PRODUCT DEVELOPMENT IN COMPANY ABC: STRATEGIC ANALYSIS AND RECOMMENDATIONS

by

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ABSTRACT

ABC is a mature company, operating in the power electronics market, using the stage gate process to develop products. This analysis evaluates the company's development process including innovation and portfolio management. An examination of the market reveals that speed-to-market and commitment to innovation are critical success factors. Benchmarking shows how comparable companies have adapted the traditional stage gate process to incorporate more flexible practices. Analysis of ABC uncovers the need to streamline the process and improve the commitment to innovation. Recommendations include reducing the number of gates, defining "Go/Kill" criteria unique to each project but adhering to them, implementing flexibility in resource allocation to foster innovation and building the capacity for ongoing process improvement. A draft of an implementation plan is provided.

All models are wrong
but some of them are useful.
George Box

DEDICATION

Dedicated to the many brilliant and creative people whom I have met on my way towards the MBA degree.

ACKNOWLEDGEMENTS

Many people have contributed time, energy, ideas and suggestions to this project for improving the ABC Company's product creation and decision-making processes. The strength of this analysis is largely due to the collective efforts of the people working for ABC. To all individuals involved in this analysis process, I am indebted.

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LIST OF ABBREVIATIONS AND ACRONYMS

BOM – Bill of Materials
CPI – Continuous Process Improvement
CSA – Canadian Standards Association
DFL – Design for Logistics
DFMA – Design for Manufacturability and Assembly
DFS – Design for Serviceability
DFT – Design for Testability
DFX – Design for Excellence
NPD – New Product Development
OEM – Original Equipment Manufacturer
PAC – Product Approval Committee
PMO – Program Management Office
R&D – Research and Development
RV – Recreational Vehicle

1 COMPANY BACKGROUND, AIM AND SCOPE OF THE PROJECT

This chapter introduces company "ABC" and the project. The general history of the company is described, and the stage gate development process, used to develop new products, is presented, emphasising the strategic importance of this process to the company. Then, crucial elements that shape the stage gate development process are specified. Finally, the chapter concludes with a description of the aim and scope of the project.

1.1 Company Background

1.1.1 General history of ABC

ABC operates in high-growth segments of the advanced power electronics market, with well-established products and systems sold to a diverse customer base in the distributed, mobile and programmable power markets. The company's products convert raw electrical power from any central, distributed or backup power source into the high-quality power required by electronic and electrical equipment. Headquartered in Canada, the company has facilities in the US and Europe. The company offers a wide range of products for both residential and commercial markets. Therefore, ABC competes with a variety of different companies ranging from big multinational corporations to niche players.

During the 21 years of the company's existence, its revenue grew and declined several times. Since its inception, the company has made several acquisitions, especially during the last five years. The company currently employs approximately 500

people in total. Two hundred thirty of the employees work in offices, and approximately 45% of these (excluding manufacturing personnel) are engineers. ABC started as a component supplier and changed its strategy to become a solution provider, a "one-stop" shop for power electronics and systems. The company experienced significant growth before the year 2000, when the demand for energy backup and energy supply equipment was very high.

1.1.2 Current state of the company

The year 2003 was a year of recovery and growth. In this year, the new CEO developed a vision for a Program Management Office (PMO), whose purpose would be to manage the stage gate development process. Alarge number of the senior team members have been at ABC for less than one year.

The ABC company's growth is fuelled by an increasing demand for advanced power electronic products, which is driven by:

- Society's dependence on electronic devices
- Concern over the supply of high-quality, reliable power
- A need for independence from traditional power sources
- Increasing interest in renewable energy and distributed power.

In 2004, ABC became a publicly traded company. The new capital raised was dedicated to supporting the company's growth strategy.

1.1.3 Introduction to the new product development process

ABC applies a value-added, stage gate development process to develop and commercialize new products. This is a cross-functional process with a mandate to

create, deliver and support new products. The purpose for having a common development process across the corporation is twofold:

1. To ensure that the life cycle management of products is consistent across the corporation and uses "best-in-class" processes.
2. To provide a common process language across the organization and a mechanism for continuously sharing and improving best practices.

The process of delivering new products is complex and requires coordination and participation among many functions. At ABC, a form of stage gate product development control adopts the principles of concurrent engineering and depends upon an effective matrix, a multi-functional Program Team. The process that defines the activities of this Program Team is broken down into four sequential stages, which are further broken down into eleven sequential phases. Stage gate control is achieved through interaction between the Program Team and a review body identified as the Product Approval Committee (PAC). Each process phase is concluded when a process milestone is judged to have been completed.

The stage gate development process was formally introduced in 1999. Employees who came from various organizations (e.g., XYZ, acquired in 1999) brought some knowledge of more formal processes. In 2003 the strategic importance of the development process was underlined by the new CEO when he introduced his idea of establishing a Program Management Office (PMO). Then, the PMO was established, with a senior management position reporting directly to the CEO. Moreover, the company has undergone significant change in terms of the organization's size and the range of products produced. These changes have motivated management to review the current stage gate development process.

1.2 The Aim of the Project

In 1999 the stage gate development process was developed and formally introduced. Since then, the company's revenue has increased 3.5 times through the introduction of new products developed internally or added through the acquisition of other companies. The company's growth strategy is dependent upon an efficient product development process. Therefore, the current product development process is being reviewed with the following goals:

1. To identify problems, challenges and opportunities to improve the current process. The stage gate development process must reflect the current mature stage of the company, including the key role of the new PMO.
2. To assess the ability of the process to develop sufficient new products to meet the corporate growth strategy targets in the context of the dynamic and fast-moving environment in which company ABC operates.
3. To develop focused recommendations based on mutual agreement with key stakeholders. Since product development is based on collaborative work of cross-functional teams, the recommendations must involve all departments.

1.3 Scope

In order to deliver focused recommendations regarding the stage gate development process, the current process must be analysed from various perspectives. As a management tool to control product development, the process has to be viewed from the top-bottom perspective. For instance, the process is closely linked with other management processes, such as strategy and portfolio management (see paragraph 2.6). On the other hand, the development process serves as a coordination tool to help Program Managers develop new products with the assurance of delivering all required

components (e.g., a quality plan and a service plan). Therefore, the process has to be analysed from the bottom-up perspective as well.

The stage gate process has been adapted by several companies to better suit the competitive, high tech environment in which these companies operate. In some instances, best practices involve innovation management in addition to the stage gate process. Therefore, in developing its recommendations, this project benchmarks the current ABC process against processes in a number of other high-performing companies.

Since the new product development process is not isolated from other management processes, the analysis and recommendations must also include portfolio management. In addition, development, as a process of creation, interfaces with innovation. Thus, the impact of the development process on innovation is described, and the company's innovative culture and values are analysed as well.

However, this analysis is first and foremost focused on the stage gate development process and does not involve an analysis of the whole company. Project recommendations must be linked with ABC's strategies, goals and business plan. Nevertheless, the analysis of these elements is not a part of the project. The analysis was conducted within the context of an already established aggressive growth strategy.

The analysis was performed respecting the ABC's need for confidentiality. Therefore, it is based mainly on publicly available information, e.g., the ABC Final Prospectus published in 2004.

2 EXTERNAL ANALYSIS

The company's internal processes, including the new product development process, need to be aligned to the company's growth strategy as a reflection of the external environment. In this chapter, the external environment is analysed to determine what type of development process is needed. This chapter describes the characteristics of the external environment and how they influence the company's development process.

First, this chapter introduces the market and ABC's customers. Since resources are limited, the company focuses on precisely defined segments of the market to serve certain customers. The segments are divided into sub-segments, each of them with unique characteristics and unique customer requirements. Second, a short description of the company's competitors is provided, with the aim of analysing their capabilities to develop new products. Third, this chapter includes a general market / environment analysis focusing on social, technological and legislative trends. The company's development process is based on various technological and legislative factors coupled with social patterns. Next, the level of intensity among competitors and other market players is analysed using Porter's Five-Forces Model. This analysis will clarify the nature of the competition and the forces shaping the industry. This chapter also examines how other high-performing companies, working in similarly dynamic markets, have adapted the stage gate process and incorporated innovation management into this process. Finally, the chapter concludes by identifying factors which seem to be critical in achieving sustainable competitive advantage in the advanced power electronics market.

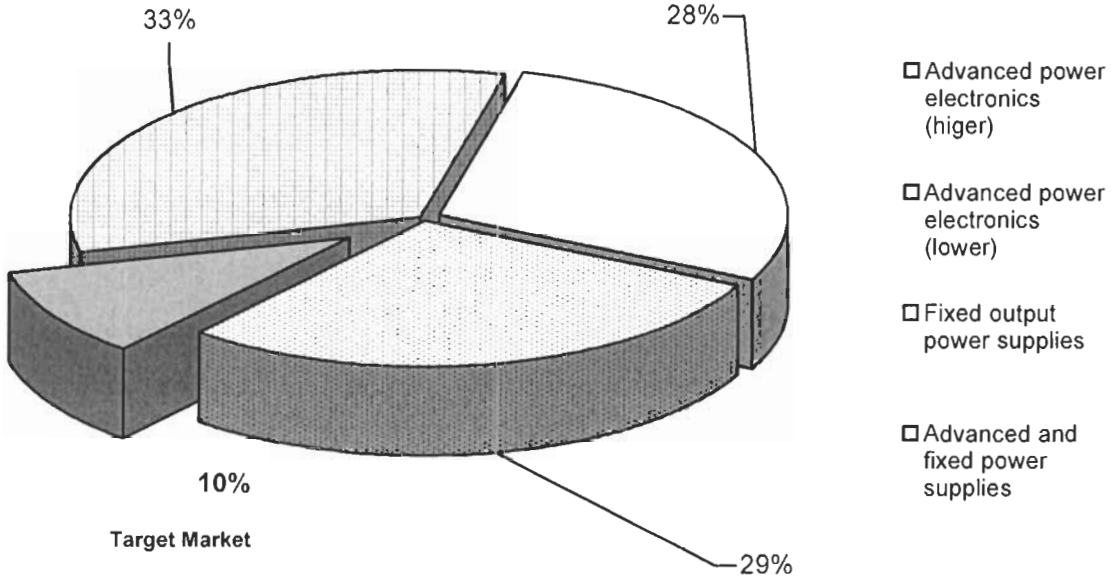
2.1 Market

Based on research by Micro-Tech Consultants, Darnell Group and Venture Development Corporation (ABC, 2004), it is estimated that sales in the worldwide power electronics market were approximately $30 billion in 2003. ABC estimates that market will grow at an annual rate of 6.3% from 2003 to 2008. The total power electronics market can be divided into four segments (see Figure 1)[1]:

1. A lower growth (4.8%) with mid to lower margin market (ABC, 2004), served by large manufacturers which integrate advanced and fixed power supplies into their own products and systems. This segment generated sales of $8.7 billion in 2003.
2. A lower growth (5.1%) with lower margin market (ABC, 2004), served by independent third party manufacturers of fixed output power supplies. This segment generated sales of $8.5 billion in 2003.
3. A lower growth (5.7%) with mid margin market (ABC, 2004), served by manufacturers of advanced power electronics products and system solutions which are designed to operate with several power sources and variable loads and which are capable of managing power using software components. Products include uninterruptible power supplies, electric motor drives and telecom power. Sales in this market segment in 2003 amounted to $9.8 billion.
4. A higher growth (16.0%) with higher margin market (ABC, 2004), served by manufacturers of advanced power electronics products and system solutions which are designed to operate with several power sources and variable loads and which are capable of managing power using software components. This is the target market and includes distributed, mobile and programmable power. Total sales in this market segment in 2003 amounted to $3 billion.

[1] For the complete market description, see "Final Prospectus", ABC, March 12, 2004: p. 18-22.

Figure 1 Global 2003 power electronics market segments in billion US $. Data source: the "Final Prospectus" - ABC, 2004.



Moreover, the target market in which company ABC operates can be further divided into sub-segments, defined by the types of products that companies offer:

1. Distributed power

    a. Solar power generation systems for residential and industrial use. The company reaches this market through distributors specializing in solar products and through system integrators.

    b. Wind power systems providing renewable energy to mid-size and big companies or institutional customers.

    c. Backup power systems for residential and commercial use, providing auxiliary power sources in the event of power outages or to improve power quality and reliability. The company accesses this market through backup power distributors and integrators.

d. Emerging technologies converting power from emerging power generation and storage technologies for residential or commercial use. Product commercialisation in this sub-segment is uncertain and does not generate significant revenue.

2. Mobile power

   a. Auxiliary on-board power systems provide an easy-to-use and easy-to-transport source of power in vehicles and boats. This market is accessed by cooperating with automobile (e.g., Recreational Vehicle) and marine manufacturers (OEMs) and with aftermarket retailers.

   b. The portable power market represents consumers seeking portable products and an easy-to-use source of power to run electronic / electrical equipment outside the home. The company accesses this market through close cooperation with leading retailers.

3. Programmable power

   This market consists of industrial customers seeking precision equipment power sources as components of their own products.

The market share of ABC in 2003 was 4.53%. This figure is based on ABC's $136 million revenue and the $3.0 billion market size estimation. To sustain its existing market share or to increase it, as projected in its growth strategy, ABC needs to introduce more products in shorter development cycles.

Many markets the company operates in are seasonal. This is due to increased demand for mobile and backup power during the summer and due to seasonality in performing installations. Therefore, the aim of the stage gate development process is to deliver products on time, when the market needs them or customers plan to install them.

Thus, planning and developing new products has to be performed according to that demand pattern; otherwise, the market window will be missed.

2.2 Customers

ABC has two primary categories of customers: residential (retail) customers and commercial or industrial customers. The company's marketing operations are organized around produced products in the three distinct sub-segments (see paragraph 2.1). The two customer groups mentioned above have unique needs regardless of the way that those needs are met. Thus, the following describes the two primary market segments[2]:

- Retail customers – individual customers who purchase products directly from retail chains:
    a. There are many new entrants, i.e., newly established stores and stores which have diversified into new markets.
    b. New products are aggressively developed by shortening development cycles.
    c. Retail customers are less price sensitive than other customers.
- Commercial / industrial customers:
    a. Original Equipment Manufacturers developing consumer products which contain products developed by ABC.
        i. OEMs are more price sensitive than aftermarket customers.
        ii. Since ABC's products influence the quality of the OEMs' products, reliability is of primary concern.

[2] Although the company meets various customers' needs, the present analysis is not intended to be a thorough examination of ABC's marketing, and only some customers' characteristics are relevant enough to be presented here.

iii. There is pressure to customize products yet keep a mass production price at the same time.

b. Large and credible companies, which use ABC's products as a source of power for their design, development and testing of electronic equipment or as power supplies for the built-in power systems of their precision electronic equipment.

Although ABC targets a very specific market (see paragraph 2.1), the above description indicates that the company has diversified and serves customers with various needs. Nevertheless, all customers value the same factors:

- time to market,
- product reliability and
- price sensitivity.

Thus, the company's product development process has to support building reliable products in a short time. Even though some customers are not price sensitive at the present time, strong competition will force the company to decrease the price of newly developed products.

Moreover, in future years, the company plans to introduce new products for new market segments, thus meeting the needs of new customers (ABC, 2004). For instance ABC expresses an interest in the fuel cell market by participating in the Fuel Cell Working Group organized by the Canadian government (Fuel Cells Canada, 2003). Therefore, ABC will develop new products using its current resources—which will require more coordination and planning during the development process—or ABC will acquire a company which has fuel cell capabilities.

2.3 Competitors

ABC provides diversified products to various markets and faces strong competition in all markets. Competitors range from multinational corporations to small market players. Thus, the competitors' ability to compete and introduce new products varies.

The company's competition can be divided into two distinct groups (ABC, 2004):

- Large corporations, which are well diversified and which have many R&D facilities throughout the world, experienced staff and robust but bureaucratic processes. They are able to fund long-term research and development and to withstand a price war. However, their bureaucracy and the fact that their operations are spread out all over the world increases the time they require to commercialize new products.
- Small companies and many new companies which disrupt the existing order by introducing new, innovative products and decreasing the time to market. However, these disruptors have limited ability to develop advanced products, which requires a long-term R&D process.

However, none of the present competitors competes with ABC in all markets in which the company operates (ABC, 2004):

In recent years, the market has become global, and thus the number of competitors is growing year by year. Moreover, other external environment factors - e.g., increasing dependence on power supplies (see paragraph 2.4.2 for more details) - encourage new entrants to compete. This, in turn, forces incumbents to diversify into new markets. Consequently the industry has become highly fragmented. On the other hand, many industry players have decided to cooperate and to form common entities.

Thus, many mergers and acquisitions have occurred in recent years. ABC is a part of that process, having acquired several companies during the last five years. As a result, competitors are moving into offering integrated system packages (ABC, 2004) and becoming one-stop shops for power solutions. Increasing competition makes product development cycles shorter. Furthermore, to sustain sufficient product development capability, the industry will face additional consolidation.

2.4 General Environment

The company's target market, i.e., advanced power electronics, is a sizeable market which is expected to continue to experience significant growth. This growth, however, will be shaped by various external factors—evolving technology, market / social trends and regulations. Careful examination of these environmental influences will increase understanding of the industry and identify critical factors for competitive advantage.

2.4.1 Technology

Since ABC is a high tech company, careful analysis of technology trends is required. However, not all technology trends are important in this strategic analysis. The following technology trends have been identified as worth citing:

- **Development of some advanced power electronics is a long process**. An example is the wind turbine development cycle, which takes five to seven years. Thus, product development is not only costly but very risky as well. New inventions which occur during the development, coupled with staff turnover and changing customers' needs, make this process even more difficult to coordinate. On the other hand, availability of the new inventions may decrease projected costs and reduce expected finished product price.

This even more underlines the importance of proper risk assessment at the beginning of the development process and risk monitoring later on.

- Since **development** is expensive and long-term (as indicated above), it **has to rely on external funding sources**, e.g., government grants, debt securities. Many mid and small-size companies cannot afford to freeze substantial resources over several years in very risky development. However, in order to compete with big corporations, these companies have to develop new advanced technology products, so they have to find external funding. Obtaining these funds usually depends on offering precise business plans, which include proper planning and estimation of development time. A properly framed development process helps to estimate the delivery time and the costs associated with it.

- Nowadays, **engineers must recognize the growing importance of the software component of electronic equipment**. Software is used to manage settings embodied in equipment, to monitor equipment and to establish communication between various devices. Software development usually allows for many trial and error iterations without a significant increase in development costs and time. On the other hand, building a hardware prototype may require significant resources and time, and thus the number of iterations should be limited to the required minimum. In order to deliver products with both hardware and software components, two different product development approaches have to be merged into one cohesive process which defines all necessary steps.

- **Technology evolves, and new disrupting technologies emerge, making products' life cycles shorter**. Products, if not replaced, become

technologically obsolete. Consumer electronic products especially become sensitive to new trends in technology. Continuous technology development has also triggered a demand boom in the form of replacements and upgrades. Therefore, new products have to be continuously introduced in a timely manner. Otherwise, operating results will suffer. Thus, the product development framework has to allow fast commercialization of consumer products in particular.

All of the above technology trends increase the risk of failure. The product development process has to be robust enough to allow precise planning and force proper action, e.g., risk assessment. However, in order to commercialize new products quickly, flexibility has to be maintained at the same time. Moreover, a proper product development process has to be flexible enough to allow adding new elements such as software. Balance between rigour in conceiving the process and elasticity in applying it, is crucial.

2.4.2 Trends

The environment in which ABC operates has evolved during the last few years. Market trends especially influence demand. The analysis below indicates crucial forces that may affect the company's ability to meet demand. Although, the overall demand is shaped by the combined effect of all forces, the careful examination of each of them is necessary.

2.4.2.1 Social trends

The environmental awareness of our society increases demand for distributed, "green" power, e.g., wind power, solar power, microturbines and fuel cells. As consumers continue to search for alternate power solutions, the likelihood that they will

turn to a DC storage solution is very high, as batteries still remain the most popular power solution (Frost & Sullivan, Jul 2004). Government incentives to invest in or buy green energy may boost demand, making investment in these power sources a more cost-effective alternative to traditional grid-connected sources. With the increasing support from governing bodies and environmental lobbies, renewable energy sources are expected to grow very rapidly, allowing for strong market growth.

Mobility has become a visible trend. Therefore, the need for portable power sources is predicted to grow. Electronic device proliferation and society's increasing dependence on energy will provide an enormous boost to company ABC's markets (Frost & Sullivan, Sep 2004). Power availability and reliability become critical in the current electronics-dependent environment. Rising requirements for power in a growing world economy necessitate more reliable and portable power supplies.

2.4.2.2 Market and industry trends

The global market is sensitive to currency fluctuations, making the cost of components and the value of products difficult to predict. Hence, various and conflicting information may flow in during the development process, increasing uncertainty about a final product cost structure. This, in turn, emphasises the importance of a proper risk assessment, which has to be a step during the development process.

Power shortages, which have occurred during the last few years, provide additional demand for reliable or backup power. For example, the California power crisis in 2001 led to a 150% growth in the backup power market from 2001 to 2002 (Frost & Sullivan, Sep 2004).

Mergers and acquisitions have become a popular way for companies to boost growth in the power electronics market. They help companies acquire knowledge, both

tacit and explicit in the form of patents. On the other hand, merged companies have to unite two previously used development processes. In order to speed up a merger process on the operational level, development processes have to be well documented. If such documentation does not reflect daily routines, operational practises and real life experience, the merger may be a long and painful experience for both parties. In some cases, the ability to develop new products may be limited.

In conclusion, customers (e.g., OEMs) are cutting costs, and competitors are decreasing prices. At the same time, new social trends that have emerged during the last few years will boost demand, encouraging new entrants into the field. Thus, the power electronics market is headed only one way, i.e., to deliver more products in a shorter time and at a lower price. This, in turn, will make product development cycles shorter.

2.4.3 Intellectual property and regulations

Patents are used to protect uniquely designed products arising from internal development and to secure revenue generated by those products. Power electronics products, based on engineering designs, might be easy to copy by an outsourcing manufacturer. Since a plethora of new ideas may arise during development, the patenting process may cause delays and make the product development process more complicated. Thus, intellectual property has to be identified and the appropriate patent applications filed early in the development process.

The energy sector, at least on the industrial and commercial level, is highly regulated by both industry and government. All products used by or related to the energy industry have to satisfy specific regulations. Since safety and industry compliance are important elements in the energy sector, the legislative power of government and

industry regulatory bodies will remain. This makes product designing and testing more complicated by creating additional steps on the path towards product commercialisation.

Deregulation of the power supply market gives power producers new opportunities. They can provide consumers with alternative energy sources and introduce new products. However, governments do not have long-term regulation policies in some energy markets, such as the still emerging renewable energy market. Therefore, product design and development might face changing requirements. Although the market has become global, many jurisdictions' (i.e., countries') regulations vary, and thus products have to comply with different requirements, which must be identified during the development process.

ABC needs a flexible development process to customize products according to specific and different requirements. The company also has to protect its designs by filing a patent application before first disclosure of a finished product. Since filing an application takes time, designs need to be frozen early in the development process.

2.5 Competitive Analysis

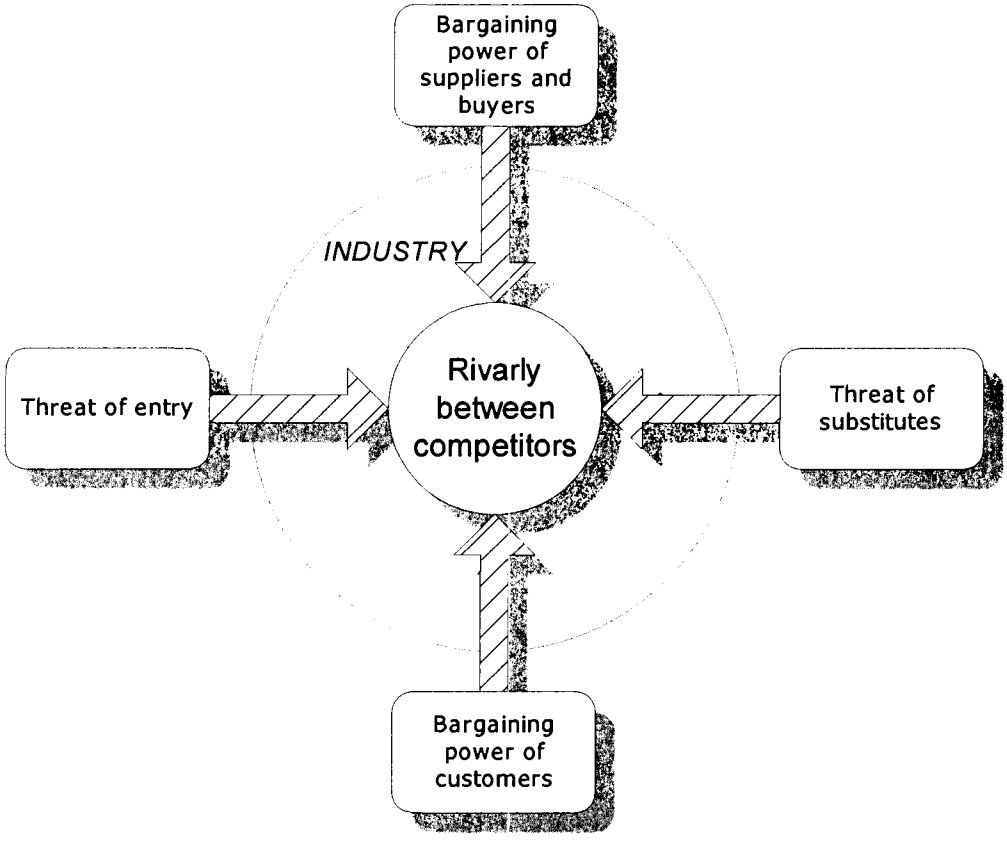
Competitive analysis, as part of the external environment analysis, identifies opportunities and threats for ABC. The analysis framework developed by Michael Porter (Porter, 1979) will be used to evaluate the capabilities of ABC in regards to competitors, suppliers, customers, barriers to market entry and the threat of substitutes. Porter argues that businesses must respond to five competitive forces:

- the threat of new entrants
- the bargaining power of suppliers
- threats from substitute products or services

- the bargaining power of buyers
- rivalry among existing firms.

Porter's Five Forces Analysis helps identify issues that might influence the product development process by forcing the company to act according to market requirements.

Figure 2 Forces governing competition in an industry. Based on Michael E. Porter, Harvard Business Review, "How competitive forces shape strategy", March – April 1979.



ABC is a well-diversified company (see paragraphs 2.1, 2.2) and thus faces different competitive forces in various markets. Since the careful study of the market is not the aim of this strategic analysis, the study outlined below summarizes only a few of the most important forces coming from all markets.

The following paragraphs describe sources of each of the Five Competitive Forces. The sources are grouped into negative ones, which decrease the threat or seriousness of the force, and positive ones (+), which increase the threat.

2.5.1 Threat of entry

New market entrants may shrink the company's market share and force the company to take corrective actions. Analysis of market factors which make that entry easy or create entry barriers helps the company prepare a response in advance. Identifying the seriousness of a threat helps the company tailor its response strategy. The list below presents some sources of threats of entry, which are important in the present analysis.

- (+) Mergers and acquisitions may allow other companies to expand into new markets.
- (+) Manufacturers may decide to promote and sell products under their own trademarks and thus become competition for the company from which they had previously purchased these products.
- (+) Although designs are protected by patents, defending the company's protected designs / products is a long and expensive process. Moreover, patent laws are difficult to enforce in some jurisdictions, such as in Asia.
- (+) Products such as portable power supplies are easy to copy.
- Know-how and tacit knowledge are embodied in organization, which creates barriers for competitors to enter the market.
- (+) High margin markets (see paragraph 2.1) are very tempting for new entrants.

- (+) High-growth markets (see paragraph 2.1) will encourage new entrants.
- (+) Many large technology companies with R&D, manufacturing, marketing and sales resources may decide to deliver power electronics more quickly and effectively than company ABC does (ABC, 2004).
- The OEM market is sensitive to brand names and thus company ABC's aim to increase brand awareness will help keep new entrants away.

The overall threat of entry is moderate to high. Many new entrants will increase competition and introduce new products to the market. Therefore, the company will be obligated to introduce new products or replace current ones. Moreover, product life cycles will be shorter, forcing the company to develop new products.

2.5.2 Threat of substitutes

The competitors of ABC may offer substitute products, taking customers away from ABC or reducing ABC's sales to existing customers. ABC may be forced to lower gross margins, which are currently very encouraging (see paragraph 2.1) and to reduce profit. The following analysis indicates some major factors regarding substitute products that have to be taken into consideration.

- Most products that the ABC company offers do not have direct substitutes and thus the seriousness of that threat is relatively low.
- (+) There are a growing number of new technologies such as fuel cells which might serve as substitutes to the company's products. Nevertheless, the development and commercialization of emerging technologies take time.
- (+) A number of "green" technologies that the company has not developed, such as hydro generation and bio-mass generation, are growing. However,

these technologies are not sound investments at the present time. Thus, the company has time to adapt.

- (+) Consumer electronic products (e.g., portable radios and mobile phones) may be equipped with more reliable and longer lasting batteries, eliminating the need for the backup power and inverters that the company develops.
- If the utility grid becomes ubiquitous, it may reduce or eliminate the need for the company's products (e.g., if shore power becomes available at camps and marinas). However, such power is expensive to develop and is usually limited geographically to the most populous places.

As the above analysis indicates, the seriousness of the threat of substitutes is low to moderate.

2.5.3 Bargaining power of suppliers and buyers

Suppliers influence the strategy of ABC and the intensity of the competition in the industry. When the number of suppliers or the quality or price of the products they supply changes, the company has to respond and adjust its strategy. The list below presents some important sources of the bargaining power of suppliers.

- (+) There are only a few suppliers of the most crucial components, so they have the power to regulate price and quantity.
- (+) There are only a few well-skilled manufacturers of supplies with a history of good relationships with the company.
- Many suppliers of the most common electronic components, such as PCB, are located in southeast Asia.
- Most electronic components are priced as commodities.

- (+) Buyers such as OEMs are sensitive to the quality of the company's products, since this in turn affects the reliability of the buyers' products.

The seriousness of this force is moderate. Although some of the above issues represent low importance, ABC is limited by suppliers which have relatively high bargaining power, and ABC must adjust its processes accordingly. Cooperation with external suppliers (electronic component providers or manufacturers) has to be streamlined.

2.5.4 Bargaining power of customers

The intensity of the competition in the industry is influenced by the number of customers and their concentration. Customers might be the major force in an industry, or their power might be reduced by strong producers. The analysis below outlines the sources of customers' power.

- (+) New global markets increase consumers' power.
- The cost of switching between technologically advanced products (e.g., solar power inverters) is high.
- (+) The cost of switching between consumer products (e.g., portable power supplies) is low.
- (+) Many low-cost portable products (e.g., battery chargers) can be simply replaced, and thus they are price sensitive.
- (+) The majority of orders for distributed power products are generated by a few dealers.
- There are many global aftermarket sellers (retail chains) of portable power products.

In a highly competitive market with global customers (see paragraph 2.2), the company's day-to-day operations have to be based on the voice of customers, and therefore the power of customers is high. In order to be successful, the company has to be market-oriented. Although the power of customers is balanced by the high switching cost of some products, the bargaining power of customers prevails. Thus, the overall seriousness of this force is moderate to high, tending to high. The high power of customers may reduce gross margins and force the company to introduce new or enhanced products much faster. The ability to commercialize products faster and cheaper has to be supported by the proper product development process.

2.5.5 Rivalry between competitors

This is the most powerful among the five competitive forces. Competitors influence each other by changing the pricing policy, quality and features of their products, by changing the services they provide and by conducting advertising campaigns. Rivalry between competing firms to a large extent influences the market in which ABC operates.

- (+) ABC's competitors are usually well funded (ABC, 2004).
- (+) ABC's competitors are well diversified in terms of the range of products they offer.
- (+) ABC's competitors are globally located, and therefore monitoring them and competing with them is difficult.
- (+) Mergers and acquisitions can make ABC's competitors stronger and allow new entrants to enter the market, weakening the competitive position of ABC and reducing its profit.
- (+) Some consumer products are easy to copy.

- (+) Aggressive advertising and promotion campaigns are standard activities in this market.

As the above analysis indicates, the advanced power electronics market is very competitive. Although the company has gained a significant market share over the last couple of years, the factors identified above may increase the activity of competitors. Many well-funded companies can introduce new products and technologies similar to those that the company has developed. Moreover, new entrants can emerge, capturing the company's market share. Therefore, the price of products, development costs and time to market will become significant forces shaping the competitive advantage. The company can grow only by streamlining its operational processes, and the development process in particular needs to be a core competence of the company.

2.6 Benchmarking and Industry Practices

Benchmarking and the best industry practices are described below. This is intended to show that organizations have moved to more mature processes with flexibility and a front-end idea-screening process. Moreover, various innovative companies, although linking innovation management with a stage gate process, manage them separately. An example of linking these two processes is provided as well.

2.6.1 Flexibility

Since ABC's initial introduction of the stage gate process, the business environment has become turbulent and more competitive. Therefore, companies have moved to more sophisticated processes, which include fuzzy gates, flexibility and fluid phases (Cooper & Edgett & Kleinschmidt, 2002). These processes integrate fuzzy gates that are situational and conditional. Processes that are more flexible and fluid allow engineers to move to the next phase before all activities from the previous one are

completed. This provides companies with shorter development cycles, bringing products to market faster and improving resource allocation. Moving to the next phase with incomplete tasks, however, increases project risk. To eliminate risk, companies become more selective in projects undertaken by incorporating effective Go/Kill criteria and moving towards portfolio management (Cooper & Edgett & Kleinschmidt, 2002). Companies have to develop skills to find an adequate balance between flexibility and robust Go/Kill criteria.

Figure 3 A one-dimensional model of transition from formalized to fuzzy new product development. Figure by author.

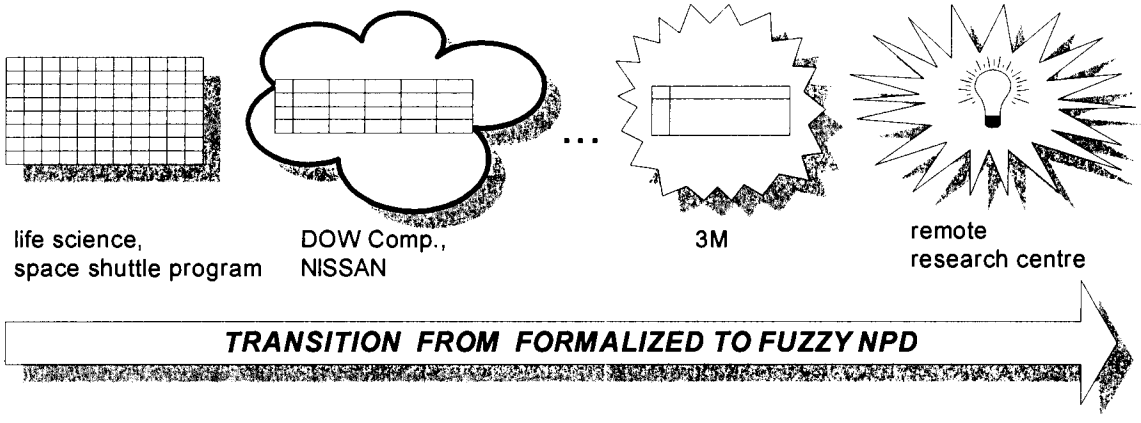


Figure 3 represents that movement, describing various product development frameworks. The rigid framework (on the left side of the figure) seems to be suitable for long-term and expensive product development programs, where the risk justifies additional steps within the framework. For instance, life science or space shuttle programs require a relatively substantial amount of money to develop a new product or technology. Moreover, product development may take several years, increasing program risk. Therefore, the development framework requires precise planning, risk mitigation

and many checkpoints where programs can be amended or even killed. This framework, however, adds huge overhead costs to each program.

Many innovative companies have incorporated fluid gates within a development framework. For instance, Nissan, perceived to be an auto cookie-cutter producer, has been acquired by Renault, an innovative auto manufacturer. Since then, Nissan delivered five new models within eight months and changed its image by commercializing innovative products. Nissan improved its long and inflexible development process and implemented a less rigid framework.

Another example of transition from formalized to fuzzy processes is Dow Chemical Company. DOW has implemented the fast product development methodology called SPEED, designed to decrease time to market (Product Development & Management Association, 2003). In 2003, Dow received The Outstanding Corporate Innovator (OCI) Award granted by the Product Development and Management Association (Product Development & Management Association, 2003). Dow's fast development, among other things, is based on flexibility, not a formal work process. This methodology includes concurrent engineering, parallel processes and flexible allocation of resources. Dow has established a capability and a philosophy to create new products and uses this combination to sell products more effectively.

3M develops new products within a very flexible framework, where work is less formalized. This framework is based on an innovative culture and innovative processes and values shared among all employees.

Finally, in some instances, companies decided to remotely locate their R&D centres. These independent and distantly located entities are focused only on developing innovation or breakthrough products. For instance, IBM has located its

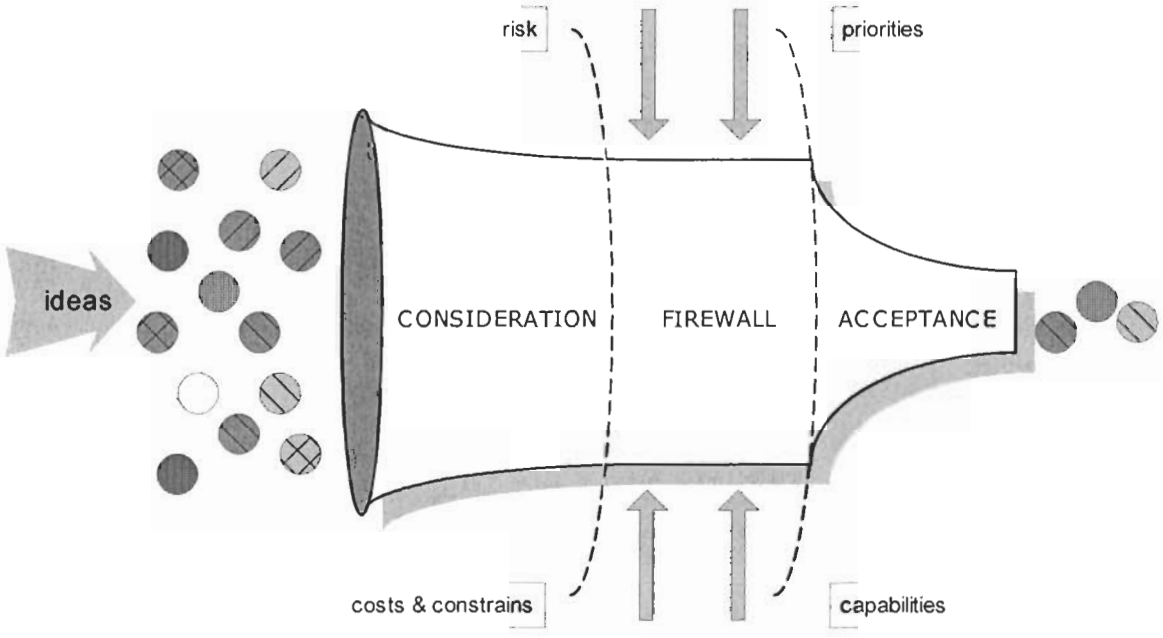
development centre in Paolo Alto (Paolo Alto Research Centre - PARC), where innovation justifies refusing work routines (Stefik & Stefik, 2004).

2.6.2 Industry practices of applying a front-end idea-screening process

Other leading companies have incorporated a discovery stage at the front end of the process (Cooper, 2002). This is intended to generate breakthrough product ideas in a separated but linked process. For instance Harley-Davidson uses portfolio management to maintain the fuzzy front-end of the development process (see Figure 4). In 2003, the company received The Outstanding Corporate Innovator (OCI) Award granted by the Product Development and Management Association (Product Development & Management Association, 2003). In this case, the role of portfolio management is to assess ideas against each other, to determine financial costs and effort requirements and to identify risky concepts. Concepts and ideas stay in the consideration stage of portfolio management until they evolve, get bigger and have a passionate champion able to sell the concept. Then, the firewall as a main part of portfolio management applies. The political power of the idea and its supporters are validated when analysis determines that an idea is feasible and profitable and conforms to the company's strategic objectives. In the last stage, the ideas have sufficient support and can be developed. Here, projects are classified based on the project hours required, the timing and the degree to which the project team intends to follow set methodology elements.

Due to the rigor of portfolio management, Harley-Davidson noticed that concepts are rarely killed once they have been accepted. Thus, portfolio management identifies successful projects and prevents flawed concepts from emerging.

Figure 4 Product Portfolio Management, Based on Product Development & Management Association, "Harley-Davidson Motor Company", The Outstanding Corporate Innovator (OCI) Award, (2003).



2.6.3 Industry practices of linking innovation and product development

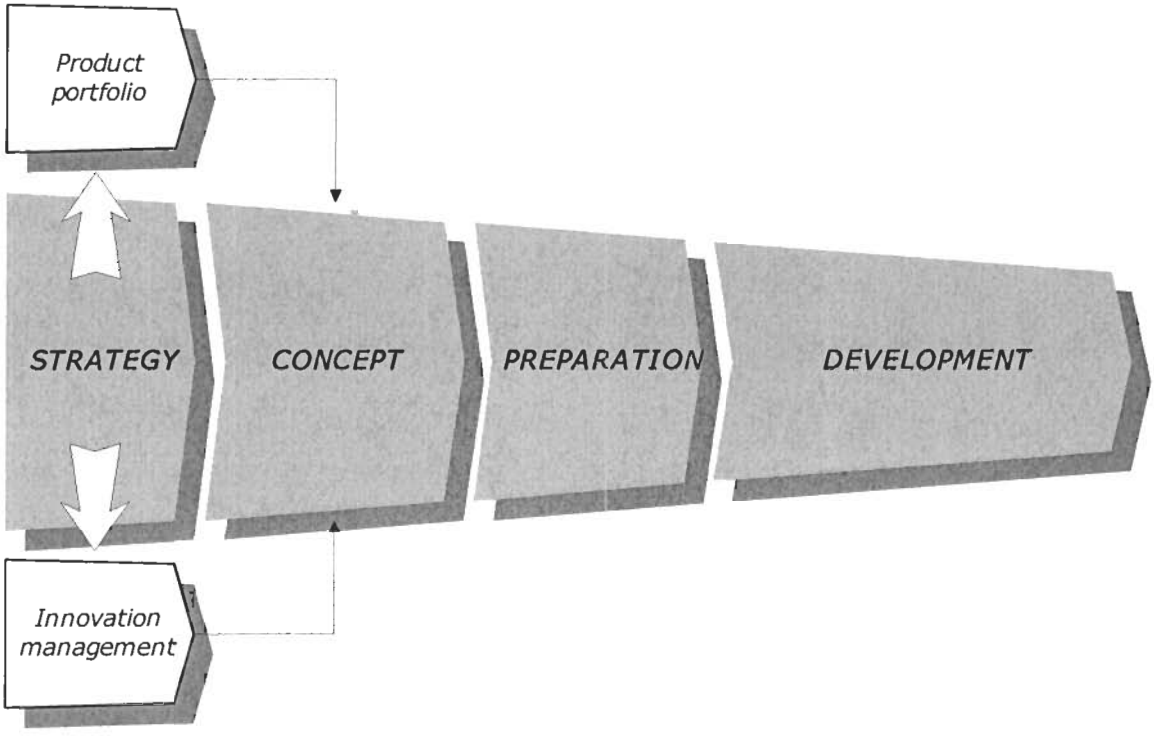
Finally, many innovative companies develop breakthrough products in a process which is separate from a stage gate development process. Although innovation is managed independently, this process is linked with the development process by supplying it with new ideas. Innovation, however, occurs throughout the whole development process. If managed properly, innovation makes the whole development process creative and innovative.

BMW received The Outstanding Corporate Innovator (OCI) Award granted by the Product Development and Management Association in 2002 (Product Development & Management Association , 2002). BMW has strong innovation objectives, indicating the number of breakthrough innovations or concept cars it hopes to produce per year. The company has three self-governing research centres (Global Innovation Scouting) in the US, Europe and Japan. Innovation is a separate process but is linked to the core new

product development framework (see Figure 5). This separation is intended to identify, analyse and select breakthrough innovations without being constrained by current development processes. The linkage is responsible for matching innovations with market requirements and the strategy of BMW. As a result, BMW remains innovative due to its rapid transfer of innovation into development.

In addition, BMW's innovation is supported by a culture which includes ongoing training, rotation of engineers between various departments, business plan capabilities, cross-functional teams, stimulating projects and a challenging atmosphere (Product Development & Management Association, 2003).

Figure 5 BMW's strategic commitment to innovation. Based on PDMA [online]



2.7 Critical Success Factors

The external analysis identifies the following critical success factors, which help a company to outperform its competition.

2.7.1 Time and money success factors

- In order to grow (increase market share, enter new market segments), the company has to introduce new products and enhance existing ones in a timely manner.
- To satisfy the cyclical market and to meet the market window, new products have to be introduced on time, as scheduled.
- Since product reliability and time to market are valued by customers, the company's product development process has to support building reliable products in a short time.
- Since products' life cycles have become shorter, product development cycles have to be shortened as well.
- In order to satisfy price sensitive customers (OEMs, end-users), new products have to be developed on budget.

2.7.2 Coordination success factors

- Companies which introduce various products at the same time and well-diversified companies need precise coordination during the new product development process.
- In order to reduce the risk of project failure, the product development framework has to be robust enough to allow precise planning and force

proper action (e.g., industry regulatory approval, market standard compliance, intellectual property protection).

- The new product development process has to be flexible enough to absorb new components (e.g., activities, sub-processes, roles). If two companies decide to merge, their internal processes and new product development processes in particular have to be merged as well.
- Outsourcing increases the need for precise coordination between partners.
- To enter new market segments or markets, the company has to attract external funding or partners. Grants usually are based on precise plans indicating development costs, perceived price of product and estimated time to market.

2.8 Conclusion

In conclusion, the increasing number of competitors, together with decreasing prices of finished goods, shorter development cycles and technology changes, will make products' life cycles shorter, limiting revenue generated (in terms of years). Thus, more products and a wider product range seem to be critical to sustain ABC's performance and to achieve competitive advantage.

Market and technological turbulence change the pace and approach to new product development. Rapidly changing preferences of customers and exponential technological developments are forcing organizations to develop new products, services and technologies faster. Speed in new product development has become the mantra of companies wishing to achieve competitive advantage (Cooper & Kleinschmidt, 1994). The analysis has shown that the power electronics market is no exception to this rule.

Finally, the competitive environment has forced companies to reject the rigid stage gate process and move to more advanced solutions. This is necessary in order for them to stay competitive and to be able to commercialize new products faster. Adaptable processes allow concurrent engineering and a more flexible allocation of resources (see paragraph 2.6.1). New product development frameworks include a fuzzy front end responsible for screening ideas (see paragraph 2.6.2). This front end is maintained by portfolio management, which recognizes successful projects while preventing faulty ideas from emerging. Finally, innovation management, although well linked to the stage gate framework, is a separate process which is not constrained by the development process.

All of the above indicate that the power electronics market is very dynamic and competitive. Changes in the environment are driven by emerging technologies, new market trends and strong competitive forces. To compete successfully, ABC has to monitor changes and adjust its processes accordingly.

3 INTERNAL ANALYSIS

The aim of this chapter is to analyse the ability of ABC to develop new products. First, the strategy of ABC is examined to determine its impact on the development process. Second, the stage gate product development process is described[3]. The stage gate process is a part of the New Product Development (NPD) framework, which combines processes (e.g., the development process, innovation management), resources and corporate values. It serves to coordinate the activities involved in developing a product or solution. The NPD framework is intended to ensure that the best products receive adequate development resources and are developed in an innovative and creative fashion. The development process is looked at in detail in order to identify areas in the process which do not meet the demanding challenges of the dynamic environment detailed in Chapter 2. This is a core part of the internal analysis. Finally, knowing that such a process is not sufficient to ensure innovative products are quickly delivered to the market, the strategic commitment of ABC to innovation and its ability to innovate are also analysed.

The internal analysis is based upon three sources of data. First, approximately 40 interviews were conducted with ABC employees. Interviewees included members of senior and middle management and operational personnel involved in product development. Second, information was gathered during program and team meetings. Finally, the company granted access to the Program Reference Library, where all

[3] In this analysis the stage gate product development process is called the development process for short.

program and product documents are stored. The data were collected during a three-month period.

3.1 Impact of the Growth Strategy on NPD

The strategy of ABC is very growth oriented. In this section, the three areas of growth are described (see Figure 6), and their impact on NPD is discussed.

Figure 6 ABC's growth strategy. Based on the Final Prospectus - ABC, 2004

3.1.1 New markets and new ways of interfacing with current markets

In order to become a one-stop shop in certain markets, the strategy of ABC is to reposition itself from being a product/component supplier to being a provider of systems solutions. The company plans to achieve this by leveraging core product platforms into

systems products to meet the needs of existing markets and needs within new markets. The development of integral solutions helps the company to become a one-stop shop in certain markets.

ABC also plans to introduce new or enhanced products to existing markets. At the same time, the company wishes to enter new markets by introducing new product lines (see New Markets in Figure 6). Increasing complexity of the products will require greater planning within the development process through co-operation between departments and external partners.

3.1.2 Industry consolidation

ABC plans to build strategic alliances and to outsource production activities (ABC, 2004). The aim of this approach is to accelerate the growth of the business by reducing costs and shortening development cycles (see Industry Consolidation in Figure 6). This will require organizational flexibility, precise coordination and robust communication.

Entering new markets, as indicated in the above section, will force the company to seek additional knowledge and experienced personnel. Such knowledge might be acquired by pursuing mergers and acquisitions (ABC, 2004).

Each partner in a merger or acquisition, however, is likely to have its own approach to product development (i.e., a unique NPD framework). In order for the partners to cooperate successfully, these processes across the organization will have to be flexible enough to allow for the exchange of knowledge and coordination of the development process.

3.1.3 Internal growth

It is projected that the entire power electronics market will develop and grow substantially in the next three or four years (ABC, 2004). The existing product lines offer expansion opportunities as well. For instance, by linking products and by establishing communication between them through communication networks, the company intends to offer integrated solutions as demanded by the market (ABC, 2004). This integration requires software control technology to be embedded inside hardware. Moreover, customers require an interface to remotely control and monitor systems. The company intends to use this communication capability to offer diagnostic and monitoring services of the company's products to existing customers (ABC, 2004). The company recognizes current market factors such as the demand for decreasing costs and shorter development cycles. Therefore, ABC plans to introduce modular hardware and software components. This internal growth (see Internal Growth in Figure 6) will strengthen the existing product lines and will force the company to review the development process in terms of the new demands it puts on it. As these products will be needed in the marketplace quickly, the other requirement will be to speed up and streamline development processes.

In conclusion, the strategy of ABC is aimed at growth. To sustain this planned growth, the company has to introduce new products and develop systems solutions rather than provide product components to a market which, according to the external analysis, is ever more demanding of timely innovation at low cost. The growth strategy therefore has to be supported by a flexible product development process, which will ensure that development projects receive sufficient funding and are developed well enough and quickly enough to reach the market on time in a highly marketable state.

Furthermore, the development process will need to be supported by an innovative culture. It is to these two aspects of ABC to which attention is now turned.

3.2 The Existing Stage Gate Process

This section provides an introduction to the development process, then an analysis of the process structure, an assessment of the key process players and an examination of the approval entity (Product Approval Committee) which allocates resources. Finally, other challenges and issues related to the development process are identified, and their impact is described. Each subsection concludes with a presentation of issues related to meeting the challenges of the strategy of ABC and the demands of the external environment.

The development process, among other things, presents and describes product development activities, policies and elements, which change as the product progresses through the development process. The main activities are mapped, and responsibilities are assigned. Each phase is concluded when a process milestone is judged by the Approval Committee during regular meetings to have been reached. Completion of a phase is determined based on a checklist. Every checklist includes items appropriate to a particular phase and a gate. The checklist covers all relevant aspects and ensures that all appropriate tasks have been completed in any stage of the product development process. The goal of the checklist is twofold. First, it helps program managers to identify the tasks that have to be completed before reaching/passing the gate. Second, it helps determine whether the gate has been passed.

3.2.1 The process structure

The entire development process is divided into four stages: Definition, Development, Launch and Post-launch. Each stage, in turn, is further subdivided into

several phases. In the following sections, each stage and its phases is presented and analysed, and then several issues are identified. All subsequent sections and paragraphs in this chapter are based on this process description. All recommendations regarding the improvement of the development process are presented in the next chapter.

3.2.1.1 Definition stage

The Definition Stage consists of three phases (Ideas, Study and Planning) and two approval gates (Planning and Implementation Approvals). During the Ideas Phase, new ideas are generated and collected through a number of activities. These include market research, internal brainstorming and communicating with customers. Once ideas appear to have a reasonable strategic fit, they are documented in a short Product Concept Document (PCD) that presents the idea and the potential market. This document is later reviewed by the Approval Committee (see paragraph 3.2.3). The Committee evaluates the ideas and the available resources and makes decisions on which product ideas will proceed to the next, more formal, Study Phase.

This screening process, however, should be part of portfolio management – not the product development process – as indicated by industry leaders (see paragraph 2.6.2). Portfolio management should provide a dynamic decision-making process for assessing value, prioritizing ideas and allocating resources to meet strategic objectives. The end result should be the ability to select the best mix of new projects that maximizes returns and minimizes risks. Instead, ideas, described in Product Concept Documents, are screened and evaluated against a Product Roadmap. The Product Roadmap used by ABC is a strategic plan specifying development of future products. The Roadmap however, provides neither information regarding the available resources nor the current portfolio of products. Therefore, the screening process applied by ABC and based on the

Product Roadmap is very static. However, if the screening process included dynamic data regarding the product portfolio, this might help ABC select only high-value projects.

During the Study Phase, ideas are further evaluated and explored, providing a base from which to prepare draft versions of the Functional Specification, Market Requirements Document, Business Plan and Program Plan. These documents are mandatory and require approval before the proposed product can proceed to the next phase, Planning. Later, during the Planning Phase, all information about potential products is consolidated to determine market prospects and product features. A Program Team is formed, and a timeline for the program is defined. All documents prepared so far need to be finalized and, together with program objectives, activities and required resources, have to be approved before the proposed product can proceed to the Development Stage.

In reality, however, Program Teams struggle to finalize the documents required to proceed to the next phase. Business and Program Plans are complex documents, which consist of data from other documents that are prepared simultaneously such as the Functional Specification and Market Requirements Document (MRD). MRD, in turn, consists of massive data regarding the hyper-competitive and continuously evolving market (see paragraph 2.5). ABC competes globally and therefore has to analyse diverse markets from different regions of the world. Consequently, ABC faces here two issues. First, the preparation of the market and competitive analysis takes longer than was anticipated in 1999 when the product development process was initially introduced. Second, the current approach does not allow proceeding to the next phase when some milestone criteria have not been met. ABC has not clearly defined the conditions to complete a stage as being “must meet” or “should meet” criteria. Although Program Teams should not proceed without market data and analysis, some of these documents

can be finalized later in the development process. Rigidly applying the highly desirable "must meet" criteria might help ABC avoid having too many projects being developed too quickly. On the other hand, defining some conditions as "should meet" criteria will allow Program Teams to move to the next phase before all documents are completed. ABC needs the ability to kill a project based on clearly defined Go/Kill criteria. Gates are the only place or moment in the development process where a weak project can be withdrawn. At the same time, however, ABC has to maintain balance between flexibility and robust Go/Kill criteria – as the benchmark analysis indicates (see paragraph 2.6.1). ABC faces this dilemma at each gate. In some instances, having more time would allow for better investigation of market opportunities, but proceeding to the next phase might result in wasted resources. Clear criteria should help management objectively make Go/Kill decisions.

3.2.1.2 Development stage

The Development Stage consists of four phases (Design, Prototype, Verification and Pilot Production) and four approval gates (Preliminary Design, Critical Design, Sales Readiness and Product Releases). During the Design Phase, a first top-level design (Pre-A model) is completed, and critical elements of the design are identified and tested. First draft versions of manufacturing and quality plans are also prepared. Later, all activities which occur during the Development Stage have to be evaluated and approved before the product can proceed to the next phase. During the Prototype Phase, working prototypes (A models) are built and tested according to a specification to prove the design and to demonstrate the product's feasibility. Customers are involved to review prototypes and to deliver opinions regarding possible enhancements. Both manufacturing and quality plans are finalized. These, together with a draft version of a

service plan, the test results and the program expenditures, are evaluated and confirmed before this phase can be completed.

Although the Design and Prototype Phases involve two steps for the engineers, who develop Pre-A and A models, for all other functional areas involved in this stage of the development process there is only one step. For instance, Marketing is still working on a Business Plan and a Market Requirements Document. Supply Chain Management provides information regarding parts availability in both phases. This is an example of where the dominant engineering culture of the company is working against performance. Therefore, these two phases take time and add overhead costs to product development, resulting from unnecessary work required to meet the milestone's criteria and present data to the Approval Committee.

Several models can be built (B Models) during the next phase, Verification. Product models are based on test results and findings from the previous phase. Upon completion of this phase, the product definition and detailed specifications should be finalized; subsequent changes are individually reviewed and kept to a minimum. Before design can be perceived as final and the phase as completed, all planned product development and product verification activities should be closed and everything should be ready for manufacturing introduction. Moreover, product price, delivery targets and proven product performance have to be established before proceeding to the next phase.

During the Pilot Production Phase, a pilot run (C models) is produced in the manufacturing environment. These units will be used as demonstration units and customer test units. Completion of this phase signifies manufacturing acceptance of the product. Customer support services and all the necessary sales tools must also be put

into place. This is the last phase of the Development Stage, and thus the product development can be perceived as completed.

In the Verification and Pilot Production Phases, design engineering completes a product design and hands it over to a manufacturing facility, but the teams have a tendency to develop "over-the-wall-design". In some instances, work is repeated because of changes which have occurred due to late input, something being overlooked or errors in specifications. Changes in product design which occur during the Pilot Production Phase cause problems. For instance, manufacturers can receive misleading or incomplete information. Moreover, due to other priorities and their existing workload, engineers are not able to create new ideas. Although some of these problems are inevitable in the development process, there appear to be more of them than are necessary and wise in ABC.

3.2.1.3 Launch stage

The Launch Stage consists of two phases (Ramp-up Production and Deploy) and two approval gates (Manufacturing Launch Readiness and Program Complete). During the Ramp-up Production Phase, product release is controlled, and the production process is proven to be to be able to be replicated, in order to increase production volume. Marketing, Quality Assurance and Customer Service start full-scale launching activities. Before the phase is completed, the product cost is confirmed, and a Master Production Schedule has to be approved.

Full-scale production starts in the next phase, Deploy. Marketing, Quality Assurance, Customer Service, Manufacturing Engineering and Design Engineering are involved in product introduction and monitoring activities to ensure that the new product, the deployment channels and the support services meet initial expectations and goals.

From now on, the product is available for general sales. Finally, the program team collects and shares lessons learned, and the Launch Stage is considered completed.

In spite of precise definition, activities in these two phases are usually performed simultaneously. This approach is followed in order to quickly launch full-scale production and introduce products into the market as quickly as possible. Program teams usually skip the middle gate, combining the Ramp-up Production and the Deploy Phases. Such an approach is widely accepted by the executive team and is justified by the highly competitive market in which ABC operates (see paragraph 2.5), where time to market is an important success factor (see paragraph 2.7).

3.2.1.4 Post-launch stage

The Post-Launch Stage consists of two phases (Continue and Discontinue) and two approval gates (Product Withdrawal and Obsolete Product). During the Continue Phase, the product is commercially available in volume production quantities. Various studies are performed, including analyses of the market, the competition and customer demands. At the end of the product life cycle or in conjunction with the development of new or replacement products, the decision to withdraw the product is taken. Then Product Withdrawal is proposed. Once this is approved, the Continue Phase is closed. During the last, Discontinue Stage, Marketing, Customer Service and Manufacturing Engineering should determine the activities necessary to discontinue production. They also plan to meet the last customers' orders and to maintain provision of spare parts and equipment to meet future warranty requirements and product repair needs. Once the final production run has been completed, the manufacturing process is closed down, and documentation is archived. This step concludes the Post-Launch Stage and the development process.

The last phase is usually coordinated by Marketing, which takes responsibility for ensuring that products are withdrawn correctly. Product Managers within the Marketing Department are responsible for the whole product life cycle, and thus this approach is fully justified. Marketing has adequate information, based on market research, to decide whether the product is obsolete and should be replaced or withdrawn. Marketing is typically the main force in identifying new product or market opportunities, which represent the voice of customers. The Program Management Office, which coordinates product development activities, does not have adequate information to make a withdrawal decision. Moreover, according to industry leaders (see paragraph 2.6), product development activities should be finished when a new product is launched. At the present time, the product development process used by ABC includes activities that cover more than product development and in fact includes the whole product life cycle. A decision to withdraw a product, however, should be made by those who have adequate information, namely Marketing.

3.2.2 Roles and responsibilities of Program Teams

At ABC, all resources required throughout the duration of a program are defined in a Program Plan prepared by the Program Management Office. The Program Plan defines human resources as a Program Team. This is a cross-functional team and thus the role and influence of each team member is different. In order to promote a sense of belonging and support, the makeup and all responsibilities of a team should be clearly defined. ABC identifies key Program Team members as follows:

- Technical Champion - This role is filled by a Senior Engineer. Responsibilities include technical ownership to invent, control and deliver products and services. The Technical Champion shares responsibility with the Program and Project Managers to deliver a proven product design. The role is both

functional and process oriented, including carrying out the principal technical activities.

- Business Champion - This is an assignment at the Senior Marketing or Sales level. Responsibilities include defining the new product offering and planning, controlling and delivering all the business and market launch activities. The Business Champion works closely with the product development team. This role is both process oriented and functional, providing leadership regarding both business and market activities. Usually this is the same person as the Program Manager.
- Program Manager – This is an assignment introduced in late 2003 by the CEO together with the Program Management Office. This person shares program responsibility with the Business and Technical Champions to deliver a proven product design. The Program Manager, as the organizational leader, is charged with responsibility for executing a portfolio of NPD projects.
- Product Manager – This is an assignment carried out within the Marketing Department. Usually this is the same person as the Business Champion. The Product Management role includes responsibility for overseeing all of the business and market activities related to the product launch.
- Project manager – This is an assignment allocated to the Engineering Department. Core responsibilities include planning, controlling and delivering products and services. However, a Project Manager coordinates the development of each individual product rather than a portfolio of products. This is a temporary assignment at the Project / Senior Engineer level.

- Other Program Team members include Quality, Customer Service, Procurement and Manufacturing representatives.
- Sub-teams, led by the Technical or Business Champions, are responsible for solving technical problems or carrying out sales / marketing activities, depending on requirements.

Although the above description indicates that the roles of key team members are defined, accountabilities do overlap, resulting in a poor understanding of responsibilities. For instance, the responsibilities of the Project, Product and Program Managers overlap, causing confusion among Program Team members. This task interdependence results in complex communication channels and plans, which are difficult to coordinate.

3.2.3 Program approval procedure and the role of senior management

The end of each phase of the development process is the determination that a key milestone has been reached, based on several criteria. Consecutive stages of the product development process are validated by a committee. This body, called the Product Approval Committee (PAC), is a senior group comprised of executive team members. It provides each Program Team with business, market and technical guidance.

Senior management reviews all activities and deliverables of each phase. As mentioned, using established business criteria, this multifunctional group reviews new product opportunities, project progress and the resources that are allocated to each product being developed at each gate. Based on the results, the committee determines whether a phase is completed and allows the program to proceed to the next phase. Therefore, the committee has a gatekeeper role. As gatekeepers, this group of senior managers serve as advisors, decision-makers and investors in a stage gate process.

The committee can amend a program plan based on feedback provided during a meeting. This includes making the decision to continue, cancel or refocus a program.

There are a number of issues associated with this approval procedure which are not conducive to fast and innovative product development. First, Go/Kill criteria are not precisely defined, allowing the management team to be less disciplined in making decisions than is required to ensure that all good products receive sufficient resources while others are killed. The development process appears therefore to be more of a tunnel than a funnel, though exact data are not available to prove this. Although flexibility in applying the framework is crucial, each gate should be a program stopper if the criteria assigned to a gate are not met. Second, PAC meetings involve each Program Team member preparing a detailed status report. Much time is therefore taken up bringing management up to speed on progress rather than making good decisions based on previously understood material.

3.2.4 Other challenges and issues

This section examines other issues that emerged from the data collection which indicate that the development process is not able to adequately meet some of the challenges it faces. First, the organizational issue is highlighted, followed by process and product related issues and then terminology issues. Finally, the impact of the new technology trend on the development process, together with a learning process, is discussed and analysed.

3.2.4.1 Organizational issue

ABC, as an organization, has evolved, and new organizational components have been introduced (see paragraph 1.1.1). For instance, in 2003 the Program Management Office was introduced as the main body responsible for the development process.

However, this new entity is not included in the formal descriptions of the existing process.

3.2.4.2 Process related issues

Every crucial element of the process should be supported by proper documentation, i.e., manuals, templates, etc. Currently program plans have different formats and different content. This in turn makes program performance measurement and benchmarking difficult or impossible. Moreover, if an item is not backed by the proper explanation, a name or a term used might be misleading. For instance, the content of the Manufacturing Documentation is not defined, resulting in the provision of insufficient data required to start production. Program documents do not provide clear information on whether a program received approval or on eventual reasons for rejection.

3.2.4.3 Product related issues

ABC produces a portable products line, which consists of high-volume, low-cost products. Successful commercialization of these products depends on ABC's ability to develop product quickly, keeping development costs low. Moreover, in many instances, products have to be customized or completely redesigned according to customers' requirements. On average, portable products take approximately three months to develop. In these cases, the existing process, which requires massive work preparation, becomes a bottleneck, slowing down development of portable products.

3.2.4.4 Terminology issues

Each product has four major releases:

- Pre-A model (outcome of the Design Phase),

- A (outcome of the Prototype Phase),
- B (outcome of the Verification Phase) and
- C (outcome of the Pilot Phase).

The design of products may be evaluated by engineers several times during the development stage. Thus, products may have more than four iterations. As a result, engineers use variations of the existing notation such as B++ or C+. This inconsistent terminology and these unclear definitions result in garbled or confused hand-offs, causing wasted effort and misdirected work. For instance, production schedules are described using various names, such as Product Schedule, Ramp-Up Schedule, Firm Build Schedule, Master Production Schedule and Program Schedule. Although the meaning of each of them might be different, they cause confusion, and employees use them interchangeably. Examples of other unclear terms include Final Configuration, List of Materials as a BOM, Test Specification and Beta Units.

Finally, the development process excludes facets of the business that have become more dominant in recent times. For one thing, the process is focused on hardware development. However, technology has changed, and new trends have appeared (see paragraph 2.4.1). ABC develops power electronics, which incorporate both hardware and software. Although software test activities are identified in the process, the previous steps of software development and their links to hardware are not included. As well, learning activities are not identified in the process, and thus lessons learned are lost, which is a significant issue, given the increased complexity of the products and the new areas of growth. A learning process would help define the resources necessary to develop new products. In addition, it would enhance the development process by capturing lessons and incorporating them into the process.

3.2.5 The measurement of performance

ABC should measure and control the development process by identifying the number of programs at each gate and by using the Net Present Value concept. This would help managers estimate whether enough new products are being commercialized to meet strategic growth objectives (see paragraph 3.1), as well as help them investigate the overall value of the investment in each program. Knowing how many products of what value are needed at any moment would help the company allocate and manage resources. This information fits with product portfolio management, which links program management with the corporate strategy. However, insufficient data was collected for a analysis of the way ABC measures product development performance.

3.2.6 Conclusion of the development process analysis

In conclusion, the existing stage gate development process has several weaknesses (see paragraph 3.2). For instance, the existing screening process is not correlated with portfolio management (see paragraph 3.2.1.1). ABC, unlike industry leaders, evaluates ideas against its Product Roadmap, making the screening process very static. The Product Roadmap, however, is a strategic plan and on its own should be neither a control nor a screening mechanism. It is portfolio management that should provide a decision-making process for assessing value, prioritizing ideas and allocating resources to meet strategic objectives. Portfolio management might be a dynamic or a continuously adjusted process, based on performance measures of the development process.

Second, Program Teams usually need more time to finalize documents, which are based on extensive research of the market in which ABC already operates or which it is willing to enter (see paragraph 3.2.1.1). Although Program Teams should not proceed to the next phase without market data, some subsequent documents, such as

the Business Plan, can be finalized later in the development process. The existing process however, does not divide conditional criteria into "should be met" and "must be met" categories. This is especially evident during the Planning Phase, when all program documents have to be completed before proceeding to the Design Phase. ABC faces this issue at each gate, and therefore defining conditional criteria more precisely seems to be crucial.

The engineering culture dominates the first two phases of the Development Stage, i.e., the Design and the Prototype Phases (see paragraph 3.2.1.2), while the rest of the Program Team, representing other functional areas, is taking only one step. Thus, merging these two phases would seem to be an effective alternative.

During the last two phases of the Development Stage, ABC confronts a transition from engineering to production (see paragraph 3.2.1.2). Design engineering teams, however, have a tendency do develop "over-the-wall-design". As a result, manufacturing engineering, which takes control over the product design, must deal with errors and changes in specifications which occurred due to late input.

During the Launch Stage, Program Teams usually combine two phases in order to launch full-scale production quickly (see paragraph 3.2.1.3). As a result, ABC is able to introduce products into the market without the unnecessary delay associated with presenting the data required to show that the milestone criteria have been met. Merging the Ramp-up Production and Deploy Phases is therefore effective. Merging the Design and Prototype Phases would be similarly effective.

Finally, ABC faces several challenges which are not associated with a particular stage or a gate but which are common from the start to the finish of the product development process. For instance, the existing process, which contains eleven phases, is very formal and includes stages that cover more than product development (see

paragraph 3.2.1). It is a common misconception among ABC employees that an asset (product) life cycle is the same as the lifetime of a program/project. Program management, however, should be focused on product development and be finalized when development activities have been completed and lessons learned have been captured. This, however, depends on the precise determination of various responsibilities and functions. ABC has to decide whether the Program Management Office or the Marketing Department should take responsibility for the whole product life cycle.

Roles and responsibilities are not clearly defined by the existing development process (see paragraph 3.2.2). The existing definitions of roles reveal the intentions of the people who designed the development process in 1999. However, since then, ABC has grown as an organization and has acquired several companies (see paragraph 1.2). As a result, the organizational structure has evolved to reflect that change. Furthermore, people who came from other companies brought some experience regarding allocation of responsibilities, and thus roles have been adjusted. Consequently, the present accountability of Program Teams does not suit current requirements, as the above analysis indicates, and needs to be amended.

Furthermore, the senior managers need to maintain and enforce a gatekeeper role based on precisely defined Go/Kill criteria (see paragraph 3.2.3). Strict criteria would help ABC select only viable projects to receive sufficient resources. However, managers have to maintain balance between robust Go/Kill criteria and flexibility in applying them – as the benchmark analysis indicates (see paragraph 2.6.1). In some instances, the current push towards shorter development cycles and skipping milestones can be justified (see paragraph 3.2.1), but it also allows some projects to go through a gate when this is unwarranted.

In addition, ABC faces other challenges related to the development of new products. First the Program Management Office, together with other new elements of the development process (e.g., software), is not included in the process (see paragraph 3.2.4.1). Second, changes occur late during product development. Together with imprecise documents, these changes cause misunderstanding and unplanned work (see paragraph 3.2.4.2). Third, the development process, in the current structure, does not properly support development of fast-to-do products such as the portable products line (see paragraph 3.2.4.3). Development of portable products requires fast, cost-effective development cycles. However, applying the existing framework adds time and costs. Finally, the development process has inconsistent terminology and definitions. Lack of consistency causes engineers to create their own descriptions such as B++ (see paragraph 3.2.4.4).

3.3 Innovation Management

The stage gate development process serves to co-ordinate and control resources across the product development life cycle. It does not, however, manage innovation as such. To successfully compete in an aggressive market (see paragraph 2.5) and to achieve a competitive advantage, ABC needs long-term, sustainable growth fuelled by breakthrough inventions. Disruptive or radical innovation will create entirely new markets and satisfy undiscovered needs. However, disruptive innovation occurs only if the company does not control it, but creates the conditions to foster innovation and a process for handling it (Stefik & Stefik, 2004). This innovation side of ABC has to be managed as much the development process, but it needs a different management style. Innovation management is aimed at fostering new ideas and transforming them into new programs which end up being solutions of value to the marketplace.

As ABC grows, innovation has to be fostered by a unique combination of processes, resources and values (Clayton, 2000). In this section, innovation management is analysed in three ways. First, flexibility of the development process is analysed. Then, the impact of people working on innovation in ABC is described and discussed. Finally, the values of ABC are evaluated to see whether they encourage innovation.

3.3.1 Flexibility of the development process

In order to foster innovation, ABC needs a flexible stage gate development process, capable of handling innovation (Clayton, 2000). The development process used by ABC, however, describes precise patterns of interaction, relationships and decision making used to transform resources into products. Program teams, guided by this pattern, develop new products in the same consistent way. If they encounter a new problem or challenge, the existing process makes them act sluggishly. This is because a new task requires a very different way of working, and the current process does not accommodate this. For instance, the existing growth strategy forces ABC to enter new markets and develop new products, which in turn requires a new way of thinking. Engineers, however, might be obligated to perform certain activities described by each phase of the process as usual and deliver the same components to meet the same milestone criteria. The development process therefore, prevents engineers from being innovative by dictating the steps and timeline when things need to be done. Creativity around product innovation, however, might occur if managers of ABC arranged technology, skills, resources and organizational commitments to form an innovation process. For instance, Program Teams can act creatively if they are encouraged to improvise (Akgun & Lynn, 2002). The more they improvise, the faster they would

develop and launch new products in the turbulent environment in which ABC operates. Partnership and collective work could promote innovation as well (Akgun & Lynn, 2002).

In many instances, the existing process adds bureaucracy, requiring data and documents to be prepared to present an idea. Although proceeding with an idea has to be based on precise analysis, the first idea presentation should be easy and informal. The bureaucratic process does not motivate people to innovate, nor does it offer flexibility, which is necessary to search for an explanation. A new solution or an idea may require a different approach from what was done before and a different kind of expertise.

3.3.2 Innovative people and culture

In most start-up companies, innovation is based on people who innovate. Therefore, people played an important role at the early stage of ABC's history. People leaving and joining the company has influenced the ability of ABC to innovate. New employees with diverse backgrounds and culture may encourage innovation. On the other hand, people leaving the company may take tacit knowledge away. An innovation management process needs to be devised that can withstand and accommodate changes of personnel.

ABC has a very strong technical engineering background that initially emerged from the company providing power electronics equipment to the test and measurement market. This background has shaped the company, which continues to have a strong engineering workforce. Although engineers interact with other functional departments (e.g. Marketing) on the operational level, their interaction pattern is based on training (Leonard-Burton, 1992). Engineers are trained to solve existing important problems and to evaluate products by user testing. During the development process, engineers use

existing components, but do not create new technologies. Engineers assume that the existing process is the right way to perform their tasks. Thus, they view issues or problems through their experience. In some instances, taking only one view can lead to biased or partial solutions and won't lead to breakthrough innovation, which ABC needs to enter new markets. This engineering culture inside ABC does not support its growth strategy and expansion into new markets, which require a new way of thinking about existing processes.

In addition, staff turnover, new employees coming from acquired companies and people working remotely in several divisions across North America make it difficult for people to work together. Although new people can foster or generate ideas, ABC's engineers focus on communication and coordination rather than on idea creation.

In conclusion, the people side of innovation needs to be managed so that they are the source of new ideas for products or solutions. Management should foster innovation by encouraging risk taking and by building an entrepreneurial culture.

3.3.3 Innovative management and values

ABC's management tends not to see innovation as requiring management, yet "chaos", in the sense of an environment in which new ideas can be thought of, needs to be present. In this section, the values of senior management are analysed in terms of their effect on innovation.

3.3.3.1 Top-down management of innovation

The senior management team of ABC is the main power which defines what to develop and what is needed. Moreover, management creates values or standards by which to judge which opportunities are more important. Management influences innovation by identifying the Product Roadmap, which reflects the company's plan to

develop products in the foreseeable future. This Product Roadmap is a list of new products that management perceives as suitable to the company's current capabilities and to the strategy goals for the following years. New ideas are evaluated and screened against that Roadmap (see paragraph 3.2.1.1).

Such an approach is adequate for developing innovations directed at mainstream customers. However, in order to create new markets, the ability to develop disruptive technology has to be created. This requires a different set of skills. For instance, ABC has to ask what is possible to develop and whether the company has adequate technical expertise and engineering abilities to develop innovative products. This set of new capabilities would need to be supported by processes sufficient to allow ABC to achieve its growth goals. Appropriate data, however, were not collected to analyse ABC's technical skills and capabilities.

3.3.3.2 The role of planning

Company ABC's management has strong opinions about priorities and procedures, i.e., the way work is done inside ABC. Therefore, management directs innovation. Management prefers PERT planning and charts over managing the chaos of innovation. However, designing and planning alone will not provide the long-term profits that could be generated by innovative products. Equally, management favours cost cutting and acquisition strategies over process or product innovations that would yield more long-term benefits.

3.3.3.3 The role of outsourcing

ABC has created innovation capabilities mainly by mergers and acquisitions of outside technologies and by outsourcing manufacturing processes (see paragraph 1.1). Different companies, however, share the same outsourcing facilities, and products are

built using the same generic parts. Thus, increased outsourcing is making products alike and does not provide ABC with competitive advantage.

In conclusion, ABC is capable of providing its mainstream market with solutions and products that are reasonably innovative. A lack of attention being paid to "innovation as chaos", combined with a very workload-heavy development process, means that, unless things change, there is little hope of ABC creating very innovative products in the future.

3.4 Internal Analysis Conclusion

In conclusion, the strategy of ABC is geared towards growth through new products (see paragraph 3.1), putting stress on the development process. This stress is twofold. First, it requires that the process maintain perfect control of resources and coordination of activities. Second, it requires that innovation management, which should be linked with the development process, be overt but not overly controlling. Overt processes might encourage and lead to innovation, but excessively controlled processes will hinder creativity.

The existing development process has helped ABC to successfully develop and commercialize many products. ABC was able to acquire several companies, maintaining and even increasing the number of products that the company produces. Since the development process is well documented and supported by templates of all the crucial documents (e.g., Business Plan, Service Plan), new employees and those who came from acquired companies quickly became familiar with the development activities that are necessary to develop new products. Having a well-documented process, ABC also could educate non-engineering departments on the effort required to develop new products. Based on that common understanding, ABC was finally able to form cross-

disciplinary program development teams and orient its organization towards a project structure. However, the market in which ABC operates is continuously evolving and becoming more competitive. Thus, the existing development process does not support ABC in the new reality of a hyper-competitive market. The conclusion of the development process analysis (see paragraph 3.2.6) describes all issues that have been analysed in the preceding sections, while the sections below only shortly summarize them.

First, the existing idea-screening process is a part of the first, Idea Phase of the development process. Academics such as Robert Cooper, together with industry leaders, indicate, however, that the screening process should be a part of portfolio management (see paragraph 2.6.2). Portfolio management, among other things, can ensure that the development process is provided with only viable ideas of new products, and can assure ABC that not too many new projects are funded – otherwise, none will have enough funding to succeed. Moreover, innovation management requires an ideas engine that can generate ideas outside of the Product Roadmap, which is too rigid. However, the appropriate data to assess whether too few ideas are generated and whether too many are resourced were not collected.

Second, the development process is a rigid process, forcing Program Teams to perform in a consistent and formal way (see paragraph 3.2.6), adding overhead costs to product development. For instance, several phases within the process do not bring additional value to products, and usually Program Teams skip or combine them. Consequently, there seems to be opportunity to shorten the development process by combining and/or eliminating several phases. As a result, the development process would be more flexible and capable of delivering new products in short cycles, similar to the processes applied by industry leaders (see paragraph 2.6).

Third, the first, Idea Phase of the development process, together with the last, Discontinue Phase, make the whole process long and add stages that cover more than product development. ABC and its Program Management Office should be focused on development activities designed to commercialize new products faster as more competitors approach the market. This approach has to be supported by updated definitions of the roles and responsibilities of all key program players.

Fourth, senior managers, who manage the development process and foster the innovative environment, need to maintain balance between having strict Go/Kill criteria, exercising flexibility in applying them and maintaining the whole process. This will help ABC to quickly respond to market changes by developing new products through a short development process and to support only viable projects with adequate and sufficient resources.

Finally, ABC has to measure the process, for instance, by identifying the number of products or programs at each gate (see paragraph 3.2.6). Having this information would help managers to estimate whether enough new products are being launched and to investigate the market value of each of them. Moreover, ABC would be able to develop a dynamic decision-making process for prioritizing ideas, allocating resources and selecting only high-value projects. Finally, management would be capable of adjusting the development process and the Go/Kill criteria to reflect the current technology trends and market requirements. This, however, has not been examined in the present analysis.

Regarding innovation, the management team creates values and standards which are sufficient to foster short-term and sustaining innovations (see paragraph 3.3.3). Therefore, the process does not foster disruptive innovation, which is needed to develop breakthrough products (see paragraph 3.2.4.4).

These weaknesses need to be addressed if ABC's growth targets are to be met. Recommendations for addressing these are supplied in the next chapter. Since receiving advice is not sufficient, ABC needs to implement the recommendations within the context of the company. Chapter 5 deals with this by identifying issues and challenges that ABC may face during the implementation process. It also pinpoints the course of action which is necessary to implement and support recommendations.

4 RECOMMENDATIONS

The aim of this chapter is to provide recommendations regarding the issues identified in the previous chapter. This chapter makes recommendations for improving the exiting New Product Development framework in three ways. First, changes are suggested to the stage gate process. Second, it is recommended that innovation management be made a part of the NPD framework and be well linked with a stage gate development process. This correlation will provide ABC with new innovative products. The ability to learn as a way to maintain flexibility and foster innovation and continuous improvement is also recommended. Finally, a complete New Product Development framework is presented.

4.1 Stage Gate Development Process

A new stage gate process with four main characteristics is recommended. First, a recommendation is made to enhance the idea-screening process at the fuzzy front end. Second, reduction of the number of gates within the stage gate process is recommended, with the aim of decreasing the overall development time. Third, flexibility should be embedded in the process, allowing ABC to evolve and continuously improve the existing process by setting Go/Kill criteria that suit the needs of the particular product being developed. Finally, performance of the process should be measured, with the aim of ensuring that all products in the pipeline receive adequate resources and that together they will meet the growth targets on ROI, both in terms of timing of commercialisation and NPV value. Additionally, other elements of the new process are recommended with

the aim of making it more design oriented, which in turn will enhance and support effective product development.

4.1.1 Idea-screening process

The first, Ideas Phase during the Definition Stage of the development process (see paragraph 3.2.1.1), should not be a part of the process but rather maintained by portfolio management – as indicated by industry leaders (see paragraph 2.6.2) and the internal analysis in Chapter 3. The development process should start at the Study Phase after the ideas are screened by portfolio management. The screening process incorporated by portfolio management will provide the development process with only those ideas which represent sound investments, conform to the objectives of the growth strategy (see paragraph 3.1) and minimize risk (see paragraph 2.6.2). In other words, the development process will be provided with already screened ideas, and thus valuable resources will be assigned only to feasible programs.

4.1.2 Reducing the number of gates

There is a balance between having too many gates, resulting in too much time being spent preparing reports for management about meeting these gates, and having too few gates, so that failing product development projects are not recognized early enough, thereby consuming resources with no return. ABC is on the side of having too many gates, according to the analysis in section 3.2.3. The internal analysis in the previous chapter reveals several opportunities to reduce the number of gates. All of these opportunities are presented in this section.

ABC should strive to monitor the balance between allowing highly innovative - but more likely to fail - product ideas through this screening phase and allowing only less innovative and therefore less risky ideas through, which will provide a lesser ROI.

For instance, during the development stage, engineers develop models in two steps or phases (Design and Prototype), while for all other functional areas there is only one step. Combining these two phases will reduce overhead costs by avoiding unnecessary work required to meet milestone criteria and present data to the Approval Committee.

Later, during the Launch Stage, the existing development process has two distinct phases, Ramp-up Production and Deploy (see paragraph 3.2.1.3). ABC, however, performs simultaneously the activities defined in these two phases, skipping the middle gate. Program teams aim to launch full-scale production as fast as possible, which is justified especially in a highly competitive market (see paragraph 2.5), where time to market is the important success factor (see paragraph 2.7). Combining these two steps would therefore be effective, in the same way that combining the Design and Prototype Phases would be (see section above).

Finally, according to the existing structure of the development process, the last, Discontinue Phase is managed by the Program Management Office. In reality, however, this phase is managed by Marketing (see paragraph 3.2.1.4). Marketing takes the responsibility for the whole product life cycle, and thus it is Marketing, together with its Product Managers, who should take the decision to discontinue a product. The withdrawal decision is based on market research and other market data. The Program Management Office does not have adequate information to take on such a decision. The new product development process should clearly indicate that Marketing has responsibility for the last, Discontinue Phase.

4.1.3 Implementing flexibility

A more flexible process would provide better focus on resources and management of the portfolio of projects, allowing for adjustment in resource allocation between various projects that are developed at the same time. The end result should provide ABC with a much more efficient roadmap, bringing products to market faster and improving resource allocation. In this section, the way ABC can incorporate flexibility and balance robust and fuzzy milestone criteria is described.

4.1.3.1 Meeting the needs of a particular product

Since the introduction of the initial stage gate process, ABC's business environment has become more turbulent and more competitive (see paragraph 2.5). Therefore, companies have moved (see paragraph 2.6.1) to more sophisticated processes (Cooper & Edgett & Kleinschmidt, 2002). The development process needs to be fluid, scalable and adaptable to the new market and technology trends and to the needs of a particular product.

ABC should not use the existing development process as a standard for every product and make the product fit the standard. For instance, the high-volume, low-cost portable product line (see paragraph 2.1) needs a shorter development process. The analysis indicates that the existing process does not sufficiently support development of this product line, resulting in a bottleneck (see paragraph 3.2.4.3). To avoid constraining development of those products, ABC has to develop each product in a way that suits the needs of that particular product. This, however, does not mean that clear gates and stages should not be set and be adhered to, as the section below indicates.

4.1.3.2 Setting management criteria

ABC can identify milestone criteria that have to be met, defining them as "must meet" criteria. These highly desirable criteria allow Program Teams to kill a project. As the analysis of the program approval procedure indicates (see paragraph 3.2.3), ABC should incorporate a better Go/Kill decision process to avoid "must do" programs. The gates are the only opportunities for programs to be killed, and thus the company has to make use of these opportunities when it is justified. "Must meet" criteria need to be clear and easy to use. These highly desirable criteria might help ABC avoid having too many projects being developed too quickly.

At the same time, ABC has to incorporate fuzzy gates, allowing for detours and the development of products in a way that suits these products. This fuzziness helps shorten development cycles and allows activities from one phase to be performed in another phase. ABC can achieve this by defining more flexible "should meet" criteria, which allow Program Teams to move to the next phase before all conditions are met. Lack of flexible milestone criteria is especially apparent during the Planning Phase, when all program documents have to be completed before proceeding to the next, Design Phase (see paragraph 3.2.1.1). The decision to skip some milestone criteria has to be associated, however, with risk management, to know when it is wise to spend more money on a product when the criteria of a certain gate have not been met.

ABC has to maintain a balance between flexibility and robust Go/Kill criteria – as the benchmark analysis indicates (see paragraph 2.6.1). For instance, the company should decide how many items in a checklist must be unsatisfactory in order to kill a program at each gate. The existing development process includes neither conditional criteria defined as "should meet" criteria nor highly desirable criteria defined as "must meet" criteria.

4.1.4 Performance measurement

To appropriately set gates, as the section above indicates, ABC needs to measure performance of the development process (see paragraph 3.2.5). ABC has to ensure that all products being developed are viable and match targets of the growth strategy. Performance measures will ensure that programs receive adequate resources from the beginning of the process to product launch. By identifying the number of products or programs at each gate or by using the Net Present Value concept, managers can assess whether enough new products are being launched, and they can estimate the market value of each program. Moreover, management will be able to make rapid adjustments to the development process and the Go/Kill criteria to reflect the current technology trends and market requirements. However, appropriate data were not collected to analyse thoroughly the way ABC measures product development performance.

4.1.5 Becoming more design oriented

ABC can incorporate activities and processes that other leading companies use. These include freezing engineering designs early and implementing design for excellence (DFX) techniques (Ahmed & Shepherd, 2000).

4.1.5.1 Early engineering designs

ABC needs to freeze designs early in the product development process. Although developing a new product involves trial and error, beyond a certain point redesign becomes wasteful. Currently, the development teams have a tendency towards developing "over-the-wall" design when work is repeated because of modifications,

which have been made due to late input, something being overlooked or errors in specifications (see paragraph 3.2.1.2).

4.1.5.2 Design for excellence

To improve efficiency of product development, ABC needs to implement many processes, particularly in the areas of manufacturing and engineering. These processes include the design for excellence (DFX) techniques such as "design for manufacturability and assembly" (DFMA), "design for logistics" (DFL), "design for serviceability" (DFS), "design for testability" (DFT) and the concurrent engineering practices (Ahmed & Shepherd, 2000). This is to provide management with more accurate information on the costs of developing products.

4.1.6 New naming convention

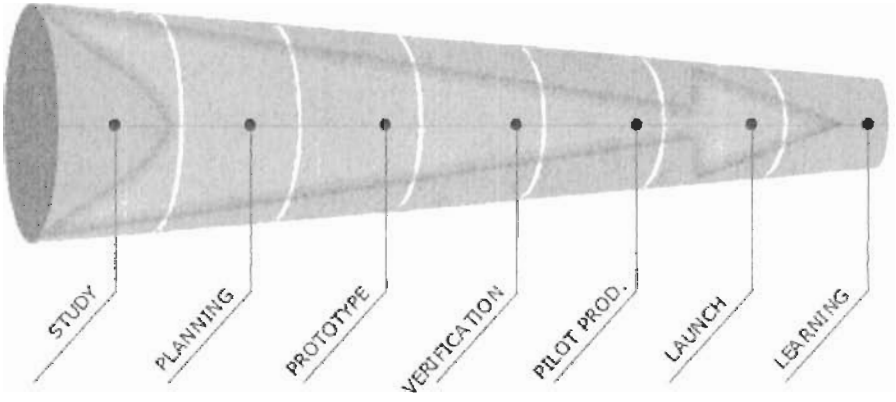
In addition, it is suggested that ABC not use the model names (A, B and C) it is using now (see paragraph 3.2.5). The physical representation of the product should evolve from a prototype and a verification model to pilot production. This recommendation is intended to change the mindset that a product design can be amended later in the development process, i.e., during the C phase. The C model is actually not a model. It is a pilot production, and the design should be frozen already (as suggested in section 4.1.5.1).

4.1.7 New stage gate process

Figure 7 summarizes the above recommendations and represents the new stage gate process recommended to ABC. It is a streamlined process, which consists of seven phases and seven Go/Kill gates. The new process is focused only on main product development activities. It starts with the Study Phase and finishes when a new product is

launched by capturing lessons learned. The last, Learning Stage reflects the closure of the product development (for details, see paragraph 4.3). However, the process is supported by the fuzzy front-end Idea Phase maintained by portfolio management. The funnel represents the likelihood that not all ideas will turn into development projects that prove to be viable.

Figure 7 Recommended new stage gate process. Figure by author.



In conclusion, the above recommendations include reducing the number of gates, which, among other things, will lead not only to reduced costs but also to increased quality, variety and productivity. Moreover, the development process should incorporate flexibility, which would further shorten development cycles. At the same time, however, ABC needs to maintain balance between flexibility and robust Go/Kill criteria, which might help ABC prevent too many projects being developed too quickly. In addition, the development process should include activities and sub-processes that other leading companies apply. These include freezing engineering designs early and the design for excellence (DFX) techniques. All of the above, however, have to be supported

by measurements of process performance. This will help ABC, among other things, to prioritize ideas, allocate resources and adjust the development process together with the Go/Kill criteria.

4.2 Fostering Innovation

In order to successfully compete, ABC has to stay innovative and needs a strategic commitment to innovation (see paragraph 3.2.4.4). However, innovation is more than new product development. Innovation is chaos with guidelines, defined by a combination of processes, resources and values (see paragraph 3.3) that ABC needs to develop. Product innovation has to be supported by and embedded in the strategy of ABC. Managers of ABC need to create and cultivate a culture of innovation. They can structure technology, skills, resources and organizational commitments, forming this into a strategy. The analysis of the current strategy, however, does not reveal this strategic commitment to innovation (see paragraph 3.1). Moreover, ABC's innovation culture is not as supportive (see paragraph 3.3), as is required to successfully compete in its aggressive market (see paragraph 2.5) and to develop innovative products that might give ABC a competitive advantage.

ABC can foster innovation by rotating engineers between different departments and providing ongoing training. The management team should create a challenging atmosphere and encourage NPD teams to improvise. The more they improvise, the faster they will develop and launch new products in turbulent environments (Akgun, Gary S. Lynn , 2002). However, the NPD teams need to be stable. The more stable the teams, the greater the likelihood that they will improvise (Akgun, Gary S. Lynn , 2002). Collaboration and collective work cultivate innovation as well. One of the many aspects of the innovative culture is developing products through cross-functional teams, which ABC has successfully implemented (see paragraph 3.2.2).

4.3 Learning and Continuous Process Improvement

The internal analysis (see paragraph 3.2.4) reveals that ABC does not have a formal learning process to capture lessons learned during the development process. Learning and the ability to adjust processes, however, are critical success factors in the turbulent environment in which ABC competes (see paragraph 2.6). Therefore, ABC needs to develop a new capability to learn and adjust its New Product Development framework. Each program or project undertaken needs to be considered a preparation and learning experience for the next one. Thus, all lessons learned during a program should be collected and shared among program partners – for instance, during the last phase of the development process (see Figure 7). Moreover, the company has to value and encourage information and knowledge sharing. Adaptation and Continuous Process Improvement of the New Product Development framework should be embedded into strategic objectives.

The company should invest in periodic review of the development process and continuous improvement to assure that the process supports quality and rapid product development. The improvement and learning processes should be facilitated by the Program Management Office.

4.4 New Product Development Framework

This section summarizes all recommendations described in the above paragraphs by presenting the suggested development framework that ABC should implement. Figure 8 is a high-level illustration of the recommended framework. This New Product Development (NPD) framework merges the development process, innovation management, resources and corporate values. The aim of the NPD framework should

be to ensure that only the best products receive sufficient resources and those products are developed in an innovative manner.

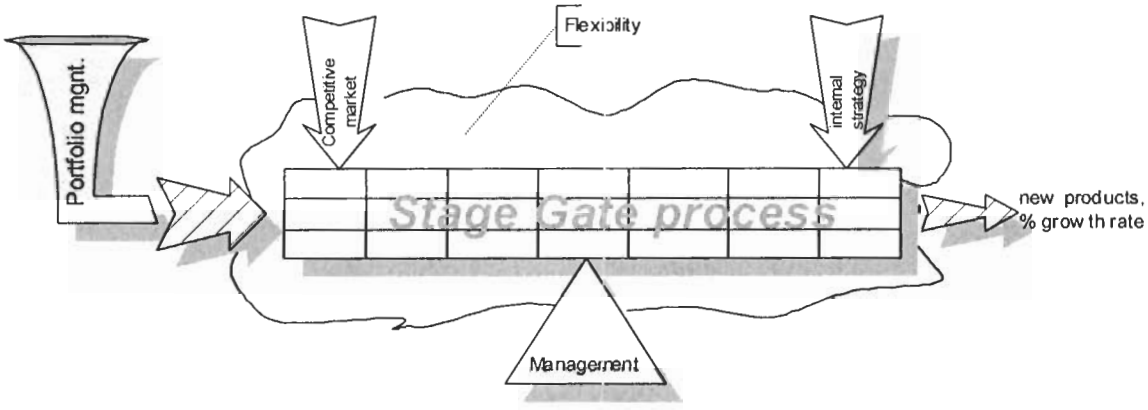
The recommended development process should be more responsive to the competitive market forces (see paragraph 2.5), which are represented by the "Competitive market" arrow in Figure 8. The market in which ABC operates influences the development process by forcing the company to decrease the price of products, development costs and time to market. The stage gate process has to support development of new products with low costs and allow for fast commercialization. Thus, the process can be shorter, decreasing, among other things, the overhead costs associated with preparing and presenting data to management (see paragraph 4.1.1) The company's growth strategy (see paragraph 3.1), represented by the "Internal Strategy" arrow in Figure 8, has to be sustained by a flexible process (see paragraph 4.1.3) capable of delivering various products in a timely manner at low cost.

Management is responsible for designing the process, encouraging flexibility and balancing the whole framework (see paragraph 4.1.3.2). The management team directs efforts to achieve strategic objectives such as the projected number of new products and the expected growth rate. These performance indicators, however, have to be measured (see paragraph 4.1.4). Moreover, as the analysis indicates (see paragraph 3.3.3.1), management creates values, i.e., standards by which to judge which ideas, projects and programs are more important. This process, however, has to foster innovation, which is aimed at creating innovative products (see paragraph 4.2).

Flexibility or fuzziness inside the process, together with fewer numbers of gates/phases (as described in paragraph 4.1), will bring new ideas and will foster innovation. New product ideas, however, should be maintained by the fuzzy front end as indicated by the industry benchmark (see paragraph 2.6.2). This is intended to screen

ideas and select only those which conform to the company's portfolio management. As regards portfolio management, this model is designed to ensure that the portfolio of projects is managed in a manner that delivers products to meet the targets for ROI.

Figure 8 ABC's recommended New Product Development framework. Figure by author.



5 IMPLEMENTATION

The aim of this chapter is to support ABC in implementing the recommendations indicated in the previous chapter and in achieving buy-in with key stakeholders across multiple departments. First, this chapter indicates problems and challenges that ABC might face during implementation of the recommendations and how to meet and mitigate these challenges. Second, this chapter provides a draft of the implementation action plan. It identifies and describes activities necessary to implement these recommendations, assigning priority and responsibility for each recommendation. Finally, further analysis of the stage gate process is suggested, with the aim of better understanding the development process and supporting implementation of the New Product Development framework.

The challenges indicated in this chapter do not depict the complete list of problems that ABC might face. The further analysis suggested below might help ABC to identify other challenges that ABC has to overcome in order to successfully implement the recommendations from the previous chapter.

5.1 Challenges and Risk Mitigation

5.1.1 Tendency towards inertia and resistance to change

Engineering teams, whose power will be less dominant because the new stage gate process is oriented more towards cross-functional product development (see paragraph 3.2.1.2), will have a natural tendency towards inaction. These individuals may block or resist the proposed change. Thus, the change should be defined as an evolution rather than a revolution. For people involved in program development, i.e., the

Program Teams, education and communication should involve explaining the reasons for change. Collaboration should be encouraged to involve those who will be affected by the new process.

5.1.2 Disagreement among stakeholders

Several stakeholders (e.g., Product Managers and Program Managers) might have their own expectations regarding the new development process. As suggested in the previous chapters (see paragraphs 3.2.1.4 and 4.1.1), Product Managers within the Marketing Department should take responsibility for the product withdrawal process. Program Managers from the Program Management Office, who are responsible for that last phase of the development process at the present time, might not accept this new configuration of power. Moreover, Program Managers' expectations will be supported by their power. Thus, stakeholders mapping can identify their expectations and power. This will help ABC's management to understand the political priorities. In addition, education can be used to persuade stakeholders that the new framework makes commercial sense and would increase ABC's competitive advantage.

5.1.3 Powerful social networks

Formal as well as informal configurations of cooperation between people might influence a decision about whether to implement the recommendations presented in the previous chapter. Informal webs of relationships among different stakeholders within ABC and the casual flow of information create social networks (Cross & Parker, 2004). These networks are not presented on any formal chart that ABC might have. Nevertheless, social networks embody the performance of ABC, the way ABC develops and executes strategy and the company's ability to innovate (Cross & Parker, 2004). Thus, to effectively manage people and projects, and to successfully implement

suggested changes, the real patterns of relationships across the entire organization should be revealed. To analyse these social networks, ABC should hire an external consulting company, which would conduct series of interviews, surveys and workshops. The unbiased view of the third party would help to analyse informal patterns of collaboration and to identify decision makers and parts of the organization that had been separated from the whole network. Such analysis would also identify powerful entities inside ABC, those who have expertise and knowledge, and how these informal networks influence the product development process. The analysis might help implement changes by repositioning decision makers and promoting communication and collaboration, which is especially important in cross-functional product development.

5.2 Draft of the Implementation Action Plan

The table below (see Table 1) summarizes the recommendations presented in the previous chapter. The table also provides additional information. First, the priority of each recommendation is suggested, distinguishing between high, medium and low priority recommendations. Each of these recommendations should be implemented, starting with the high priority ones, which seem to be critical to achieve improvement in product development. Second, responsibility is suggested, indicating the particular position or the organizational entity which should take the responsibility for implementing each recommendation.

Table 1 Recommendation summary. Table by author.

No	Recommendation name	Paragraph	Priority	Responsibility
1.	Idea-screening process	4.1.1	Medium	PMO
2.	Reducing the number of gates	4.1.2	Medium	PMO
3.	Implementing flexibility	4.1.3	High	PMO
4.	Performance measurement	4.1.4	High	PMO
5.	Becoming more design oriented	4.1.5	Low	Engineering
6.	New naming convention	4.1.6	Low	Engineering
7.	New stage gate process	4.1.7	High	PMO
8.	Fostering innovation	4.2	High	CEO
9.	Learning and CPI	4.3	Medium	PMO
10.	New Product Development framework	4.4	High	CEO

The Program Management Office, with a senior management position reporting directly to the CEO, should be the main body responsible for implementing the majority of the recommendations indicated in the previous chapter. The main objective of the PMO is to manage the stage gate development process. Thus, the PMO has adequate authority and resources to coordinate these activities. However, some recommendations can be put into operation by the VP of Engineering. These are design for excellence techniques and the new typology providing new model names to be used by engineers during the development process. Since both of these recommendations influence daily engineering routines, the head of the engineering group seems to be better positioned to implement them.

Regarding fostering innovation, the importance of this issue and its impact on the entire organization were broadly described in chapters 3 and 4. Thus, this high priority

recommendation has to be coordinated by the entity with an inherently embodied holistic view of the company, namely the Chief Executive Officer. As well, the responsibility for implementing the new framework should be coordinated by the CEO. The role of senior management in balancing the new framework has been described in the previous chapter (see paragraph 4.4). For instance, the management team, which is supervised by the CEO, directs the entire development framework to achieve strategic objectives such as the projected number of new products and the expected growth rate.

In addition, this section indicates activities which seem to be necessary to support implementation of the recommendations described in Chapter 4 and to overcome the challenges indicated in paragraph 5.1.

5.2.1 Achieving executive buy-in and formal approval

ABC should achieve buy-in from key stakeholders across multiple departments regarding the recommendations presented in Chapter 4. ABC must receive the agreement and commitment of senior managers to the new direction. The new development framework cannot be implemented if employees are not committed to it. Therefore, the recommendations from the previous chapter should be presented to the executives. ABC has to make sure the change is well understood, accepted and supported by the executive team. Senior managers might have personal agendas that should not be tolerated since they may detract from implementation of the new framework. At the same time, however, the change should be used as a means to increase satisfaction, excellence and business growth represented by the strategy of ABC. Executives also should define clear responsibility for managing the change of the process and assemble a group of motivated people to execute the plan.

5.2.2 Communication and implementation monitoring

ABC should establish accurate, timely and unbiased communication, which is a fundamental requirement for successful implementation of the recommendations. Effective communication will allow everybody to express their opinions and make further suggestions.

For instance, people involved in the implementation of the new product development framework should periodically meet to establish and maintain continuity in tracking changes and implementation of those changes. The use of follow-up meetings is essential. The meetings might yield the appropriate performance feedback and keep all parties aware of the change process and issues which emerge along the way. Follow-up meetings will help ABC identify expectations and create accountability among employees involved in the process. Moreover, the meetings might help ABC anticipate areas of conflict and navigate around them before they affect the change process.

5.2.3 Training

ABC should explain the change by training employees on all levels across the entire organization. This is intended to get everyone on board and also to convince or eliminate nonbelievers early. By training employees, ABC can ensure total commitment of the organization to the new direction.

5.3 Further Data Collection and Analysis

5.3.1 Low-level analysis

The analysis in Chapter 3 is a high-level view of the development process from the top-down perspective. ABC should perform a low-level analysis to analyse details of the development process, including activities or processes inside each gate. Documents

required at each gate / phase should be precisely defined and supported by proper templates (e.g., Feasibility Study), describing the contents of each document.

Additionally, ABC should explore other possibilities and suggestions identified in the previous chapter, such as design for excellence (see paragraph 4.1.5.2). This analysis will help ABC define a precise action plan towards implementing these suggestions.

5.3.2 Process measurement

ABC needs to measure performance of the development process by identifying the number of programs at each gate or calculating their NPV. Given the expected drop-out rate of projects as they proceed up the pipeline, ABC has to indicate whether the portfolio is sufficient to give the ROI required to meet the growth targets. The management team has to estimate whether enough new products are commercializable to meet the growth objectives of the corporate strategy (see paragraph 3.1) and to investigate the overall return on investment in each program. Managers should be able to develop a dynamic decision-making process to allocate and manage resources, and to select only high-value projects. Process measurement, however, has not been examined in the present analysis

In conclusion, ABC might face several challenges in implementing the recommendations indicated in Chapter 4. First, engineering teams might resist change or even block implementation of recommendations (see paragraph 5.1.1). This tendency toward inertia should be overcome by education designed to explain the rationale behind the proposed changes. Second, several stakeholders might express different expectations regarding the new development process (see paragraph 5.1.2). Thus, ABC has to identify stakeholders, their power and priorities. Finally, ABC, like many other

organizations, might be driven by informal webs of relationships (see paragraph 5.1.3). To successfully implement the recommendations, ABC must uncover these patterns of relationships and identify powerful entities.

To mitigate the risks indicated above, ABC has to prepare a risk action plan, which will address all challenges. First, ABC should achieve agreement among key stakeholders (see paragraph 5.2.1). Commitment of senior executives will help define responsibilities and overcome those entities which might resist the change. Second, the process of implementing changes should be monitored on a regular basis (see paragraph 5.2.2). This is intended to identify and overcome issues that might arise along the way. Third, ABC has to provide employees involved in product development with training (see paragraph 5.2.3). Training will help ABC to ensure total commitment of all employees. Finally, effective and unbiased communication between all people involved in this change is a key component of successful implementation (see paragraph 5.2.2).

Although the recommendations presented in Chapter 4 are based on a broad study of ABC, the analysis performed was not exhaustive. Thus, ABC has to take additional steps to make sure that the development process is analysed thoroughly. For instance, ABC has to perform a low-level analysis to uncover other challenges that ABC might face and to clarify details of the development process (see paragraph 5.3.1). Finally, ABC has to measure the development process, which would help ABC control and manage effectively the development of new products (see paragraph 5.3.2).

BIBLIOGRAPHY

ABC (2004), "Final Prospectus".

Akgun, A. E. & Lynn, G. S. (2002). "New product development team improvisation and speed-to-market: An extended model", *European Journal of Innovation Management*, (Vol.5, Iss. 3: 117-130), Bradford.

Clayton, M. Ch. (March-April 2000). "Meeting the challenge of disruptive change", *Harvard Business Review.*

Cooper, R. G. & Kleinschmidt, E.J. (1994). "Determinants of timeliness in product development", *Journal of Product Innovation Management,* (Vol. 11).

Cooper, R. G. & Scott J Edgett and Kleinschmidt, E.J. (Sep/Oct 2002). "Optimizing the stage gate process: What best-practice companies do-I", *Research Technology Management.* (Vol.45.) Washington.

Cooper, R. G. & Scott J Edgett & Kleinschmidt, E.J. (Nov/Dec 2002). "Optimizing the stage gate process: What best-practice companies do-II", *Research Technology Management.* (Vol.45.) Washington.

Coyne W. E. (March-April 2001). "How 3m innovates for long-term growth"; *Research and Technology Management.*

Cross R. & Parker A. (June 7, 2004). "How Org Charts Lie", *Harvard Business School Working Knowledge.*

Cross R. & Parker A. (2004). "The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations", *Harvard Business School Publishing.*

Farris, G.F. & Hartz, C. A. & Krishnamurthy, K. & McIlvaine, B. (Nov-Dec 2003). "Web-enabled innovation in new product development ", *Research Technology Management*, (Vol.46, Iss. 6: 24). Washington.

Frost & Sullivan (Jul 2004), *Destined to Grow - Inverter Markets* from <http://www.frost.com/ >.

Frost & Sullivan (Sep 2004), *World DC-AC Power Inverter Markets*, from <http://www.frost.com/ >.

Fuel Cells Canada (March 2003). "Canadian Fuel Cell Commercialization Roadmap", Append. 1.

Hollins, B. & Pugh, S. (1990). *Successful Product Design*, Butterworths, London.

Johanson G. (2002). *Exploring Corporate Strategy*, 6th edition, Pearson Education Limited.

Kaplan, R. S. & Norton, D. P. (September-October 1993). "Putting the balanced scorecard to work" *Harvard Business Review.*

Kaufman, S. A. (1995). "Escaping the Red Queen effect", *The McKinsey Quarterly,* Number 1.

Leonard-Burton D. (1992). "Core capabilities and core rigidities – a paradox in managing new product development", *Strategic Management Journal.*

Porter, M. E. (March-April 1979). "How competitive forces shape strategy", *Harvard Business Review.*

Product Development & Management Association, (2002). "BMW Group AG", *The Outstanding Corporate Innovator (OCI) Award*, from <http://www.pdma.org/innovators/>.

Product Development & Management Association, (2003). "Dow Chemical Polyolefins and Elastomers", *The Outstanding Corporate Innovator (OCI) Award*, from <http://www.pdma.org/innovators/>.

Product Development & Management Association, (2003) "Harley-Davidson Motor company", *The Outstanding Corporate Innovator (OCI) Award*, from <http://www.pdma.org/innovators/>.

Shepherd, Ch. & Ahmed, P. K. (2000). "NPD frameworks: a holistic examination", *European Journal of Innovation Management*, (Vol.3, Iss.3: 160), Bradford.

Stalk, G. Jr & Hout, T. M. (1990), *Competing Against Time: How Time-Based Competition Is Reshaping Global Markets*, New York: The Free Press.

Stefik, M. & Stefik, B. (2004). *Stories and strategies of radical innovation*, Massachusetts Institute of Technology.