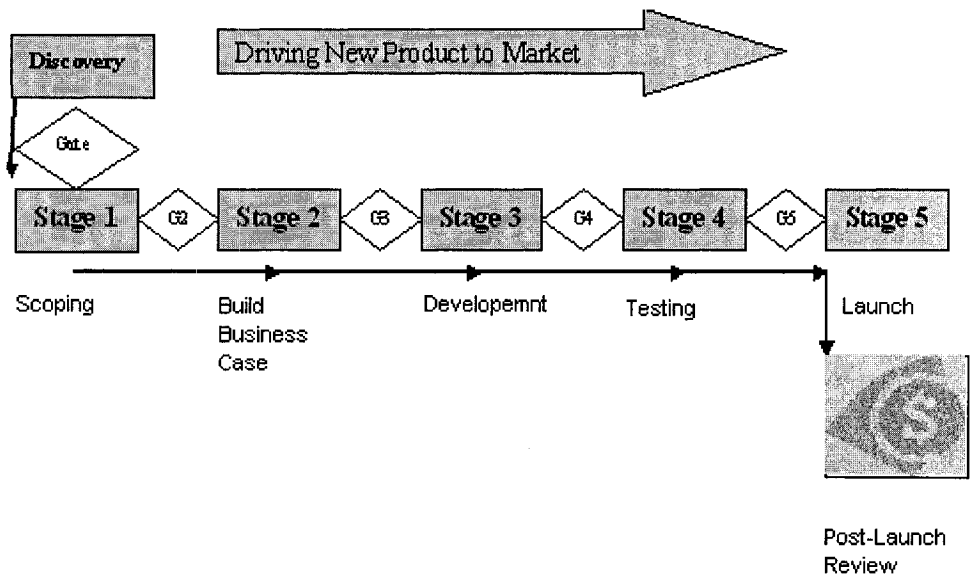


Figure 4.1: Stage-Gate™ Model- From Discovery to Launch (Cooper, 1984)

The Stage-Gate™ New Product Development (NPD) process developed by Drs. Robert G. Cooper and Scott J. Edgett is widely regarded as the best-in-class approach to developing new products. However, many companies have yet to even scratch the surface of the high performance they could be achieving with this process.

4.2 Stage-Gate™ Process

"A Stage-Gate™ process is a conceptual and operational road map for moving a new-product project idea to launch - a blueprint for managing the new-product process to improve effectiveness and efficiency" (Cooper, 2001). Similar to the BAH model, the Stage-Gate™ model also incorporates critical success factors and industry best practices (Cooper, 1998). In this model the stage-gate approach divides the innovation process into a predetermined set of stages which are very similar to the BAH model, with each one consisting of a set of prescribed, cross-functional and parallel activities. It begins with a discovery stage, followed by a number of other stages, each described below. At the entrance to each stage is a gate which serves as the quality control and Go/Kill check point in the process.

4.2.1 Discovery Stage

Today's key management issue in NPD is searching for a breakthrough idea or a major innovation. Ideas are the feedstock or trigger to the NPD process, and they make or break the process. One cannot expect a superior NPD process to overcome a deficiency in good new product ideas. The need for great ideas coupled with a high attrition rate of ideas means that the idea generation stage is pivotal: great ideas are needed, and lots of them.

Cooper (2001) describes the Discovery Stage as the pre-work designed to discover and uncover opportunities and generate ideas which is so important. Activities in the discovery stage include undertaking directed but fundamental technical research; seeking new technological possibilities; working with lead users to uncover unarticulated

needs; and conducting strategic planning exercises to uncover disruptions in the marketplace leading to identification of gaps and significant opportunities.

4.2.2 Stages

Stages are where the action occurs. The players on the project team undertake key tasks to gather information needed to advance the project to the next gate or decision point. Stages are cross-functional: there is no R&D or marketing stage. Rather, each stage consists of a set of parallel activities undertaken by people from different functional areas in the firm, working together as a team and led by a project team leader.

In order to manage the risk associated in NPD via a stage-gate method, the parallel or concurrent activities in a certain stage must be designed to gather vital information - technical, market, financial, operations - in order to drive down the technical arid business risk.

Table 4.1 shows the general flow of the typical, or generic, stage-gate process. Here, following idea generation are the five key stages:

Stage 1 Scoping: a quick investigation and sculpting of the project.

Stage 2 Building the business case: the detailed homework and upfront investigation work leading to a business case; a defined product, a business justification and a detailed plan of action for the next stages.

Stage 3 Development: the actual design and development of the new product. Additionally, the manufacturing process is mapped out, the marketing launch and operating plans are developed, and the test plans for the next stage are defined.

Table 4.1: From Idea to Launch: A Typical Stage-Gate™ Model

IDEA	Discovery Stage
Gate 1	**Idea Screen** Does the idea merit any work?
Stage 1	**Preliminary Investigation** Prelim market assessment Prelim technical assessment Prelim financial & business assessment Action plan for Stage 2
Gate 2	**Second Screen** Does the idea justify extensive investigation?
Stage 2	**Detailed Investigation** User needs & wants study Competitive analysis Value proposition defined Technical feasibility assessment Operations assessment Product definition Financial analysis
Gate 3	**Decision to Develop** Is the business case sound?
Stage 3	**Development** Technical development work Rapid prototypes Initial customer feedback Prototype development In-house product testing Operations process development Full launch & operations plans
Gate 4	**Decision to Test** Should the project be moved to external testing?
Stage 4	**Testing & Validation** Extend in-house testing Customer field trials Acquisition of production equipment Production/operation trials Test market/trial sell Finalized launch and operations plans Post-launch & life cycle plans
Gate 5	**Decision to Launch** Is the product ready for commercial launch?
Stage 5	**Launch** Market launch & roll-out Full productions/operations Selling begin Results monitoring Post-Launch & life cycle plans under way
Post Launch Review How did we do vs. projections? What did we learn?	

Stage 4 Testing and Validation: the verification and validation of the proposed new product, its marketing and production.

Stage 5 Launch: full commercialization of the product- the beginning of full production and commercial launch and selling.

At first glance, this overview portrays the stages as relatively simple steps in a logical process, but it is not as straightforward as it looks. What we see in the figure is only a high level view of a generic process, a concept. In a real company process, drilling down into the details of each stage reveals a much more sophisticated and complex set of activities. Drill-down provides a detailed and operational road map for the project team - everything it needs to know and do to successfully complete that stage of the process and project, as shown in Table 4.1.

4.2.3 Gates

Before entering each stage, a gate or Go/Kill decision point must be crossed, as shown in Figure 4.1. Effective gates are central to the success of a fast-paced, new product process:

- *Gates serve as quality-control checkpoints:* Gates ask questions such as - is this project executed in a quality fashion?

- *Gates also serves as Go/Kill and prioritization decision points:* Gates provide the funnels where mediocre projects are successively called out.

- *Gates are where the path forward for the next stage is decided, along with resource commitments*: Gate meetings are usually staffed by senior managers from different

functions, who own the resources the project leader and team require for the next stage. These decision-makers are called "gatekeepers" (Cooper, 2001). Gates have a common format as shown in Figure 4.2.

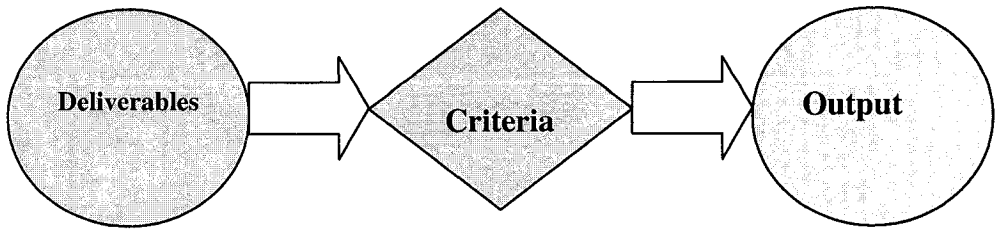


Figure 4.2: Common format of a gate (Cooper 2001).

Deliverables: These are the inputs into the gate review- what the project leader and team deliver to the meeting. They are the results of the actions of the previous stage, and are based on a standard menu of deliverables for each stage. Management's expectations for project teams are thus made very clear.

- *Criteria:* These are questions or metrics on which a project is judged in order to make the Go/Kill and prioritization decision.

- *Outputs:* These are the results of the gate review- a decision (Go/Kill/Hold/Recycle). An action plan is approved, and the date and deliverables for the next stage are agreed upon.

According to Cooper (1984) those firms that have made the effort to design and implement such a process have reaped the benefits faster and they are more successful and enjoy more efficient product development.

4.3 Summary

Cooper's Stage-Gate Model shares similarities with the original BAH model in that it comprises some of its stages but, it goes further by including "gates". The requirements are clear; what is expected of a project team at each stage and gate is defined clearly. A distinguishing feature of the Stage-Gate process (vs. BAH) is that it is cross-functional at both the stages and the gates, which aids in decreasing organizational roadblocks. The process provides a road map to facilitate the project, and it better defines the project objectives and tasks. But the design and implementation of a Stage-Gate process is more complex than the BAH model as it is cross-functional at both stages and gates and some stages occur concurrently.

The benefits of Stage-Gate process are clear. The model puts discipline into a process that, in many firms, is seriously deficient. Those firms that have made the effort to design and implement such a process have reaped the benefit faster. Thus are more successful and enjoy more efficient product development.

5 ORGANIZING FOR NEW PRODUCT DEVELOPMENT

5.1 Introduction

As per the Booz, Allen, and Hamilton (1982) study, half of the problems tallied in the survey were concerned with organization. Organizational structure, a critical problem in the past, has dropped in importance, reflecting the increasing attention of top management to the new product function. However, problems concerned with the coordination of people working together constructively and creatively have increased in importance. The way in which the NPD process is structured within an organization can have an effect on the outcome of a project. Important factors that contribute to the success of a new product project include the allocation of authority and responsibility, top management support and involvement, and the personal involvement of individuals.

5.2 Allocation of Authority and Responsibility

The optimum allocation of authority and responsibility for planning and developing new products is determined by looking at a number of factors. A survey of 100 executives from industrial and consumer manufacturing sectors, covering five different areas of management, revealed a similar conclusion (Hopkins, 1980). Specifically, it was concluded that the ideal structure of the new product development process varied depending on:

- the kinds of new products envisioned,
- the nature of the company itself (size and structure), and

- the prevailing management style and philosophy.

Primarily, it depends on the prevailing management philosophy and the volume and complexity of new product activity in the firm. Implementing Stage-Gate is usually a significant cultural adjustment for organizations, and therefore requires that many people at many levels contribute to making the change happen. Defining the roles is necessary to successfully implement and provide a description of their responsibilities in such a way so that each member will know what is expected to make it happen. Successful companies ensure clarity around roles through written role responsibilities specifying the boundaries and articulating how the roles interface with each other. It is essential that employees not only understand their new role but also understand how to be successful.

5.3 Top Management Support and Involvement

Top management support is a necessary ingredient for successful product development, but it must be the right kind of support. The Stanford innovation project and the Hewlett-Packard study both found top management support to be directly linked to new product success (Maidique and Zirger, 1984, 1985, 1990; Wilson, 1991). But one of the four new product studies by Cooper found a different twist: top managers' support was associated with failures with almost equal frequency as successes. Those projects in which top management is committed, i.e. is involved directly in the management of the project and provides considerable guidance and direction for the project, are only marginally more successful (Swink, 2000). Senior management's role is not to get involved in projects on a day to day basis, or to be constantly meddling and interfering in

the project, or to micro-manage projects. This meddling behavior is unproductive for two reasons: it usurps the empowerment of the team and furthermore, senior management typically is not effective at either picking winners or managing projects. Where top management support is critical, however, is in getting the product to market. When killed projects ideas were compared to launched products in the new product studies, top management support emerged as an important variable.

The message is that top management's main role in product development is to set the stage for product development to occur, to be a "behind-the scenes" facilitator, and not so much an actor front and center. This stage-setting role is vital: management must make the long-term commitment to internal product development as a source of growth. It must develop a vision and strategy for product development that are driven by corporate objectives and strategies (Peter, 1988).

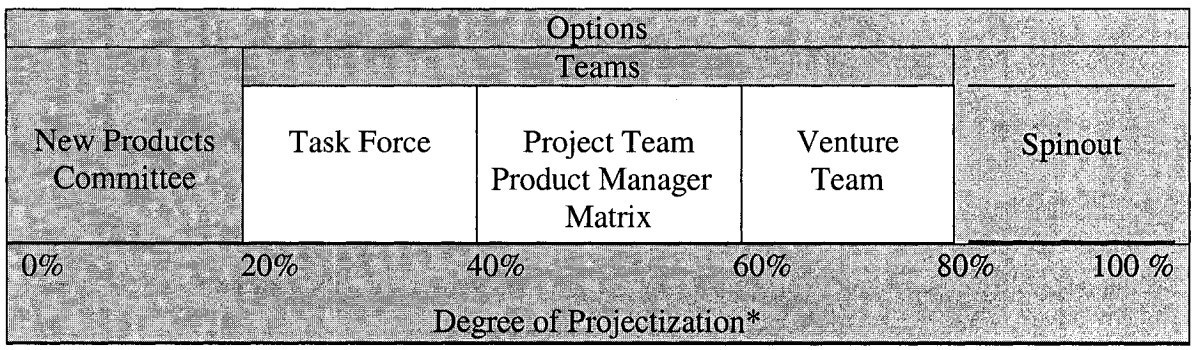
5.4 Individual Involvement

Another contributing element in the success of a new product project is the personal commitment of the individuals working on or involved with such a project. The importance of personal dedication on the part of members working on a project can be seen in the role that a "product champion" plays in the success of a project (Booz, Allen and Hamilton, 1982). A product champion is a venture manager, selling his/her ideas to top management in order to accelerate progress towards commercialization. The champion personally ensures that the product idea is pushed ahead, even when top management is opposed to it. Often, a product idea which would normally have fallen

victim to attrition – that is, dropped at some point along the development process—has proven to be a commercial success due mainly to the efforts of a product champion.

5.5 Types of Structural Forms

The structural forms of new product management that exist in industry have been classified under many different titles. Many of the titles differ by name only; their actual functions in managing the new product effort are actually quite similar. New product work can be structured in six alternative ways as per Crawford (1987). One option is to provide no special structure and let the regular organizational structure do the work. Small firms must use this option, and it works well even if they are innovative because such firms are really just small teams. The other five options are all variations of the team concept. Figure 5.1 shows them graphically. In every case, an assigned group of people represents the firm's various functions, and one individual has some degree of responsibility for the team.



* Defined as the extent to which participants in the process see themselves as independent from the project or committed to it.

Figure 5.1: Options in New Product Organization (Crawford, 2003)

- *The new products committee:* A new product committee consists of mangers from different functional departments. It may be responsible for only one function of the new product process, e.g. search or screening, or for the entire development process. Generally, it reviews and acts upon new product ideas generated elsewhere in the firm Crawford, 2003). The main advantage of this approach is that it brings together different types of expertise from various departments. A disadvantage exists in that buck-passing and ineffective decision-making may result, probably due to lack of full-time responsibility on the part of committee members (Hopkins, 1974).

- *The spinout:* Sometimes a company wants to do something almost impossible within the regular organization. Management knows from there experience that any team that is going to work on certain projects would have to face terrible obstacles within the organization. To counter this problem a small team is separated from the organization and moved to different place. This is done since the success of the team is felt to require independence from the rest of the firm. These teams are "spun out" from the rest of the firm and separately funded, and thus can proceed with only top management to worry about. The chances are the teams will either succeed or its members will end up leaving the company.

- *The venture team & the task force:* Venture teams and task forces represent team approaches working full or part time, on the evolution of a single product idea. This type of structure is increasing in use and consists of members from different functional areas who are free to develop an idea. These groups report directly to top management. Once a project is about to be commercialized and the group's task is completed, the team is disbanded (Scheuing, 1974).

- *The project team:* The middle range of projectization is most common today and is typical of product manager organizations. Behind most successful new products has been a product team. The team may consist of the company's sales manager and its development engineer or up to a five-person group with representatives from each major functional area: marketing, manufacturing, engineering, R&D, and finance and control (Booz, Allen, and Hamilton, 1982). Team members are expected to walk the fine line between emphasis on their departments and loyalty to the project.

5.6 The Ideal Organization Form

The ideal NPD organization within each division or strategic business unit has the following characteristics:

- Clear responsibility for all NPD activities assigned to an individual executive.
- One or more multifunctional teams, each with its own experienced leader who reports to the overall NPD executive.
- For each team, a clear assignment, adequate resources, and authority to make whatever changes necessary to meet the charter.
- Full and active support of a top management sensitive to the organizational dynamics of new products situations.

This ideal organizational format is often seen in firms with successful new product track records as per Crawford (1987). There can be no one best way for organizing new product activities which will apply universally to all organizations. The

best organizational form can only be determined after a thorough analysis of the specific needs and circumstances of each individual organization. The responsibility of this analysis and the final decision on organizational form rests with top management.

5.7 Summary

This chapter covered issues surrounding the subject of organization and control of the new product function. Organization is not beholden to any fixed structures for NPD. There are general approaches (committees, various types of teams, and spinouts), and each certainly fits some situations better than others. But managing the structure is the tough part.

As a closing thought, for any NPD program, effective organization of the new product function is essential. First, it provides top management with a means for controlling a vital part of the company's total effort. Second, it provides for the specific assignment of responsibility for getting an important job done. Third, it provides the vehicle through which people from many departments can work together to make the NPD program a success.

6 CRITICAL SUCCESS FACTORS AND METRICS FOR STAGES OF NPD PROCESS

6.1 Critical Success Factors

Over the last two decades, several studies have examined the determinants of new product success and identified many factors that distinguish successful products from unsuccessful ones. Factors that are necessary and guarantee commercial success are termed as critical success factors (CSF) and these make the difference between winning and losing: it is imperative to reflect on how one can benefit from each and how one can translate each into an operational aspect of the new product process.

Daniel (1961) and Rockart (1979) proposed that organizations need to identify factors that are critical to the success of that organization, and they suggested that the failure to achieve goals associated with those factors would result in organizational failure. In fact, it is even suggested that NPD itself is a CSF for many organizations. Given that this is now a well-known fact, the idea is to determine what factors in NPD are essential for success.

Studies show that such factors include: product uniqueness, a clearly defined product concept, customer need for product and market attractiveness, project synergy with the firm's resources and expertise, market orientation and proficiency, top management support for the NPD effort, and a high quality of execution of the NPD process. In particular, one dimension that shows up in almost every study as a factor that is significantly linked to the rate of success of new products is a formal NPD process (Booz, Allen and Hamilton, 1982; de Brentani 1989, 1991; Cooper and Kleinschmidt, 1987, 1990, 1995; Cooper, 1979, 1990, 1991, 1994, 1995, 1999; Griffin, 1997). The

challenge is to design a blueprint or process for successful product innovation - a process whereby new product projects can move quickly and effectively from the idea stage to a successful launch and beyond.

6.2 Metrics

A metric is a set of measurements to track product development and allow a firm to measure the impact of process improvement over time. Metrics are a subset of measures of those processes whose improvement is critical to the success of the organization. A lack of useful metrics is undoubtedly one reason that the success rate of NPD has not improved appreciably over the past 40 years (Crawford, 1979, 1994). If companies could measure their NPD process, if they had reliable metrics to gauge their performance, then specific problem areas could be addressed and managers might see the same improvement in their NPD efforts that they come to expect from their quantifiable total quality management programs (Lynn and Reilly, 2000).

Metrics can play an important role in helping companies to enhance their NPD efforts and are important for at least three reasons. First, metrics document the value of NPD and are used to justify investments in this fundamental, long run, and risky venture. Second, good metrics enable Chief Executive Officers (CEOs) and Chief Technical Officers to evaluate people, objectives, programs, and projects in order to allocate resources effectively. Third, metrics affect behavior. When scientists, engineers, managers, and other NPD employees are evaluated on specific metrics, they make decisions, take actions, and otherwise alter their behavior in order to improve the metrics. The right metrics align employees' goals with those of the corporation. The wrong

metrics are counterproductive and lead to narrow, short-term, and risk avoiding decisions and actions.

This thesis proposes a framework that applies metrics recommended to measure each critical success factor in order to improve the performance of new product stages.

6.2.1 Characteristics of a Useful NPD Process Metric

Any metric that might be applied to NPD will often focus on one function or another or on the entire NPD process. But no one function is the sole contributor to the process that produces new products. A metric for the productivity of the R&D organization, for example, may show constant improvement. In spite of this improvement, however, there may be no improvement in the rate at which new products reach the market (Meltzer, 2002). What is important to measure is the effectiveness of the stages of NPD process in an interdependent fashion. Disadvantages of metrics are ones that are difficult to understand, costly to collect, reactive, and do not help guide improvements. A metric should possess several characteristics for the effectiveness of the NPD process. Each metric should:

- *Not place blame:* How the process or stage is to be improved is a matter that must be separated from the need to improve it. It is up to the individual contributor or senior management to find the means for improving the process. The aim of the metric is to improve the process, not to emphasize blame or praise on a particular individual or organizational function.
- *Be practical:* Metrics that require significant additional data collection and effort should be avoided.

- *Be easy to apply and understand:* All functions in the firm should be able to employ the metric.
- *Be widely applicable:* The metric should be applicable to moving technology products and to commodity products. Good metrics for NPD process should be adaptable to both situations.
- *Make use of historical data:* Metrics should compare the effectiveness of the practice of the present NPD process with the process as practiced in years past using existing historical data.
- *Be well-documented*: Unambiguous operational definitions and collect data that is accurate and complete.
- *Take on continuous values:* Metrics should be able to take on continuous values where applicable so that incremental improvement can be observed.
- *Process-oriented versus goal-oriented:* An NPD process requires two types of metrics: goal-oriented (outcomes) and process-oriented (effective and efficient process). In any NPD project, organizational participants focus on achieving intended results. To do so, the process must be well defined and therefore measured for performance at various points. The goals must be focused around improving the process, and not just on reaching milestones. Process-oriented goals focus development efforts on achieving progress in an ongoing manner as opposed to achieving objectives by milestones set far apart in time.

Thus a useful metric must be accurate, informative and objective. It must be easily communicated and understood by those who need to act on it. It must provide an agreed basis for decision making at the intended organizational level. The value it

provides must be understood by the people who collect the data and the people who must act as a result of the data. Finally, both goal-oriented and process-oriented metrics are required for an accurate assessment of NPD performance.

6.3 Critical Success Factors and Metrics for Stages of the NPD Process

With so many variables and so many stakeholders involved in the product development process, managers may face a difficult challenge just deciding which measures are useful for evaluating NPD critical success factors. One way to look at the health of a firm's NPD process is to look at an analogous process. For example, the process by which the financial health of a company is measured by an accountant who will audit the books is a process of discovery. Similarly, an audit of the NPD process is also means of discovery, but the goal is different. Its goal is the continuous improvement of the process. If there is to be a continuous improvement, there must be a metric that allows for the comparison of the current performance of the NPD process with performance in the past.

In what follows, each stage of the NPD process and its respective critical success factors, metrics, and tools and techniques to define this metrics are explained in detail. These are all then brought together in a framework proposed to identify the key of NPD process followed by the factors that impact new product outcomes by proposing metrics for all this factors.

6.4 New Product Strategy (NPS)

Prior to commencing an NPD project, companies must set clear objectives (Wind, 1982). The purpose of the first step of the NPD process is to provide guidance for the new product effort. It identifies the strategic business requirements that the new product should comply with, and these are derived from the corporate objectives and strategy of the firm as a whole. These business requirements assign roles to be played by the new products, which in turn are influenced by the individual needs of the industry (Booz, Allen and Hamilton, 1982). Metrics and critical success factors shown in Table 6.1 play an important role in forming a successful NPS.

Table 6.1: CSF and Metrics for NPS Stage

Stage	Critical Success Factors	Metrics	Tools and Techniques
New Product Strategy	• Clear Strategy • Well Communicated Strategy	• Return on Investment (ROI) • Degree of Communication	▪ Financial Analysis • Balanced-Scorecard as a Communication Tool

6.4.1 Critical Success Factors for NPS Stage

Clear Strategy

A clear strategy is required to achieve NPD goals. A firms' strategy should provide a clear understanding of the goals or objectives for the company's new product program, and should indicate the return-on-investment (ROI) expected such that the

contribution of new products to corporate goals is well understood. Furthermore, clearly defined arenas- specified areas of strategic focus, such as products, markets, or technologies- are needed to give direction to the firm's total new product program.

Well Communicated Strategy

The problem at this stage of NPD is not only one of developing a clear strategy but also its implementation, i.e., translating the strategy into terms that everyone understands and thereby bringing focus to their day-to-day actions, and communicating the strategy with other members in the organization. Prior research suggests that companies that recognize the importance of interfunctional coordination and effectively sharing an NPS across departments will have more successful new products (Cooper, 1999). The role of new products in achieving company goals was clearly communicated to all in such firms.

As Table 6.1 illustrates, once a clear NPS is defined, the related confounding problem is communicating clearly the needs, requirements, resources, and plans for a new product effort - in essence, internalizing the strategy. This communication must take place in multiple forms; however, a well-documented plan and specification must serve as the foundation. In summary, the establishment and communication of a clear plan and a strategy for an NPD project is a key requisite for success. Businesses that have a well-articulated NPS fare much better than those lacking in this aspect and they have 32 percent higher NPD success rates, meet sales objectives 42 percent more often, and meet profits objectives 39 percent better (Cooper and Kleinschmidt, 1995).

6.4.2 Metrics for NPS

Return-On-Investment

Good metrics are related to organizational goals. A company's ROI is one such metric that proves to be useful in setting the new product goals. An NPS must include an ROI as a metric. If the cost to implement an improvement exceeds the resulting benefit, or the payback does not exceed the resulting benefit, or does not affect the corporate bottom line, the value of implementing change must be questioned. In fact, the reason for the metric should also be questioned. The aim here is to compare the return expected to be received from the project with some pre-established requirement.

Degree of Communication

The degree of communication among the members of the organization is dominated by sharing information and achieving the highest amount of coordination of shared activities. To reach a considerably high degree of collective intelligence, the range in communication has to be extended to cooperation and collaboration. Collaboration assumes a high level of coherence among individuals as the team pursues a common goal. Each individual member of the team has fuzzy knowledge regarding the strategy or objectives of organization, though being expert in a particular domain. Collaboration on the other hand has less stringent requirements for intellectual coherence and shared knowledge. The individual members of a team cooperate by carrying out their individual tasks without necessarily having knowledge of all contribution made by other to the project.

6.4.3 Tools and Technique for NPS

Balance-Scorecard

The Balance Scorecard (BSC) provides the instrumentation the firm needs to navigate to future competitive success. BSC translates an organization's strategy into a comprehensive set of performance measures that provides the framework for a strategic measurement and management system. The scorecard measures organizational performance drivers across four perspectives: financial, customers, internal business processes, and learning and growth, as shown in Figure 6.1. These four perspectives provide the framework for the Balanced Scorecard.

The objectives and the measures of BSC are the collection of financial and non-financial performance measures; they are derived from a top-down process driven by the strategy of the business unit. The BSC translates the strategy into tangible objectives and measures. The measures are balanced between the outcome measures - the results from past efforts - and the measures that drive future performance. The scorecard is balanced between objectives, easily quantified outcome measures and subjective performance drivers of the outcome measures.

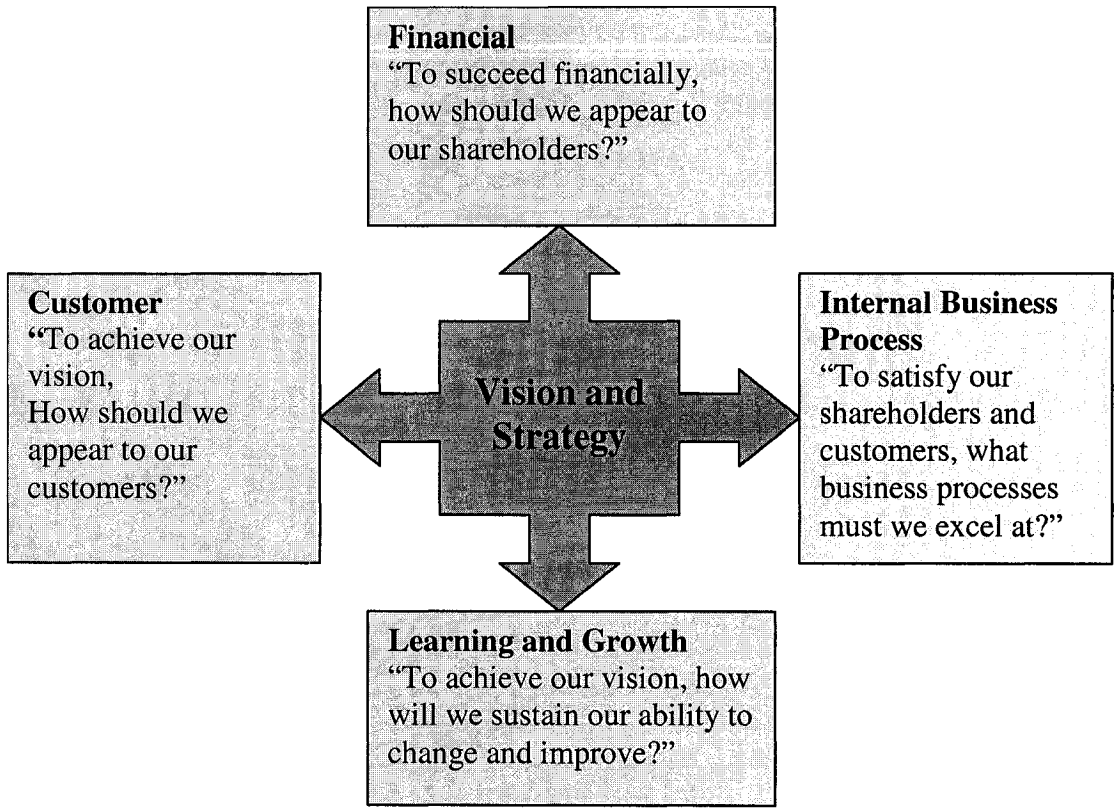


Figure 6.1: The Balanced Scorecard Provides Framework to Translate a Strategy into Operational Terms (Kaplan and Norton, 1996)

Organizations should use the scorecard as a strategic management system, to manage their strategy over the long run (see Figure 6.2) and use it for the measurement focus of the scorecard to accomplish critical management processes:

- Clarify and translate vision and strategy
- Communicate and link strategic objectives and measures
- Plan, set targets, and align strategic initiatives
- Enhance strategic feedback and learning

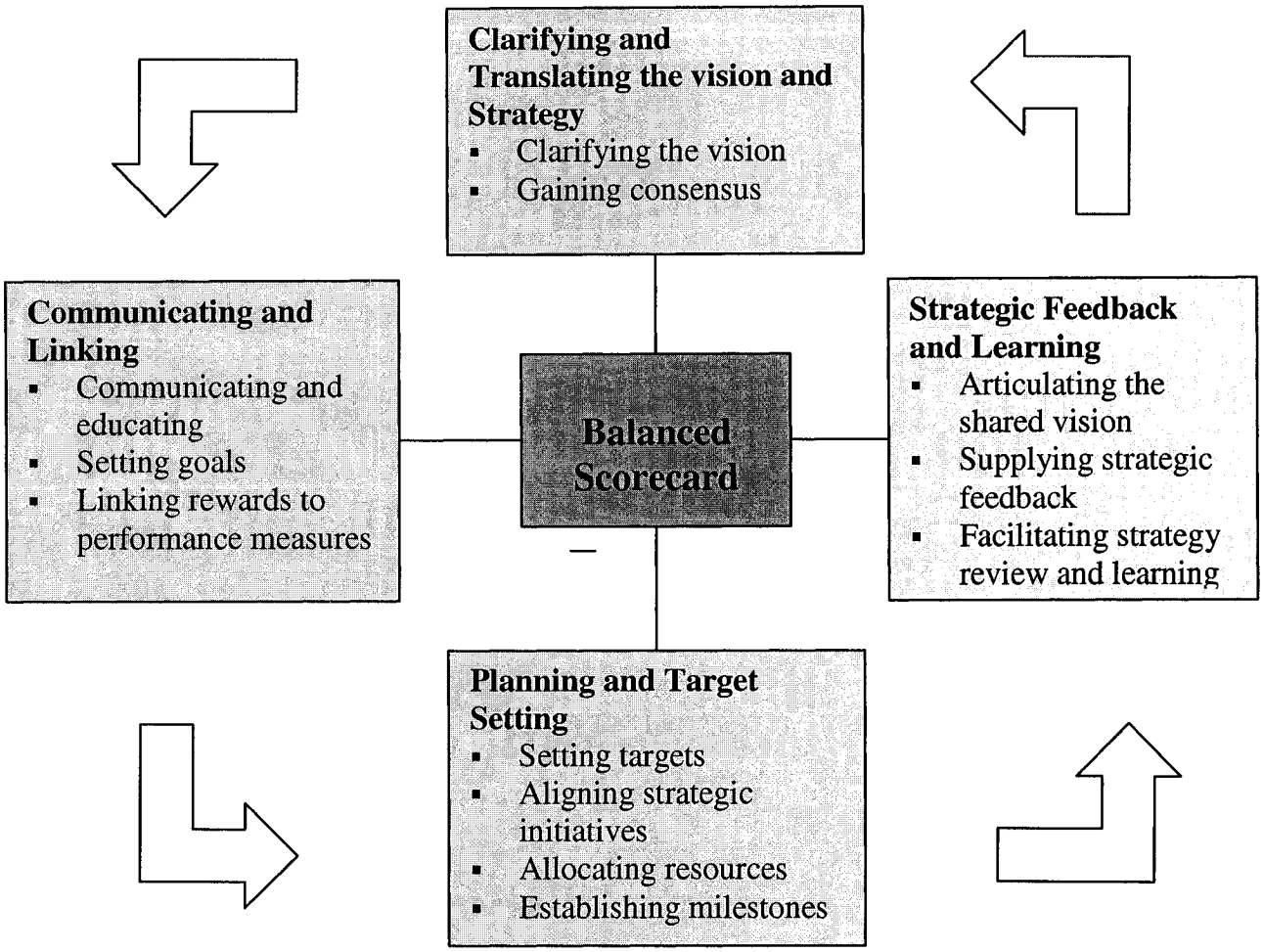


Figure 6.2: The Balanced Scorecard as a Strategic Framework for Action (Kaplan and Norton, 1996)

Communicate and link strategic objectives and measure

The BSC strategic objective and measures are communicated throughout an organization via company newsletters, bulletin boards, videos, and even electronically through groupware and networked personal computers. The communication serves to signal to all employees the critical objectives that must be accomplished if an organization's strategy

is to succeed. Once all employees understand high-level objectives and measures, they can establish local objectives that support the business unit's global strategy.

The organizational communication and education program should not only be comprehensive but also periodic. Multiple communication tools can be used to launch the Balance Scorecard program: executive announcement, videos, meetings, brochures and newsletters. This initial announcement should then be followed continually, by reporting scorecard and outcomes on bulletin boards, newsletters, groupware, and electronic networks.

The design of such a program should begin by answering fundamental questions. An example of the comprehensive communication program is shown in Figure 6.3.

- What are the objectives of the communication strategy?
- Who are the target audiences?
- What is the key message for each audience?
- What are the appropriate media for each audience?
- What is the time frame for each stage of the communication strategy?
- How will top management know that the communication has been received?

Communication Vehicles						
Target Audiences	**Strategic Dialogue**	**Detailed Monthly Reports**	**Review Meeting**	**Kickoff/Leadership Road Show**	**Video**	**Periodic Update Brochure/ News Letter**
Corporate	√		Semiannually	√	√	Quarterly
Strategic Business units Leadership Team	Semiannually	√	Monthly Meeting year End	Kickoff	√	Monthly
Directors	Semiannually	√	Monthly Meeting	Kickoff for Directors	√	Monthly
Stores	√	As Needed	As Needed	Kickoff for Group leaders Road Show by Group Leaders	√	Monthly
Distribution Center	√	As Needed	As Needed	√	√	Monthly
Support groups • Real Estate • Store Planning • Key Suppliers	As Needed	√ √		√	√	As Needed

Figure 6.3: Example of a comprehensive communication program (Kaplan and Norton, 1996).

Financial Perspective

The BSC links financial objectives to corporate strategy. The financial objectives serve as the focus for the objectives and measures in all the other scorecard perspectives. Every measure should culminate in improving financial performance. The scorecard discusses the strategy, starting with long-run financial objectives, and then links them to the sequence of actions that must be taken with financial processes, customers, internal processes, and finally employees and systems to deliver the desired long run economic performance.

Many corporations, however, use identical financial objectives for all of their divisions and business units. This uniform approach is certainly feasible, consistent, and fair since all business unit managers will be evaluated by the same metric, but different business units may follow quite different strategies. So when they start developing the financial perspective for their BSC, business unit executives should determine appropriate financial metrics such as ROI for their strategy.

Return on Investment (ROI)

The return-on-investment (ROI) compares the company's yearly income with the investment in the asset. A standard of measure of project profitability, this is the discounted profits over the life of the project expresses as a percentage of development investment. The aim here is to compare the return expected to be received from the project with some pre-established requirement. The simplest method to determine ROI is to divide the average annual income by the total investment as shown.

$$\text{ROI} = \frac{\text{Predicted Annual Income}}{\text{Original Investment}}$$

While the ROI is not too challenging, management should understand how the ROI benchmarks have been calculate so that relevant comparisons can be made for the project under evaluation. This long-term metric set by the corporate objectives should be linked with the new product strategy and this can be done using the BSC framework of financial perspectives.

6.5 Idea Generation

After setting a well-defined NPS for NPD, the idea generation stage begins. This is the stage where the search for product ideas is made to meet company objectives. The element of idea generation concerns the birth, development, and maturation of a concrete idea. After defining the markets and segments based on the NPS it wishes to target, the firm must advance and nurture ideas wherever they occur to take advantage of the identified opportunities. As per the study done by Booz, Allen and Hamilton (1982), a firm has to generate at least seven ideas to generate one successful. Griffin (1997) says that an average of 100 ideas must be generated in order to yield 15.2 successes.

Firms that are effective at idea generation are those that do not focus solely on the first source to generate ideas, i.e. ideas that are originated from inside the firm, but that concentrate on all potential idea sources (Crawford, 1997). The firm can derive new ideas from internal sources (i.e., employees, managers), external sources (i.e., customers, competitors, distributors, and suppliers), and from implementing formal research and development. However firms should encourage their employees to generate ideas.

There is a multitude of sources for new product ideas, and there are also many different methods that a company can utilize directly in order to generate ideas.

Brainstorming, morphological analysis and gap analysis are most commonly employed methods for generating ideas (Crawford, 1997) (as discussed in Chapter 3). The main purpose of this stage is to create a number of different ideas from which the firm can select the most feasible and promising one(s). A greater likelihood of achieving success depends in part on the number of ideas generated.

As per the marketing concept, customers can be a good place to start searching for new product ideas. The relatively high rate of success for product ideas originated from marketing personnel and customers (Sounder, 1987). The CSF and its metrics for the Idea Generation stage are shown in Table 6.2.

Table 6.2: CSF and Metric for Idea Generation Stage

Stage	Critical Success Factor	Metrics	Tools and Technique
Idea Generation	• Customer Focused Idea Generation	• Number of Customer Focused Ideas Generated	• Lead User Methodology • Ethnographic Approach

6.5.1 Critical Success Factor for Idea Generation Stage

1. Customer Focused Idea Generation

Customer focused idea generation is a CSF for this stage as per studies done by many researchers that show that a thorough understanding of customer's needs and wants is vital for new product success (Cooper 1993; Crawford 1987). Successful businesses

and teams that drive winning new products have a dedication towards the voice of the customer.

A strong customer involvement is necessary right from the idea generation stage. Are ideas suggested by customers highly likely to result in success? Are NPD likely to succeed if they originate in the firm's marketing department? According to Souder's (1987) review of causes of NPD success and failure, he concluded that internally generated ideas had lower success rates then externally generated ideas. A relatively high rate of success is achieved for project ideas that originated from marketing and customer as compared to ideas originating from R&D, suppliers, and management

6.5.2 Metrics for Customer Focused Idea Generation

1. Number of Customer Focused Ideas Generated

Measurable goals or metrics to track idea generation and enrichment include: number of ideas generated from the customer, number of ideas retrieved and enhanced from an idea portfolio, number of ideas generated over a period of time, percentage of ideas commercialized, value of ideas in idea bank, percentage of ideas that resulted in patents, and percentage of ideas accepted by a business unit for development. Among all of these metrics, the number of ideas generated from the customer is the most associated with the CSF of the idea generation stage.

Firms must devote more resources to customer based idea generation activities, such as focus groups with customers; detailed, one-on-one interviews with customers; customer site visits, especially by technical people; the active solicitation of ideas from

customers by the sales force; and the development of a relationship with lead users (Cooper, 1999).

6.5.3 Tools and Techniques to Generate Ideas for NPD

Understanding customer and market needs is a consistent theme for successful product development in studies by Song and Parry (1996) and Cooper (1999). There are many creativity and brainstorming techniques for enriching the idea stream. Effective methods for enriching the customer based idea stream utilize lead user methodology and ethnographic approaches.

1. Lead User Methodology

The lead user methodology takes a different approach as compared to traditional approaches in which ideas are generated based on customer input and usually collect information on new product needs from a random or typical set of customers. The lead user process collects information about both needs and solutions from the leading edges of the target market and from markets facing similar problems in a more extreme form.

The general overview of the lead user methodology involves four major phases. The process gets under way when a cross-disciplinary team is formed. Teams typically consist of four to six people from marketing and technical departments, with one member serving as project leader. Team members usually spend 12 to 15 hours per week on the project for its duration.

Phase 1: Laying the Foundation. During this initial period, the team identifies the kinds of markets they want to target, as well as the type and level of innovations desired by key stakeholders within the company.

Phase 2: Determining the Trends. It's an axiom of the process that lead users are ahead of the trend. But what is the trend? To find out, the team must talk to experts in the field they are exploring; that is, to people who have a broad view of emerging technologies and leading-edge applications in the area under study.

Phase 3: Identifying Lead Users. The team now begins a networking process to identify and learn from users at the leading edge of both the target market and related markets. The group's members focus on gathering information that will help them to identify especially promising innovations and ideas that contribute to the development of breakthrough products.

Phase 4: Developing the Breakthroughs. The goal is to move the preliminary concepts toward completion.

After the workshop, the project team further hones the concepts, determines whether they fit the needs of target-market users, and eventually presents its recommendations to senior managers. In this way, the rich body of knowledge that was collected during the process continues to be useful during the remaining steps of product development and marketing (Lilien, Morrison, Searls, Sonnack and Hippel, 2002).

2. Ethnographic Approaches

An ethnographic approach is a descriptive, qualitative market research methodology for studying the customer in relation to his or her environment. Researchers spend time in the field observing customers and their environment to acquire a deep understanding of customer's lifestyles or cultures as a basis for better understanding their needs and problems. In this approach, observation, interviews and

the documentation are done for traces that people leave as they go about their everyday lives.

Ethnographic fieldwork includes elements of other types of research such as contextual inquiry, observational research and participant observation. Contextual inquiry is a form of ethnography that is specifically focused on asking questions. It is contextual, in that the asking of questions takes place in the natural environment of use. Observational research entails simply watching users in their environments, without asking questions about why or how things are being done. Participant observation is a more intensive form of observational research that focuses on the researchers joining the culture being studied in order to better understand that culture.

Applied ethnography draws number of different research methods as shown in Table 6.3. It listens to what people say, while at the same time watching what people do and what they use. Applied ethnography is the best way to discover the difference between what people say they do and what they really do in their daily lives.

Table 6.3: Three Main Ethnographic Approaches

	What people say	What people do	What people use
LISTEN			
Make notes	Conversations		
Audio-record	Interviews		
OBSERVE			
Watch		Behavior	Behavioral traces
Make notes		Mapping Patterns of behavior	Wear and tear on objects, pathways, etc.
Sketch or Diagram		Relationships between people	Product usage
Photograph		Time-lapse photography	Photos of product use
Videotape		Videos of daily living	Videos of activities
Digital Technology		Web-cameras	Web-cameras

Since it allows the use of multiple converging perspectives - what people say, do, and use - it will always reveal more and provide greater insight. This deeper level of understanding is derived from customer to generate customer-based ideas.

6.6 Screening and Business Analysis

After gathering enough new product ideas through various sources from the idea generation stage, the problem that then arises for most firms is selecting which ideas to pursue in order to achieve the most business value. Making a good selection is critical to the future health and success of the business. The point is that product development costs rise substantially with each successive stage in the NPD process (Booz, Allen and Hamilton 1982).

The ideas that have been classified as "Go" ideas must be screened further using criteria set up by top management (Cooper and de Brentani, 1984, de Brentani, 1986). These ideas must be described on a standard form that can be accessed by a new product committee. The committee then assesses each idea against a set of criteria, which verify the attractiveness and visibility of the idea as well as its fit with the company's strategy, objectives and resources. The ultimate result from the screening and evaluation i.e. "Gate 2" is a ranking of NPD proposals, such that the resources can be allocated to the projects that seem most promising (Crawford 1997; Wind, 1982).

The next stage in the NPD process which is very important is the business analysis or business case stage as per Copper (1993). This is the detailed investigation stage that clearly defines the product and verifies the attractiveness of the project prior to heavy spending. In Cooper's (2001) stage-gate model, the business evaluation step is defined as the "critical homework stage" and this business case stage is often found to be weakly handled. According to study by Cooper's NewProd studies of new product failures show that weakness in the upfront activities seriously compromises the projects. Inadequate market analysis and a lack of market research, moving directly from an idea

into a full-fledged development effort, and a failure to spend time and money on the up-front steps, are familiar themes in product failures. The quality of execution of the predevelopment steps is closely tied to the product's financial performance (Cooper, 1980). Screening and business analysis are proposed as two different stages in the BAH model: in the screening stage, initial analysis is done based on the NPS, resources and competition, while in the business analysis stage, ideas are evaluated using quantitative performance criteria. In Cooper's stage-gate model, the Building the business case stage (stage 2, as described in Chapter 4) merges the screening and business analysis stages of BAH's model, and ideas are ranked ordered based on both screening and business analysis used by BAH model. Although this thesis focuses on BAH's model, the two stages of BAH's model are considered as one, as in Cooper's model, for simplicity of the proposed framework.

In every successive stage of the NPD process, as estimates become more refined and accurate, companies should continue conducting financial evaluation throughout the NPD process, but at this stage it is critical. A review of a costs, potential sales and profit projections of the new product are undertaken in order to determine whether these factors satisfy the company's objectives or not. If a result from this stage shows that the product meets the objectives, then the new product concept can move to the development stage. According to Griffin (1997) among the firms taking part in study, 75.6% developed formal financial objectives against which performance was measured.

The qualitative side of evaluation involves a review of each of the activities in this stage, checking that the activities were undertaken and the results were positive. Next is the decision stage were the project has to pass through set criteria. Finally, because of a

heavy spending commitment after passing through this stage, the result of the financial analysis is an important part to this screen (Cooper, 2000).

The final component of the business analysis stage is the action plan. A detailed plan of action is created for the next stage and tentative plans are developed for all subsequent stages. This critical stage opens the door to a significant commitment of resources and to a full-fledged development program based on financial analysis (see Table 6.4) which forms the base for the CSF and its metrics proposed for the screening and business analysis stage.

Table 6.4: CSF and Metrics for Screening and Business Analysis Stage

Stage	Critical Success Factor	Metrics	Tools and Techniques
Screening and Business Analysis	• Up-Front Homework	• Expected Commercial Value (ECV) • Net Present Value (NPV) • Internal Rate of Return (IRR) • Profitability Index (PI)	• Financial Methods of Evaluation

6.6.1 Critical Success Factor for Screening and Business Analysis Stage

1. Up-front homework

Up-front homework is a CSF for the screening and business analysis stage as too many new-product projects move from the idea stage right into development with little or

no early preparation (Rosenau, Griffin, Castellion, and Anschuetz, 1996). The results of this approach are usually disastrous. Up-front homework includes activities such as financial analysis, undertaking thorough market and competitive analyses, research on the customer needs and wants, concept testing, and technical and operations feasibility assessments. Solid pre-development work drives up new product success rates significantly and is strongly correlated to financial performance. All of these activities lead to solid business analysis prior to beginning serious development work. Firms devote on average only seven percent of a project's funding and 16 percent of the person-days to these critical up-front homework activities, which is not enough to make a successful product according to the NewProd (1999) study. The conclusion is that more time and resources must be devoted to the activities that precede the design and development of the product.

As per a study done by Cooper, Edgett, and Kleinschmidt (1999), the most dominant method used by 40.4% of businesses for performance results is a financial approach, as shown on Figure 6.4, followed by strategic approaches and scoring models. Using financial methods, profitability, return, payback or economic value of the project are determined and projects are judged and rank-ordered on these criterion.

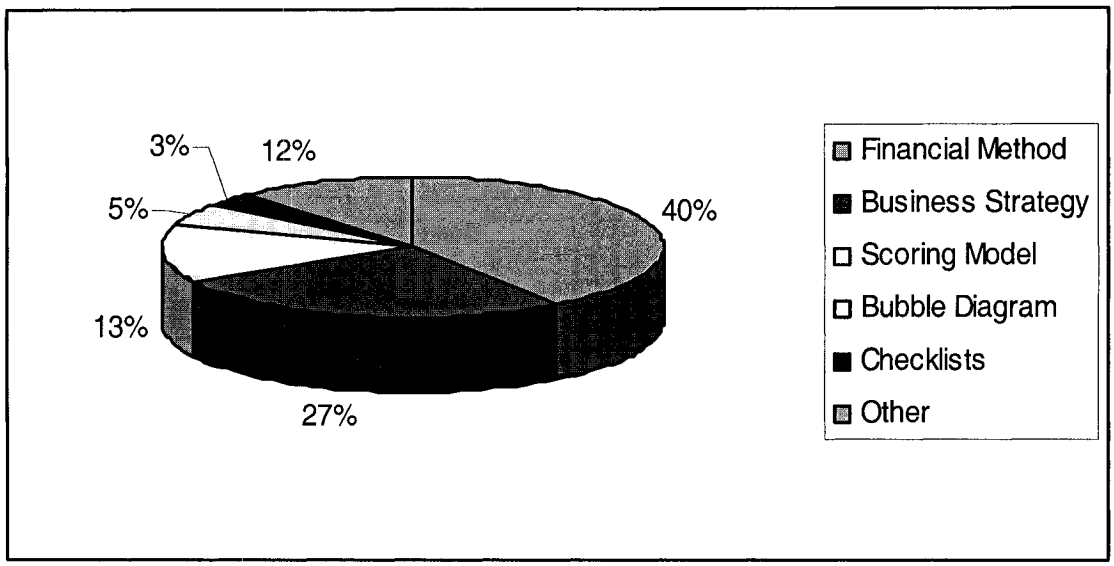


Figure 6.4: Dominant Portfolio Method Employed (Cooper, Edgett, and Kleinschmidt, 1999).

6.6.2 Metrics for Upfront Homework in the Screening and Business Analysis Stage

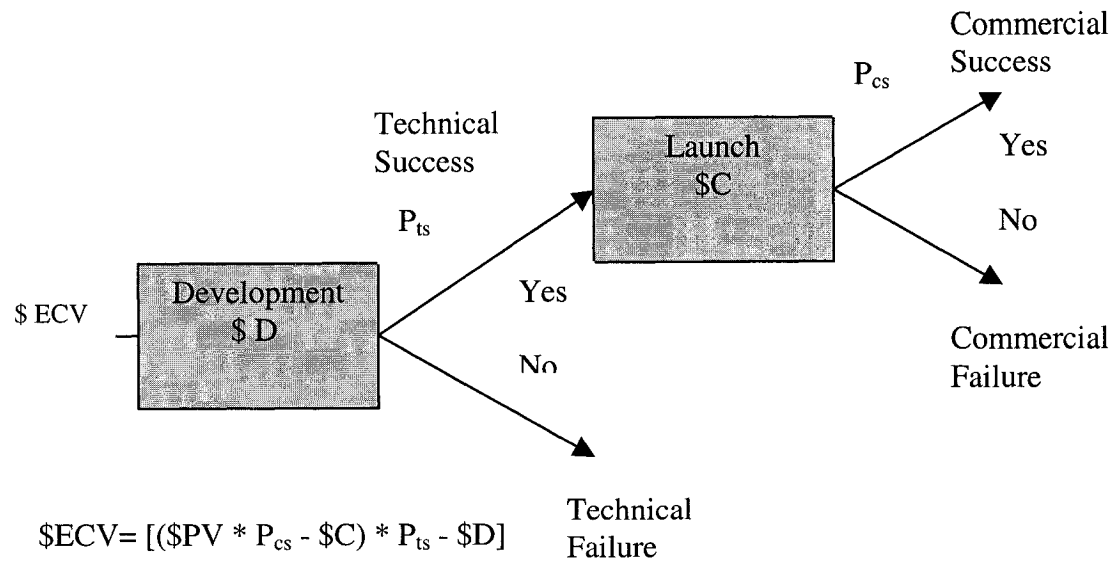
Financial or economic models treat project evaluation much like a conventional investment decision. Returns on investment (ROI), net present value (NPV), internal rate of return (IRR), and the Profitability Index (PI), are metrics that are proposed as being most useful for measuring the success of the screening and business analysis stage. These metrics should be used to rate, rank order, and ultimately select projects. ROI metrics relates to strategic objective of NPD. Each metrics have there own advantages and disadvantages, NPV method ignores probabilities and risk; it assumes that financial projections are accurate and financial goals are important. ECV weakness is on the dependency on extensive financial and other quantitative data. This metrics all together gave more clear details about the projects financial performance to select the best project from the group.

6.6.3 Tools and Technique of Screening and Business Analysis Stage

The financial methods of evaluation for the proposed metrics and how they measure the financial performance of each project are explained below. The end result of each method is a rank-ordered or prioritized list of go projects and hold projects, with the projects at the top of the list scoring highest in terms of achieving the desired objectives; the value in terms of that objective is thus maximized.

1. Expected Commercial Value (ECV)

The Expected Commercial Value (ECV) method seeks to maximize the value or commercial worth of the project, subject to certain budget constraints, and introduces the notion of risks and probabilities. The ECV method determines the value or commercial worth of each project to the corporation. The calculation of the ECV is based on a decision tree analysis and considers the future stream of earnings from the project, the probabilities of both commercial success and technical success, and both commercialization costs and development costs. Figure 6.5 illustrates the calculation and definition of terms.



$$\$ECV = [(\$PV * P_{cs} - \$C) * P_{ts} - \$D]$$

$ ECV = Expected commercial value of the project
$PV = Present value of projects future earnings
P_{cs} = Probability of commercial success
$C = Commercialization cost
P_{ts} = Probability of technical success
$D = Development costs remaining in the project

Figure 6.5: Determining the Expected Commercial Value (ECV) (Cooper, Edgett, and Kleinschmidt, 2000).

Therefore, the ECV measures the value of the project in terms of its expected financial returns from the perspective of the company's overall commercial strategic objectives. In order to arrive at a prioritized list of projects, the ECV of each project is determined using the formula detailed above and projects are rank ordered accordingly.

2. Net Present Value (NPV)

The present value criterion for evaluating proposed capital investments involves summing the present values of cash outflows required to support an investment with the

present value of the cash inflows resulting from operations of the project. The inflows and outflows are discounted to present value using the firm's required rate of return for the project. The NPV is the difference in the present value of the inflows and outflows.

$$\textbf{NPV} = \sum_{t=0}^{n} \frac{CI_t}{(1+k)^t} - CO_o$$

CO_o = present value of the cost of the project
CI_t = cash inflow to be received in period t
k = appropriate discount rate
t = time period
n = useful life of asset.

If the NPV is positive, it means the project is expected to yield a return in excess of the required rate; if the NPV is zero, the yield is expected to exactly equal the required rate; if the NPV is negative, the yield is expected to be less than the required rate. Hence, only those projects that have a positive or zero NPV meet the criterion for acceptance.

3. Internal Rate of Return (IRR)

The internal rate of return is that rate which exactly equates the present value of the expected after-tax cash inflows with the present value of the after-tax cash outflows. This is expressed in equation:

$$\textbf{IRR} = \sum_{t=0}^{n} \frac{CI_t}{(1+r)^t} = \sum_{t=0}^{n} \frac{CO_t}{(1+r)^t}$$

CO_t = cash outflow in period t.

Once the IRR of a project has been determined, it is a simple matter to compare it with the required rate of return to decide whether or not the project is acceptable. If the IRR equals or exceeds the required rate, the project is acceptable. Ranking the projects is

also a simple matter. Projects are ranked according to the IRRs: the project with the highest IRR is ranked first and so on.

4. Profitability Index (PI)

The profitability index (PI) is the ratio of the present value of the after-tax cash inflows to the outflows. A ratio of one or greater indicates that the project in question has an expected yield equal to or greater than the discount rate. The profitability index is a measure of a project's profitability per dollar of investment. As a result, it is used to rank projects of varying costs and expected economic lives in order of their profitability.

$$\textbf{PI} = \frac{\text{Present value of cash inflows}}{\text{Present value of cash outflows}}$$

$$\textbf{PI} = \frac{\sum_{t=0}^{n} \frac{CI_t}{(1+k)^t}}{CO_o}$$

Projects are rank-ordered according to this productivity index in order to arrive at the preferred portfolio, with projects at the bottom of the list placed on hold.

In order to ensure that project ideas are carefully screened, and that the business analysis is carefully carried out, these metrics are certain to help select projects so as to maximize the sum of the values of all active projects in the firm's pipeline in terms of business objectives.

6.7 Development

Once the results of the business case of the new product conform to company objectives, the new product team can move on to the next stage, called development. Development is a complex stage made up of activities that range from prototype development to volume ramp up and test marketing. The interaction between the program and project manager is no longer one of selling or buying the concept, but rather one of bringing the product to market on time, within budget, and to the required specifications.

On average, one third of total NPD expenditures are committed during this stage with 40 percent of total NPD time (Cooper, 1999). In the development stage, business case plans are translated into concrete deliverables. What is critical for success at this stage, as shown in Table 6.5, is 1) to move through development to launch as quickly as possible; and 2) to ensure that the product prototype or final design does indeed meet customer requirements, which requires seeking customer input and feedback throughout the entire development stage. It is important to gain competitive advantage and to enjoy the product's revenues as soon as possible and it also minimizes the impact of a changing environment.

Thus, as the product proceeds from one step of the development stage to the next, the new product team should reassess the market, position, product, and technology in order to increase chances of delivering a successful product (Cooper, 1993; Urban and Hauser, 1993). Marketing and R&D functions, in particular, should collaborate because, while marketing can express the needs of customers, R&D has the capacity of turning a product concept into an actual physical entity. Therefore they should work together to

make sure that the product meets customer requirements (Urban and Hauser, 1993). As compared to a traditional hierarchical team, a cross-functional team has gained more and more recognition in companies. The objective of this type of team is to work together in identifying and solving problems efficiently by coordination of resources and ideas. Customer input and feedback is a critical activity throughout development, both to ensure that the product is right and also to speed development toward a correctly defined target.

Table 6.5: CSF and Metrics for Development Stage

Stage	Critical Success Factors	Metrics	Tools and Techniques
Development	• Speed	• Development time • Degree of functional integration • Degree of team commitment • Concurrency of activities	• Dynamic Time to Market • Team Cohesiveness • Degree of Parallelism
	• Customer feedback	• Degree of design effort on real customer priorities	• Quality Function Deployment

6.7.1 Critical Success Factors for Development Stage

Speed

Development of new product takes months, in some firm years, and much that is unexpected can occur during this time frame. The market may change partway through development, making the original estimates of market size and product acceptance invalid. Customer requirements may shift, rendering the original set of product specifications obsolete. Competitors may introduce similar products in the meantime, creating a less receptive market environment. These and other external changes mean the original product definition and justification are no longer valid.

Reducing development time is a vital competitive weapon and yields competitive advantage; it means that there is less likelihood that the market or competitive situation has changed by time the product reaches the market and it means a quicker realization of profits (Cooper 1993, 1999, 2001). Companies that develop products quickly gain many advantages over their competitors: premium prices, valuable market information, leadership reputations with consumers, lower development costs, and accelerated learning (Cooper, 2001). Therefore, the goal of reducing the development time is critical. Most importantly, fast development minimizes the impact of a changing environment. If the development time can be reduced from eighteen months to nine, the odds of things changing are similarly greatly reduced that makes the need to reduce the time during the development stage. Most firms have reduced product development times over the past five years with the average reduction being about the one-third. In short, the challenge here is to shorten development time so as to minimize the chances that the development target has changed.

Customer Feedback

Seeking customer feedback is a vital activity throughout development stage, both to ensure that the product design is right and also to speed development toward a correctly defined target. The original voice-of-customer research that was done prior to development may not be enough to resolve all the design problems during development (Cooper, 1999).

Customer feedbacks are perhaps the most certain way of seeking continual and honest customer input during the development phase. Seeking customer input should become an integral part of the design team to speedup and make development stage successful.

6.7.2 Metrics for Development Stage

1. Development Time

Development time is defined as the duration from the start to completion of the development stage, i.e., the length of time to develop a new product after passing business case stage to initial market sales. Precise definitions of the start and end point vary from one company to another, and may also vary from one project to another within the company. How quickly the team moves through this stage is critical for the reasons stated earlier, and as such, it is imperative that the team measures their progress according to time.

2. Degree of functional integration

A cross-functional team is defined as a team consisting of representatives from the various functions involved in product development, usually including members from marketing, R&D, and operations (and perhaps others, such as purchasing, as needed).

The most effective development teams also involve suppliers in the early stages of development, and frequently rely on suppliers for a large portion of the subsystem design (Clark, Kim, and Fujimoto, 1988). Cross-functional teams have replaced a more functional approach in which each team relinquishes project responsibility to a down-stream function (e.g. the engineering team hands-off to the manufacturing team). This paradigm requires frequent communication between functions represented on the team and co-location greatly facilitates this process. Cross-functional teams are essential for timely development, improving design quality, and lowering development costs.

Cross-functional integration that really matters occurs when individual design engineers work together with individual marketers or process engineers to solve joint problems in development. Thus, to be truly effective, cross-functional integration functions, and even more than adding new kinds of activities that support cross-functional interaction. True cross-functional integration occurs at the working level. It rests on the foundation of tight linkages in time and in communication between individuals and groups working closely related problems. How these groups work together determines the extent and effectiveness of integration in the design and development of the product (Wheelwright and Clark, 1992).

3. Degree of team commitment

Related to the above is the degree to which team members are committed, or dedicated, to the project. Since project team members' time commitments are typically spread across a number of projects at any one time because departmental managers are vying for team members' time, team members are often on and off development projects. This creates a discontinuity and increases development time. It is in this stage that it is

crucial to have a team with dedicated team members. A dedicated, accountable team leader- that is, not doing too many other projects or other assignments at the same time, and held accountable for the result.

4. Concurrency of activities

Parallel processing involves activities that are undertaken concurrently (rather than sequentially), thus more activities are undertaken in an elapsed period of time. The purpose is to achieve product designs that reflect customer wants as well as manufacturing capabilities and to do so in the shortest possible time. However, due to the need for prerequisite information, not all activities or phases in the NPD process can be overlapped with minimal risk. Therefore, the degree of parallelism must be measured to ensure minimal downstream risk.

The new product process must make use of a cross-functional team to undertake its parallel activity. In parallel processing, the NPD process is far more intense than the sequential approach and more work gets done in shorter time period. There is less chance of an activity or task being overlooked or handled poorly because of lack of time; the activities are done in parallel, not in series, and hence the total elapsed project time is reduced. The entire new product process becomes cross-functional and multidisciplinary; the whole team is on the field together, participating actively in each activity and in decision-making. This results in fast development of new products typically with better quality of design.

5. Degree of design effort on real customer priorities

The degree of design effort on real customer needs is a qualitative in-process metric which ensures as much as possible that the final design meets customer

requirements. This requires seeking customer input and feedback throughout the entire development stage and thus the customer becomes an integral part of the design team to overcome technical problems that arise and that necessitate product design changes during the development stage. Customer needs and wants assessment must be a vital and ongoing activity throughout development, both to ensure that the product is designed right and also to speed development toward a correctly defined target.

6.7.3 Tools and Technique to Measure Development Time and Increase Speed and to Assess Customer Needs

The literature review has shown that there exist a number of tools and techniques to reduce development times that are consistent with sound management practice.

1. Dynamic Time to Market (TTM)

Dynamic Time to Market is a tool which can be useful in predicting the end date of the said project as well as in tracking the progress of a project. It works in the following way: when a schedule prediction is made, the prediction date is plotted against the date the prediction was made. As more and more points are plotted, the graph (Figure 6.6) can be extrapolated to estimate a prediction date. Based on simple regression analysis, this forecasting tool takes into account the error in extrapolation.

It is explained by an example in which project A is clearly on track. Regardless of the date of prediction, the predicted date remains the. A project that is on schedule will always proceed directly horizontally towards the diagonal line. The off-track project shown by project B is slipping and will start trending upward and asymptotic to the diagonal line. The more the project is off-track, the more vertical the slope of the line becomes. If a project has a serious short term slip, the line will go vertical indicating an

infinite completion date. In the rare event that a project is ahead of schedule, the trend line will move downward and to the right.

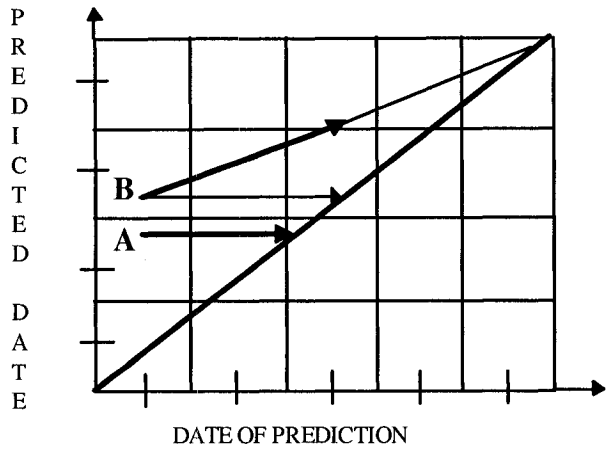


Figure 6.6: Dynamic Time to Market: Tool for prediction of end date and for tracking the progress of Project.

The "second opinion" of development time is calculated by extrapolating the actual project line to intersect the diagonal line. At the intersection, a perpendicular is dropped to the "predicted date" axis. This date will provide a sound second opinion. By dynamic time to market the team members will get an early warning of potential late delivery and appropriate action can usually be taken by the team to maintain schedule integrity. Thus projects are kept on schedule to achieve timely product development.

2. Team Cohesiveness

The degree of team cohesiveness gauges the growth of the team as a working group and it is a function of length of time that a team has worked together in a past or present project (Balkrishnan, 1998). It is the extent to which team members are attracted to the team and motivated to remain in it. The measure of cohesiveness is given by:

$$C = \sum_{i=0}^{s} w_i \bullet t_i$$

Where,

s - no of subgroups,

w - proportion of subgroup i with respect to the total no of members

t - length of time subgroup i have worked together. Note that one person can be a member of more than one subgroup and one member can also form a subgroup.

It is a weighted average of the time the members of a cross-functional team have worked together. There is possibility that subgroup members of cross functional teams have worked together before, and therefore, be more cohesive than other sub-groups within the cross functional team. The higher the value of C, the higher is the cohesiveness.

Outcome of higher cohesiveness is that the team members share more information, strong interpersonal bonds and more effective resolution of conflicts. However, one drawback of this metric suggested by Balakrishnan (1998) is that, even if the value is high, problems and difference of opinions among members can have a negative impact on the team's performance.

Product development involves requires organizing the assets and resources of a company into integrated product development teams with complete responsibility for designing, producing and delivering valuable products to customer, i.e., it is a cross-functional team effort. Teams enable greater decision-making capabilities, speed, and provide more creative solutions. In addition, numerous motivational aspects are associated with project teams.

3. Parallel Processing

Overlapping means doing various activities in parallel rather than doing them sequentially. By overlapping activities, the cycle time, i.e. the total time taken to complete the product development from concept until the product reaches market, can be greatly reduced. Overlapping activities saves time due to 1) parallel processing of activities, 2) better and more timely identification of design problems, and 3) improved communication earlier and throughout the team.

This metric serves as an indicator of the degree of concurrency in the process. In general, the higher the number of overlapped activities, the higher the degree of concurrency and the shorter is the development time. A lower number of overlapped activities indicates a lower degree of concurrency in the process and may also indicate opportunities for improving the process to achieve objectives.

Krishnan *et al.* (1997) developed a deterministic model based on properties of the design process that help to determine when and how two development activities should be overlapped (Figure 6.7). These properties are defined as 'upstream information evolution' and 'downstream iteration sensitivity'. The former is the rate at which upstream information converges to a final solution, and the information is modeled as an interval that gets refined over time. Sensitivity describes how vulnerable the downstream activity is to any changes in the upstream information, and is defined by the time needed by the downstream activity to incorporate the changes, which represents rework. Different patterns of information exchange between two activities, represented by the arrows in the diagram, are studied.

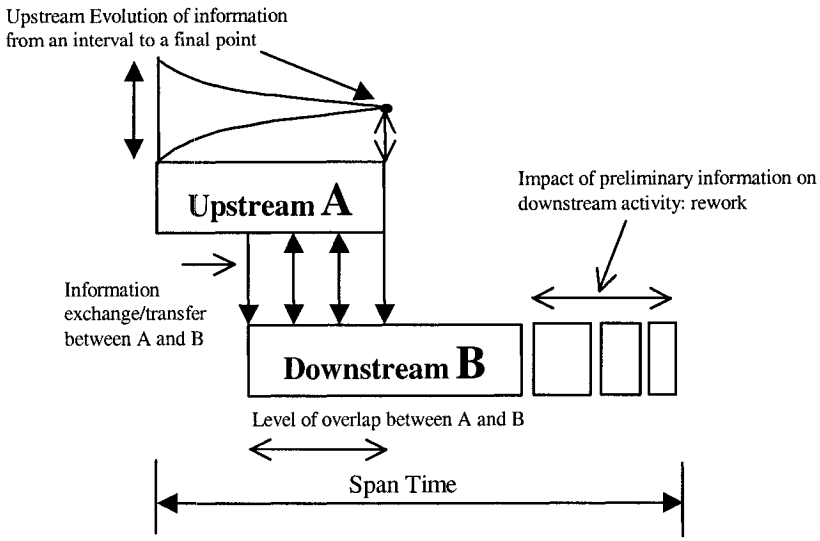


Figure 6.7: Krishnan et al's Model (1997).

Various overlapping policies between the upstream (A) and downstream (B) activities are examined based on varying the values of these two properties, and an integer program is developed to minimize span time. In practice, evolution and sensitivity are not always easy to define quantitatively. The authors have therefore developed a conceptual framework to address the problem of overlapping, where qualitative inputs provide insights on how to overlap activities. This framework consists of a two-by-two grid which considers four combinations of evolution (slow or fast) coupled with sensitivity (low or high). Using these parameters, they can prescribe qualitatively, what types of interdependent activity pairs can benefit most from overlap.

4. Quality Function Deployment (QFD)

Quality Function Deployment is proposed as an effective tool for obtaining customer feedback during the development stage. It is a systematic process that ties what the market requires to how it will be accomplished in the NPD effort. Its use is therefore most valuable during the portion of the NPD activity in which a multifunctional team

agrees on the specification and makes their production process implementation choices, and it is an important mechanism to promote multifunctional teamwork. It captures the voice of the customer and deploys it throughout the NPD activity. Its full use involves many matrices and a vast amount of detail and it is common to use the "House of Quality" (Griffin, 1992), which is built up from six interrelated matrices (Figure 6.7). These matrices relate the customer needs with design attributes, which in turn are linked with process operations (Figure 6.7). The last phase connects process operations to production requirements to complete the cycle. The following are the components of the House of Quality:

- *Customer Attributes:* Describe what the product must do; a structured list of needs and wants, determined by market research; represent the Voice of the Customer.

- *Engineering Characteristics:* Describe how the product may achieve its required performance in general terms which are not solution specific. Represent the Voice of the Designer.

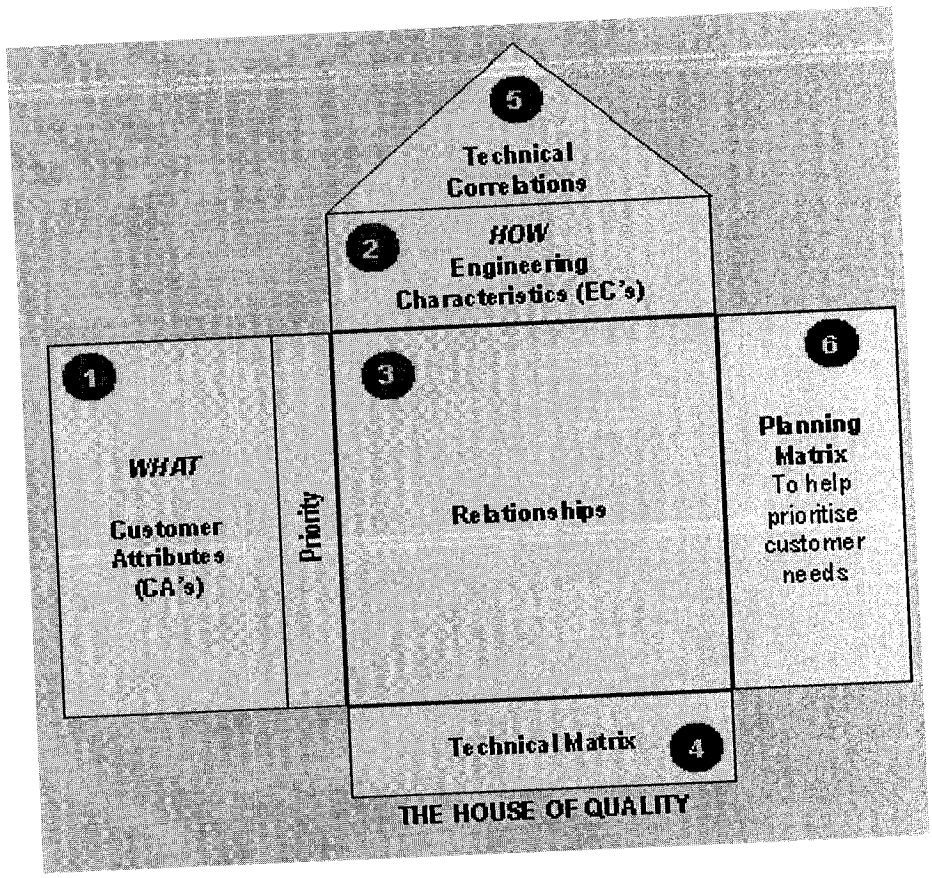


Figure 6.7 House of Quality (Griffin, 1992).

- *Relationships Matrix:* Considers the relation between the customer attributes and the engineering characteristics, indicating where there are strong, moderate or weak relationships.

- *Technical Matrix:* Indicate the technical priorities based on the relationships between customer requirements and engineering characteristics. Also provide quantitative design targets for each of the engineering characteristics, based on the technical priorities and competitive benchmarking.

- *Technical Correlations:* Record whether or not the engineering characteristics are mutually supporting or contradictory.

- *Planning Matrix:* Provide quantitative market data for each of the customer attributes. Values can be based on user research, competitive analysis or team assessment.

QFD is typically viewed as a four-stage process to design products that truly meet customer needs, a proposed metric within the framework for development (Figure 6.8).

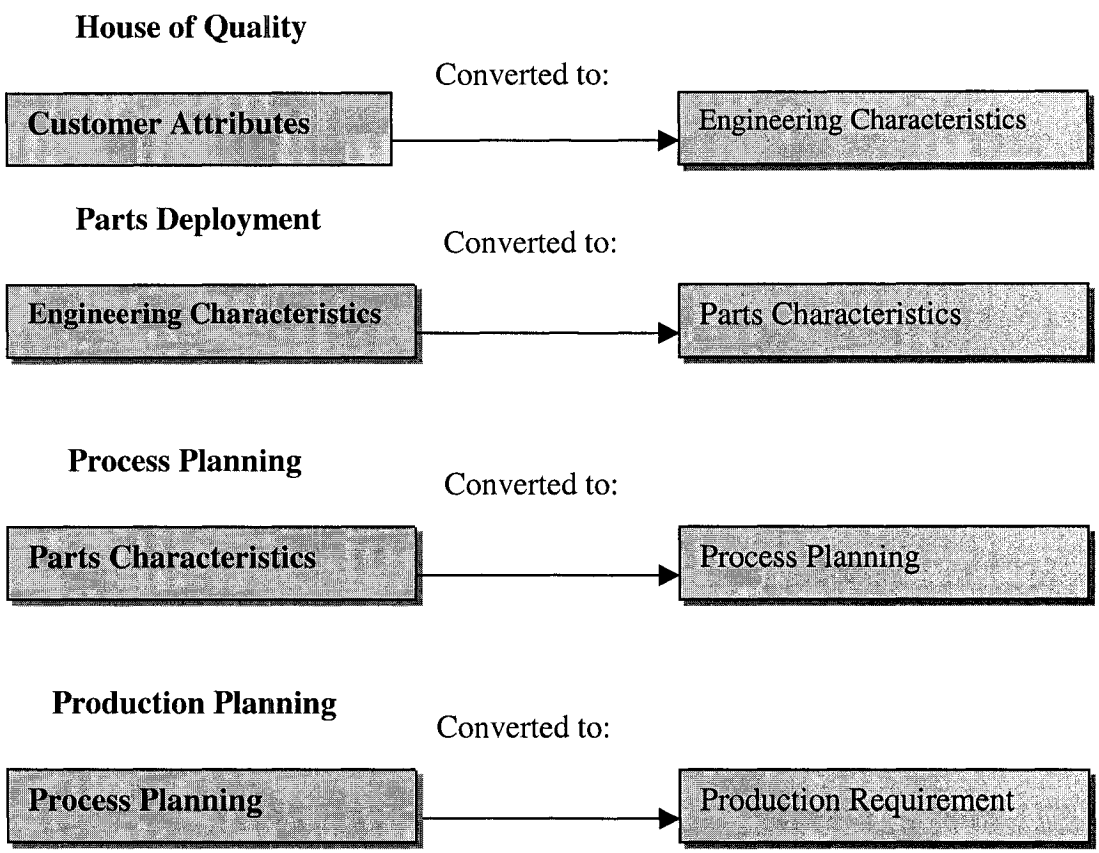


Figure 6.8: Later Stages of QFD (Hauser, Clausing, 1988)

The first house of QFD links customer needs to design attributes, and thus arrives at a technically feasible design concept or product definition. The second house of QFD links the design attributes from the first house to solutions. Design attributes are placed on the left side of the house, and solutions are placed at the top of the house. When this second house is linked to the HOQ, these solutions are based on customer needs. This

second house is thus a useful tool at the development stage. The third house links design solutions from the second house to process operations (marketing, R&D, manufacturing, and delivery are coordinated) and at the end process operation are linked to product requirement to complete the cycle.

QFD thus provides a tool to enhance communication between, and structure decision-making across, marketing and R&D since it provides a translation mechanism from customer needs to the language of the engineer. It overcomes many of the communication barriers and this enhanced communication leads to reduced cycle time. The QFD is therefore an effective tool for measuring the customer input during the development stage, and also helps to speed up development time.

6.8 Testing

The purpose of this stage is to provide final and total validation of the entire project: the commercial viability of the product, its production, and its marketing (Cooper, 1987). Design and testing go hand in hand, with testing being conducted throughout the development stage. Information obtained during testing is used in developing the product. This phase is extremely important in that it may dramatically decrease the chances of failure in launch, since it has the capacity of revealing flaws that could cause market failure (Urban and Hauser, 1993). Studies by Cooper (1998, 1999) show that a test phase that is customer oriented is the critical factor - whether it is done and how well it is executed - is significantly correlated with the new product success. Different types of testing, i.e. concept testing, prototype/development testing, and test marketing, should be conducted in this stage (Cooper, 1993, 1998, 2001). It should be

noted, however, that testing should not be solely restricted to this stage; it must be conducted throughout the NPD process.

Table 6.6: CSF and Metrics for Testing Stage

Stage	Critical Success Factor	Metrics	Tools and Techniques
Testing	▪ Product Functionality ▪ Customer Acceptance	• Product Performance • Customer-Perceived Value	▪ Validation Testing ▪ User and Field Testing

6.8.1 Critical Success Factor for Testing Stage

Product Functionality

Problem is that final product may not have the same functionality which was described earlier in the NPD stages as technical problem may have been encountered during development that forced a relaxing of certain performance requirements or an omission of features desired by customers. Therefore checking for product functionality is critical for testing stage so as to insure that the design meets customer's expectations or not. The aim here is to see whether the technical or procurement personnel have produced a product with the attributes which they had shown during concept testing.

Product functionality is critical for the testing stage as the aim here is to see whether a product with the attributes called for has been produced. The physical features, perceptual features, functional modes, and perceived benefits must be examined at this

stage. It must be proven that claimed attributes exist and the causes for missing attributes must be found.

Customer Acceptance

Customer acceptance is critical for this stage to gauge whether the product is acceptable to the customer, to measure the customer's level of interest, liking, preferences, and intent to purchase, and to determine those benefits, attributes, and features of the product to which the customer responds.

Not only must the product work right in the lab or development department, but, more importantly, it must also work right when the customer uses it. The product must excite and, indeed, delight the customer; who must find it not only acceptable but actually like it better than what he or she is currently buying. In short, the customer reaction must be sufficiently positive so as to establish purchase intent.

6.8.2 Metrics for Testing Stage

Product Performance / Performance Indicators

The performance of a product is how well the product achieves the functionality desired. Product performance is usually measured in such ways as testing physical features, perceptual features, functional modes, and perceived benefits.

Features are those aspects of an offering that create the benefits; they are typically a focal point of NPD. Perceived benefits are the best point in the needs continuum on which to focus conversations with customers because they represent customer-oriented perceptions but are still close enough to supplier-oriented features to permit that linkage to be made by the product developer.

Validation and User testing techniques are used to gather data on product performance. These primary research techniques generate quantitative results. At this stage in the NPD process, these are the types of research results necessary to make final critical decisions and reduce the risk of possible failed launches.

Customer-Perceived Value

Customer-perceived value is measured to determine whether the customer is willing to purchase the tested product or not and to gauge whether the product is acceptable to the customer. Important metrics for this stage are: perceived relative performance, customer satisfaction (Like/Dislike), and the preference score to determine the nature of the competitive situation. These are qualitative metrics, but are very important nonetheless to record the basic likes/dislikes of the customer early before the product gets launched into the market. Based on the qualitative data, managers can take action to make changes in the product.

6.8.3 Tools and Technique for Testing Stage

Validation Testing

Validation testing is of a product model that closely resembles the final product that will be manufactured and sold, and is often called system testing and usually takes place in-house. The purpose of the testing process is to ensure that all product performance requirements and design specifications have been met. The validation test is normally conducted late in the development process to ensure that all of the product design goals have been met. This includes usability, performance, and robustness. Validation tests normally aim to evaluate actual functionality and performance, as is expected in the production version and so activities should be performed in full.

It is probable that the validation test is the first opportunity to evaluate all of the component elements of the product together, although elements may have been tested individually already. Thus, the product should be as near to representing the final item as possible, including packaging, documentation and production processes. Also included within validation tests will be any formal evaluation required for certification, safety or legislative purposes. It may be preferable for evaluation to be carried out independently from the design team, but with team input on developing standards and measurement criteria.

Data from a validation test is likely to be quantitative, based on measurement of performance. Normally, this is carried out against some benchmark of expected performance or criteria set before. Usability issues may be scored in terms of speed, accuracy or rate of use, but should always be quantified. Issues such as desirability may be measured in terms of preference or user ranking. Data should also be formally recorded, with any failures to comply with expected performance logged and appropriate corrective action determined.

User and Field Testing

This testing is performed by real users or customers, and in some cases, this testing must precede product shipment. This is not to be confused with marketing customer testing, where certain strategies regarding sale and marketing of the product are explored. The purpose of testing is to understand how the product performs in the end-user environment.

Customer based testing is indeed complex, and there is no way it can be simulated in laboratories, where use is isolated from users' mistakes, competitive trashing of the

concept, and objections by those in the user firm or family whose work or life is disrupted by the change. Products that are entirely new to the market should receive beta testing because there is no base of data on which to judge customer acceptance.

Test protocols are produced by the company and can range from rigorous to nonexistent. In the first case, the developer closely monitors and follows up the beta test with in-house staff or contracted staff from a specialty testing company. In the second case the developer may simply contact the customer by phone or has an group or individual contact to ask for opinions on the product.

The test result attempts to confirm that the user feels the same toward the prototype as toward the verbal concept discussed earlier in the NPD stage. The results of the testing either confirm that the product meets its requirement or show the areas where the product is deficient.

6.9 Summary

The CSF's, metrics, tools and techniques proposed for successful NPD are all brought together in a framework proposed in Table 6.7. This framework proposes what should drive positive new product performance.

This thesis proposes that to achieve success, NPD firms should have a clear and well communicated new product strategy. These firms should have well defined new product arenas along with long term trust, with clear goals. Successful businesses and teams of NPD have a dedication towards the voice of the customer. It is critical that firm should gather as many ideas as possible and a large number of these should come from customers so that the firm can be in a position to design and develop winning new

products. Up-front homework prior to the initiation of product design and development is found to be a key factor in a firm's success. The quality of execution of the predevelopment steps - initial screening, preliminary market and technical studies and business analysis - is closely tied to the products financial performance. Firms should try to shorten the development time so as to minimize the chances that the development and customer needs have changed when the product comes into the market. It is important to verify and validate product performance requirements and design specifications along with customer's acceptance before launching the product into the market via validation and user field testing.

Table 6.7: Critical Success Factors and Metrics for Stages of NPD Process

Stage	Critical Success Factor	Metrics	Tools and Technique
New Product Strategy	• Clear Strategy • Well Communicated Strategy	• Return on Investment (ROI) • Degree of Communication	▪ Financial Analysis • Balanced-Scorecard as a Communication Tool
Idea Generation	• Customer Focused Idea Generation	• Number of Customer Focused Ideas Generated	• Lead User Methodology • Ethnographic Approach
Build Business Case	• Up-Front Homework	• Expected Commercial Value (ECV) • Net Present Value (NPV) • Internal Rate of Return (IRR) • Productivity Index (PI)	• Financial Method of evaluation
Development	• Speed • Customer feedback	• Development time • Degree of functional integration • Degree of team commitment • Concurrency of activities • Degree of design effort on real customer priorities	• Dynamic Time to Market • Team Cohesiveness • Degree of Parallelism • Quality Function Deployment
Testing	▪ Product Functionality ▪ Customer Acceptance	• Product Performance ▪ Customer-Perceived Value	▪ Validation Testing ▪ User and Field Testing

7 DISCUSSION AND CONCLUSIONS

New product success is a challenging task for companies. Many companies are aware of the major role new products must play in their future and quest for prosperity, and as such, are constantly searching for ways to revitalize, restructure, and redesign their NPD practices and processes for better results.

This thesis explored and analyzed the new product process and attempted to identify ways in which firms can improve their performance when developing new products, mainly through the study of factors that are critical to success. These factors were identified through an extensive study of the practices and performance of successful firms presented in the NPD literature. The CSF's which have been described in the literature are generally defined for the overall development process, rather than specifically addressing each stage. To overcome this problem, the underlying purpose of the study was to systematically identify CSF's that impact the new product development performance for each stage in the NPD process.

Each stage of the NPD process, critical success factors, metrics used to measure the CSF's, and tools and techniques to define metrics, are explained in detail in this thesis. A practical framework was then developed, bringing together each of the latter, outlining the CSF's for each stage, defining appropriate metrics used to evaluate these CSF's, and specifying the tools and techniques that can be used to determine the metrics, to enable effective management of the NPD process.

The literature review revealed that what is prescribed and what most firms do in practice are miles apart when it comes to the new product process. An extensive literature review revealed that many studies were performed on CSF's, on metrics, and on

tools and technique used for improvement. Presumably, no other study to date has developed a framework as presented in this thesis, which can be crucial for NPD success. The unique approach presented in this thesis, if followed with proper implementation of the NPD model, will guarantee NPD success.

This study has shown that there are a number of factors that are critical to NPD success. To begin with, a formal, high-quality new product process is the strongest common denominator among the best-performing businesses. It is very important to have a systematic NPD model with discipline to ensure NPD success. The BAH model, for example, which underlies most other NPD systems that have been put forward, and the "Stage-Gate™" system, a series of NPD process models developed by Cooper (1984, 1996, 1998), which also use the BAH model as a base, are two such processes commonly used. The BAH model is a multistep new product process, where the product moves from idea to physical product, to launch stage, with the number of evaluations and testing points in between. Many organizations have adopted some variation of the basic model developed by Booz, Allen and Hamilton (1982) by incorporating parallel processing and multiple functional teams in product development process. Cooper's Stage-Gate Model shares similarities with the original BAH model in that it comprises some of its stages but it goes further by including "gates". Those firms that have made the effort to design and implement such a process have reaped the benefits faster.

It appears that firms generally follow the seven stages as identified by Booz, Allen and Hamilton (1982) and Cooper's Stage-Gate™ as a new product process. These stages are new product strategy, idea generation, screening and evaluation, business analysis, development, testing and commercialization. The discussion throughout the

thesis has been structured around these stages. The quality and nature of the process that drives performance most and the ingredients of such a quality process uncovered in our study are as follows, for each of these stages, respectively:

NPS: The important driver for NPD success is to have a clear and well communicated new product strategy for the company where goals or objectives for the entire program were specified; the role of new products in achieving company goals should be clearly communicated to all in the firm; clearly defined arenas should give direction to the firm's total new product program, and the new product program must have a longer term thrust and focus. The NPS essentially sets the strategic roles new products will play in fulfilling corporate objectives.

Idea Generation: The better the pool of ideas, the greater the probability that a commercially successful product will be produced. New product ideas generated from the customer has higher rate of success and customer involvement is necessary right from the early NPD stages to make the product successful. Lead user Methodology, Ethnographic-based voice of the customer research is needed to determine product requirements, and to determine customer value and perspective. Customer needs, wants and preferences regarding product requirements and design seeks insights into competitive product strength and weakness which help to transform a sketchy product idea into a concrete and winning new product concept.

Screening and Evaluation: Once the organization has generated a good pool of ideas for new products, the purpose of this stage is to identify those with best potential for success. There should be tough screening and evaluation criteria where projects can be prevented from entering into the next stages. Making a good selection is critical to the future health

and success of the business. The point is that product development costs rise substantially with each successive stage in the NPD process, so it is better to stop poor ideas to move into next stage by putting tough screening criteria.

Business Analysis: More, up-front homework, time and resources must be devoted to the activities that precede the design and development, i.e., the business analysis stage. Up-front homework means undertaking thorough financial analysis, market and competitive analyses, technical and operational feasibility assessments. Solid pre-development work drives up new product success rates significantly and is strongly correlated to financial performance. Financial models select projects so as to maximize the commercial worth of the projects in the pipeline in terms of business and strategic objectives. The process should include protocols (sharp, early product definition) before actual development starts, and there should be an emphasis on both market and technical assessments before projects move into development phase.

Development: Speed and customer feedback are needed to minimize the impact of an ever-changing market and/or competitive situation, especially during the development stage. The goal should be to reduce the development cycle time by organizing around a true cross functional team, parallel processing of activities, and team commitment toward the project. The customer should be made an integral part of the design team to overcome technical problems that arise and that necessitate product design changes during the development stage.

Testing: Testing makes an integral series of evaluations leading to the common goal of design improvement and meeting customer's expectation. Product functionality should be checked during the testing stage along with customer acceptance to evaluate actual

functionality and performance, as is expected in the production version and so activities should be performed in full. Validation testing and user field testing are important as to ensure that all product performance requirements and design specifications have been met and to gain customer's reaction.

Metrics play an important role in helping companies to enhance their new product development efforts. Metrics signal success, but it is essential to be sure that metrics are applied uniformly so as to allow valid comparisons to be made among developments. Metrics for each CSF have been defined so as to have current performance measures for each stage of NPD. Metrics should be easy to apply and understand, practical and widely applicable to be a useful metrics for the effectiveness of a company's NPD process. A set of good metrics is crucial to the success of a product, as metrics direct the development process by driving actions and decisions. Unlike its use in the engineering literature, the management use of the term "metric" includes both quantitative and qualitative measures which the product development team members can influence through their efforts. Tools and techniques aid in accomplishing a task to define these metrics in detail. Each tool and technique corresponding to a metric is discussed in this thesis for the evaluation of the metric to generate technical results.

Product development success factors that capture the nature of the NPD process and factors that describe the NPD project are as follows: having a unique, superior product; having a strong market orientation throughout the process; getting sharp, early product definition before development begins; having the correct organizational structure: multifunctional, empowered teams; and commitment from top management.

The consistently high failure rate among commercialized new products has prompted much research into finding causes of new product failure. The main reasons for failure are: technical problems, higher than expected costs, inadequate market analysis, the lack of a systematic new product process with discipline, and a lack of product value for the customer.

New product development is a highly risky activity, which makes it such a challenging one to manage. Managers can reduce uncertainties, and thus total risk, by moving in an incremental fashion throughout the NPD process. By phasing the NPD process, the overall level of risk can be minimized because each stage can provide information that will reduce the level of uncertainty.

Firms are not beholden to any fixed organizational structures for NPD. There are general approaches (committees, various types of teams, and spinouts), and each certainly fits some situations better than others. Effective organization of the new product function is essential. First, it provides top management with a means for controlling a vital part of the company's total effort. Second, it provides for the specific assignment of responsibility for getting an important job done. Third, it provides the vehicle through which people from many departments can work together to make the NPD program a success, i.e. through functional integration.

The probability of success of the NPD process can be raised if firms diligently pursue the CSF and define the metrics for each stage of NPD as outlined in this thesis. The payoff of such processes can be seen by the organization in the form of improved teamwork less recycling and rework, improved success rates, earlier detection of failures, a better launch, and even shorter cycle times. Furthermore, if an organization has a sound

knowledge of what the NPD process should encompass and how it should be carried out when developing and introducing new product, chances are it will experience a favorable impact on financial and non-financial performance measures such as success rate, sales impact, spending on budget, profit returns and window of opportunity.

7.1 Future Research

Although NPD processes are relatively recent phenomenon, they are seen as necessary for effective NPD. A formal NPD process or Stage-Gate process do indeed work, they reduce the errors and omissions, they reduce rework and failure rates, and they even decrease the cycle time. The focus has to be moved from defining the process to assuring successful implementation of the NPD process as different organization have different problems, to better managing the up-front portion, to better measuring the process, and to continually improving the process.

Several different research directions could provide additional useful information both to firms finding CSF's and measuring product development success, as well as to academics conducting research in this area. The first research opportunity exists in implementing or testing the proposed framework. This would be useful to do over the longer term both among the community of NPD companies and through academic research to determine the impact of this research on both practice and research.

Similarly, Chapter 3 discusses failure factors that should be avoided in practice. Future research also should aim to understand better how to effectively avoid failure factors for effective NPD program. Further extensive research could be done including both critical success and failure factors for NPD firms.

Another research direction could study measures of product development success and failure and identify all currently used measures, organize them into categories of similar measures that perform roughly the same function, and contrast the measures used by academics and companies to evaluate new product development performance.

Another issue that needs further study is whether cross-functional new product development teams, concurrency of activities and interdepartmental integration equally influence product development performance, whether one of these constructs is more influential than the other, and whether such influence is dependent on the type of department being examined.

Successful new product development is fundamentally a multidisciplinary process. While this view has helped lead management to the widespread adoption of cross-functional new product development teams, this generates another major issue for research, that is, to determine whether simply increasing the level of functional integration is truly a guarantee for enhancing the performance of new products.

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