A CASE STUDY: TRANSITION TO LOW-COST PRODUCT DEVELOPMENT BY HIGH-TECHNOLOGY PRODUCT DEVELOPMENT TEAMS

by

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Submitted to the Sloan School of Management
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ABSTRACT

Many large American manufacturing companies have historically offered premium products that were high in value and price. Consolidation of markets and increased offshore competition have presented a challenge to these firms to create low-end, value-rich products that are priced low. This thesis examines the approaches of three different product development groups and then generalizes an approach for how a large high-technology company might transition from high-end to low-end products. This thesis tests the hypotheses that in order to transition successfully to the low-end market, companies must: 1) redesign their product lines en masse and revisit the core building blocks of these product lines, including product architectures, manufacturing processes, and distribution channels, and 2) adopt new talents and skills to accomplish (1).

Project managers and engineers were interviewed from two separate product development groups working to produce low-cost projects within companies that traditionally produced high-cost products. These two groups were part of a single company, a leading medical equipment manufacturer. The Hewlett-Packard DeskJet Group, a celebrated example of low-cost product development, was also studied from the literature as a benchmark comparison. Although the interviews and data from the literature did not constitute a statistically significant sample, evidence supporting the general hypotheses was found.

The author recommends a longer run focus on product family planning in addition to the use of Design for Manufacturing and Continuous Improvement methods to optimize the modules from which the product lines are comprised. Cross-functional information coordination between marketing, engineering, finance, and production is believed to be crucial to the development of low-cost, high-value products. Furthermore, well-defined goals for cost reduction and an increased awareness of cost drivers to help realize these goals are critical to the transition to low-cost product development.

Thesis Supervisor: Professor James Utterback

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Chapter 1: Problem, Hypothesis, and Methodology

To cherish traditions, old buildings, ancient cultures and graceful lifestyles is a worthy thing -- but in the world of technology to cling to outmoded methods of manufacture, old product lines, old markets, or old attitudes among management and workers is a prescription for suicide.
(Maddock, 1982)

1-1. The Problem

Many large American manufacturing companies have prospered by offering premium solutions that were high in value and price. Consolidation of markets and increased offshore competition have presented a challenge to these firms to create low-end, value-rich products that are priced low. This change in paradigm is challenging the marketing strategy, product development processes, technology creation methods, and most importantly, the management thinking within these companies. This thesis will look at how three different product development groups are tackling this dilemma and then generalize an approach for how a large high-technology company might transition from high-end to low-end products.

1-2. The Hypothesis

This thesis will test the hypotheses that in order to transition successfully to the low-end market, companies must:

(1) Redesign their product lines en masse and revisit the core building blocks of these product lines, including product architectures, manufacturing processes, and distribution channels.

(2) Adopt new talents and skills to accomplish (1).

1-3. Sample and Methods Description

The sample consisted of three product development groups at two companies. Due to the proprietary nature of the information shared during interviews at one of the companies, the company and specific project names could not be listed. They will be referred to as Groups A and B. *In addition, in some examples, proportions may be used in place of the actual data.* Groups A and B were product development groups from two different divisions within a leading medical equipment manufacturer. Group C was the DeskJet Group within the Printer Division of Hewlett-Packard. The first two groups were selected on the recommendation of an academic who had previously worked with them. Group A has successfully offered products to the low-end market, and Group B is currently working to develop products for the low-end market. The DeskJet Group, a celebrated example of low-cost product development, was selected as a benchmark for comparison with the other two groups.

Field interviews were conducted with project leaders and design engineers from Groups A and B. Published literature was used to compile the case study of Group C. The following outline of topics was used as a guideline for the interviews and literature search:

1. Market Conditions
2. Product Development
3. Production
4. Marketing Strategy/Channels
5. Financial Performance

6. Organizational Structure/Culture

Most of the questions were covered in each interview, although many of the questions could not be answered by all of the interviewees. In hindsight, a more rigorous approach would have been beneficial to the study. Additional metrics and interviewees would have provided a stronger knowledge base from which to draw conclusions. Construction of an explicit outline and draft of the thesis body prior to the interviews would have been advantageous. This would have provided a foundation for an easier transition from data gathering to reporting.

Furthermore, many of the references reviewed post-interviews to support and evaluate my findings would have been even more beneficial to me before conducting the interviews. Although I was familiar with most of the literature prior to the interviews, a focused, consistent and comprehensive list of questions and metrics used in all interviews would have resulted in a more potent set of data. I did find that a review of relevant case studies prior to my interviews was very helpful. For example, Harvard Business School cases covering issues on Becton Dickinson & Company and Baxter International provided useful insight into the healthcare industry.

The flow of the thesis is as follows: The main body of the thesis will be divided into three chapters covering the topics of market innovation, product development, and culture. Each chapter will compare and contrast these areas within the three groups. The final chapter will evaluate the validity of the above hypotheses and then summarize major findings.

Chapter 2: Market Innovation.

The works of Foster and Christensen both provide strong evidence that entering firms in high-technology industries often gain significant strategic advantage by recognizing, developing, and marketing radically new technologies. They further suggest that alternative technologies and product architectures are often missed due to a lack of *market* innovation rather than a lack of technology innovation. (Christensen 1992, Foster 1986.) New entrants often take advantage of discontinuities in technology or consumer demands. Do companies understand their customer needs? Foster believes, "Sometimes certainly, but often not accurately enough to know what those customers will do when approached by a discontinuity in products available to them. Customers are notorious about wrongly predicting what they want...the discontinuity, when it comes, may not come in the main market sector, the sector where a company knows the most about its customers' needs. It will probably come in a niche."

It seems clear that market innovation is critical to long-term success in technology companies, but what is not clear is how best to achieve market innovation. The three groups considered in this study each entered new markets in their initiatives to be more competitive; however, the approaches used by each group in their marketing strategies varied. Industry background, product offerings, and marketing strategy will be covered to provide an understanding of the competition, the products, and the consumers for each group.

2.1 Industry Background

Groups A and B are divisions within a single leading medical equipment manufacturer, Company ABC. Group C is the DeskJet Division within the Hewlett-Packard Corporation (HP). Both ABC and HP have been quite successful at integrating and commercializing a wide breadth of technologies in individual products in their respective markets. Groups A and B develop products for the medical equipment industry, while Group C develops products for the printer industry.

The medical equipment industry is a fragmented one, with a mix of large and small niche players. In 1993, hospital supplies was a $90B industry in the U.S. and growing. The purchasing process for medical equipment is complex and changing. The usage requirements and process vary by individual healthcare facility. In many cases, the customer must commit to a single supplier for a particular type of product, so it is advantageous for a company to offer a line of integrated products. Sales force and customer education are important factors in the purchasing decision. Since the mid-1980's, government changes in Medicare reimbursement policies have placed tremendous cost containment pressures on U.S. hospitals, healthcare-related businesses, and insurers. Most hospitals now belong to a multihospital chain or at least a multihospital buying group. These organizations have increased the purchasing power of hospitals for equipment and supplies, negotiating bulk discounts via centralized purchasing groups.

Historically, the medical technicians and physicians have had product preferences based on top quality and not price. More and more, upper levels of hospital administration have become influential in the buying process. These people usually come from different backgrounds than product users, and they are always price sensitive. While end users are interested in improved features, purchasers are also focusing on long-term compatibility, risk of obsolescence, and price. Historical margins of 50% are disappearing along with brand loyalty as standardization increases. Another trend, the rapid increase in nonhospital treatment sites, including home, surgicenters, emergency centers, and free-standing diagnostic centers, has further increased the price pressure on manufacturers and distributors trying to meet the needs of health care providers. Although the market for alternative-site treatment may potentially outgrow the hospital market, the margins will almost certainly be lower. The healthcare industry has historically been filled with niche players that can charge high premiums, while the printer industry, on the other hand, has been composed of large players meeting the needs of the mass market.

The printer industry is dominated by big, brand-name manufacturers, including Hewlett Packard, Canon, and Epson. Worldwide printer sales are expected to reach about 50 million units ($31.7 billion) by 1999, compared with about 25 million units ($21.9 billion) in 1993. Over the past five years, dot matrix printers have been replaced by laser printers and an ever increasing number of inkjet printers. IDC Asia Pacific peripherals programs manager Lane Leskela believes that in 1996, 50% of new purchases will be of inkjet printers (Cambell, 1995).

Color-capable printers are expected to be the largest growth segment within inkjet technology in 1996, and are expected to cause a decline in monochrome printer sales this year.

Two strong drivers of growth in the consumer market have been the introduction of Windows 95 and the increasing amount of information being downloaded from the Internet and other on-line services for printing. Inkjet printers can print on any paper and are comparable in price and speed to dot matrix printers. Laser printers can also print on any paper and are much faster, but they are significantly more expensive and require more maintenance. Home users typically consider price, print quality, and speed when purchasing a printer. Corporate purchasers typically have a broader range of considerations, including price, reliability, network compatibility, service and support, print quality, speed, operating cost, size, and more than ever, state-of-the-art imaging applications. While the healthcare industry has historically focused on the high-end segment with high-priced niche products, the printer industry has been quick to adapt the feature/price mix of its product lines in order to gain any consumer surplus in the market.

All three of the product development groups studied challenged themselves to produce a high-value product at a bargain rate. Company ABC and HP have both been doing well financially over the past few years; nevertheless, the particular groups studied for this paper were determined to build leadership in new markets with reduced cost structures in order to better secure future success.

2.2 Product Offerings

This section provides a brief summary of the product offerings of Groups A, B, and C. In the following section, Marketing Strategy, the drivers and intentions of these product offerings will be discussed in detail.

Group A has historically offered a single product line, A1, to its customers. The A1 is considered a high-value, high-price product. The A1 was targeted at U.S. hospitals and leading healthcare facilities worldwide. A low cost initiative resulted in the development of a second product offering, A2. While the A1 meets all customer needs and commands a premium price, the A2 offers the most important features as defined by the users at a significantly reduced price. The A2* will be a derivative product, offering fewer features at an even lower price. The A2 was initially intended for price-sensitive buyers, particularly buying groups, alternative sites, and non-U.S. facilities; however, its surprisingly high profit margin drove a push for sales in all markets.

Group B currently produces three products: B25, B20, and B10. The B25 and B20 are considered "high-end" products, while the B10 is considered a low-end product. The B25 is designed to meet all of the needs of a top medical professional, as defined by the marketing group. The B20 is a minor variation of B25, targeted at users who want all of the bells and whistles but can't quite afford the B20. Basically, the B20 has an almost identical cost structure, but is sold at a lower price and commands a lower margin. The B10, on the other hand, offers only the most basic functionality to its user. It utilizes a completely different technology (mechanical rather than electromechanical) to provide minimum functionality at a significantly lower price. This product has allowed many small-scale hospitals and clinics that otherwise could not afford it to offer the basic service provided by this product. This group of consumers expects minimal functionality.

The next generation of products from Group B includes two products, T and S. Product T will be positioned similarly to the B25/B20 products as a high-value, high-priced product. S, however, will be positioned as a high-value, low-priced product, a significant improvement over B10's position as a low-value, low-priced product. S will be sold not only to those consumers who previously purchased the B10, but also to those who previously purchased the B20/B25 models. S will have add-on features that will allow it to be upscaled both in features and price to meet the needs of various market segments. Previously, this group offered a choice between a luxury model or an econobox. Now, consumers will be able to select a model that meets their needs and budget, and the company will be maximizing profitability in the face of a changing market.

Group C, the HP Deskjet group, was originally formed to offer an alternative product to dot matrix printers using inkjet technology. Its original product, The ThinkJet, was considered a failure, primarily blamed on its high price of well over $1,000. Dot matrix printers, with print quality inferior to The ThinkJet, were selling at the time for $350 to $500. In 1990, the group introduced the original DeskJet model with a retail price of $995. In 1993, the price was reduced to $365. In 1994, the DeskJet was offered at the same low price with the additional feature of color printing. Currently, HP offers five major models of the DeskJet -- the DeskJet 340, 600C, 660Cse, 855C, and 1600C, ranging in retail price from $365 to $1699. Table 2-1 below summarizes the differences between these various inkjet printer models. All of the DeskJet printers offer 600-dpi black resolution and 300-dpi color resolution.

	DJ340 (IBM)	**DJ600C (IBM)**	**DJ660Cse (Macintosh)**	**DJ855C (IBM)**	**DJ1600C (IBM)**
Speed	3 ppm	4 ppm	4 ppm	7 ppm	9 ppm
Max Memory	48k	512k	512k	1MB	100MB
# Fonts	6	50	50	40	45
Paper Capacity	30 pg	100 pg/20 env	100 pg/20 env	150 pg/15 env	180 pg
Warranty	1 year	3 year	3 year	1 year	1 year
List Price	$365	$369	$399	$663	$1699

Table 2-1. HP Inkjet Printer Product Comparison.

Figure 2-1 on the following page summarizes the product offerings of the three groups.

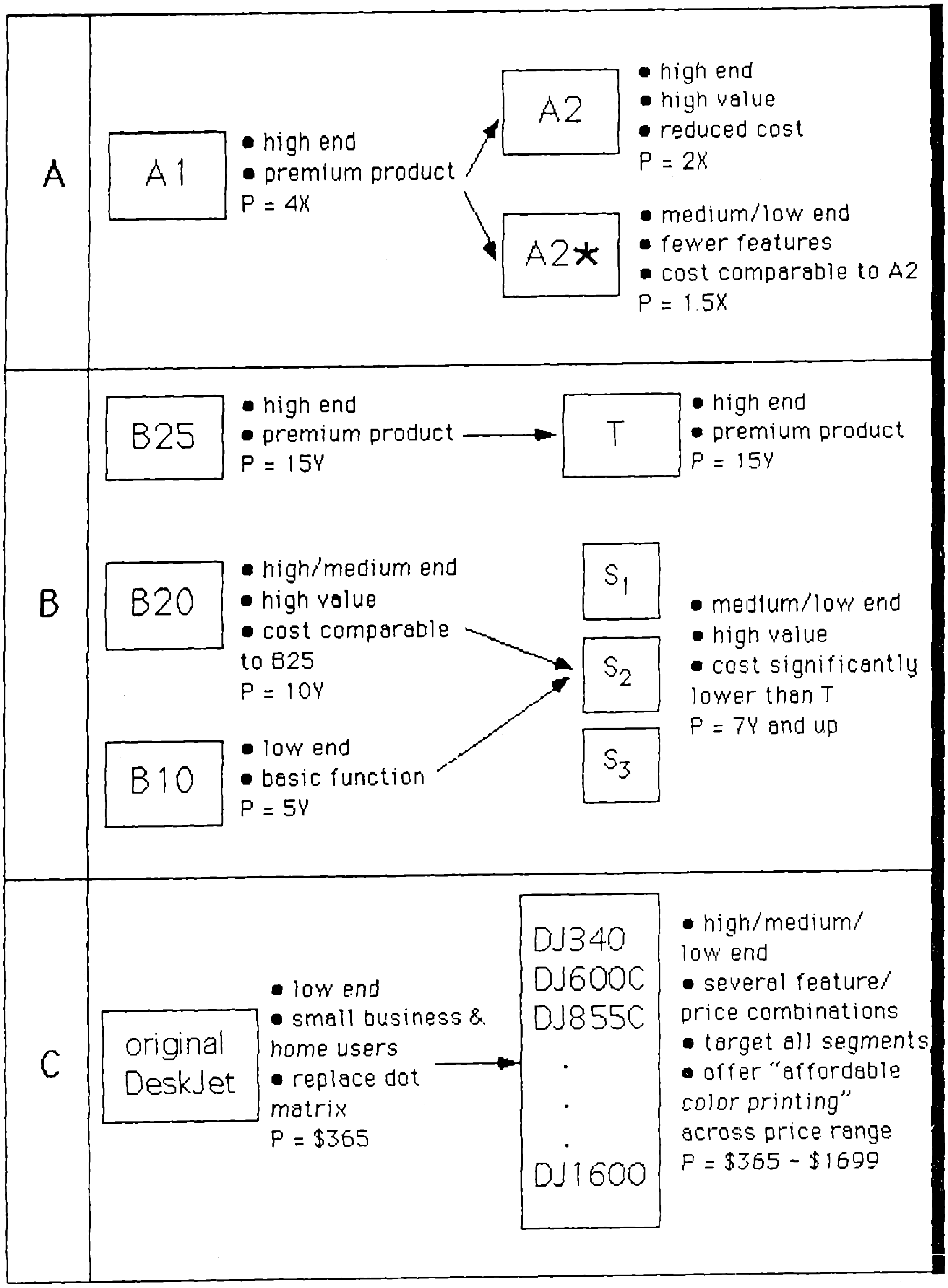


Figure 2-1. Product Summary for Groups A, B, and C.

2.3 Marketing Strategy

All three of the groups decided to refresh their product lines. The strategic intent, however, was quite different for each group. Group A decided it needed a new product to meet price demands of both existing and potential customers. Group B, on the other hand, planned to continue to target the high end and the low end with incremental improvements on its two existing product platforms, even though it was aware of market gaps and entering competitors. Group C was initially trying to commercialize a new technology and enter the low-end market.

Group A has recently restructured market segmentation to more explicitly target the price-sensitive segments as shrinking budgets and growing costs have led to more stringent purchase requirements. The group has historically offered A1 as a high-value, high-price product to leading medical facilities througout the world. Through its low cost initiative, the group is now offering a lower-priced alternative, the A2. The marketing strategy for the A1 product was targeted primarily at the end user, while the A2 product team is targeting the buyer. Since the development of A1, the end users of this specific type of product had declining buying power both in terms of decision-making power and resources. During the development of A1, end users were interviewed and observed by marketing and engineering representatives in an attempt to understand every minute user need. With A2, the fundamental needs would be met; however, the focus was on prioritization rather than total inclusivity of those needs.

For group B, the development of a new, low-cost product was initiated in response to general trends in the market and within Company ABC. The current B25 and B20 are considered high-end products, while the B10 is considered a low-end product. The B25 is designed to meet all of the needs of a top medical professional; the B20 is a minor variation of B25. The B10 offers only basic functionality.

The next generation of products includes two products, T and S. Product T will be positioned similarly to the B25/B20 products as a high-value, high-priced product. S was originally intended to be an incremental improvement on the B10. However, due to unusual resource constraints, new development methods allowed the low-end model to "free-ride" on a high-value, desirable subsystem at a significantly reduced cost from the T product line. The positioning of S was changed to a high-value, low-priced product platform, a significant improvement over B10's position as a low-value, low-priced product.

T will be marketed to consumers who are the least price sensitive. S will be marketed not only to those consumers who previously purchased the B10, but also to certain groups of previous B20/B25 customers. S will have add-on features that will allow it to be upscaled both in features and price to meet the demands of various market segments. Consumers will be able to select a model that meets their needs and budget, and the company will be maximizing profitability in the face of a changing market. The improvement in functionality of the "low-end" model can be attributed primarily to the use of common components, the sharing of a high-value subsystem, and strong interaction between R&D, finance, and marketing functions.

Group C, the DeskJet group, intended initially to market its product to the lowest end of the printer market, dot matrix customers. Consumers wanted better print quality, a choice of typefaces, the ability to use any type of paper, and a price below $1,000. Inkjet printers were initially positioned as a replacement for dot matrix printers, and later continued to be upgraded with new features like color and portability.

Initially, the inkjet was not priced competitively with dot matrix printers. Although HP was aware that consumers wanted a price very competitive with dot matrix printers, the company waited to reduce prices until it recouped certain portions of its development and manufacturing costs. The DeskJet orginally listed for $995 upon introduction in 1990, and was later reduced to a price of $365 in 1993. The 1994 model, offered at this same low price, included the additional feature of color printing. When the price reductions first hit, DeskJet sales took off. However, after the initial boom, sales decreased dramatically. Many dealers mistakenly positioned the DeskJet along with HP's fast, high-priced laser printers. HP took an active role in positioning the DeskJet against dot matrix printers and sales reappeared as consumers recognized HP's "Laser quality at half the price" as an affordable alternative.

HP essentially revolutionized the personal printer market, providing near-laser quality at dot-matrix price. HP also created a new market: low-end color printers. Due to continuous focus groups and market research, HP was well aware that most consumers would welcome color as a nominal cost feature. In 1994, HP sold over 4 million color printers, compared with $360,000 in total nonimpact color printer sales in 1991. By positioning color as a low-cost add-on feature instead of a luxury item, HP was able to take advantage of this market opportunity.

By 1993, HP had invested over $2 billion in inkjet technology, compared with an estimated world market for inkjet products of $30 billion. "It took off like they never imagined," says Marco Boer, an analyst with International Data Corp. in Framingham, Mass. (Nelson, 1993) In fact, in 1992 HP sold 2.2 million inkjet products, outselling laser printers, and HP now dominates the world computer printer market with a 60% market share. In 1992, 25% of HP's $16.4 billion in revenues could be attributed to printer sales. (Nelson, 1993) Furthermore, the after-market for printers is very profitable, with users spending up to four times the cost of a printer on replacement cartridges.

Will inkjet printers cannibalize laserjet sales? HP executives don't seems to think so, at least not in the near future. The demand for high-quality, high-speed, black-and-white printers is considered a separate market. (Packard, 1995)

2.4 Findings

New marketing techniques may be necessary when entering new market segments. Group A and B both found that buyer needs, in addition to user needs, must be well understood to be successful in the low-end healthcare market. Historically, the end users made the purchasing decision. But the shift in purchaser and market segment added a new dimension to the product feature decision-making process. In Group C, Hewlett-Packard found that its sales and marketing retail positioning had to be modified to reach the majority of potential customers in the lower priced market segment.

An understanding of profitability drivers can enable marketing representatives to more effectively reach consensus with the finance and R&D representatives. Group A's new product, which had a higher profit margin than the existing product, could be upscaled to meet the needs of many current customers. By understanding profitability, marketing could provide incentives to the salespeople to sell the most profitable product and not necessarily the most expensive one to meet customer needs. By further understanding manufacturing cost, the marketing representatives in all of the groups might have more constructive discussion regarding feature decisions.

A new product can often find or create new market segments that were far beyond the original intentions. Positioning flexibility is critical. In addition, rapid and cost-effective product adaptability is key in serving these markets. Group C has sold derivatives of its platform product to essentiallly all segments of its industry. The group has actually created a new market, affordable color printing, which is transforming the way people create documents around the world.

Chapter 3: Product Development.

3.1 The Process

The overall product development process was found to be very similar for all three groups. A matrix organization is used in both functional areas and product groups. Functional areas include engineering, manufacturing, and marketing groups. Product groups consist of cross-functional teams. A new product concept can come from any of the functional areas. New product ideas and program funding are reviewed and approved at the divisional level with input from the various functional areas. A program manager is responsible for a particular product program. A program manager typically has project managers who further delegate tasks to individuals who also report back to functional areas. The amount of empowerment bestowed upon individuals varies depending on leadership style and perceptions of the capabilities of each individual. The following subsections will discuss some of the most interesting findings about the processes of each group.

3.1.1 Group A Process

This group was working to produce a low-cost alternative to an existing high-value, high-priced product, the A1. The current product cost was retailing for over three times its cost. The new product group attempted to achieve a cost reduction of over 70% for the new product and actually succeeded in surpassing this goal.

Design objectives #1, #2, and #3 were cost, cost, and cost. In past projects, typical design objectives would have been performance, time to market, and cost. The cost objective was set at a little over half the cost of the existing product.

A comprehensive cost analysis was conducted for both the existing product and competitive products. Pareto charts, special types of vertical bar graphs, were used to visually display the relative magnitude of various cost drivers for each product. The pareto charts showing the actual cost data were posted very visibly in the engineering areas. The charts illustrated both cost and price information for internal products and all competitive models. In addition, a large plot illustrated the design concepts that led to significant cost savings. Costs were prioritized by magnitude, and various methods were used to reduce costs. Ideas for reducing costs came both from within the company and externally. Examination and imitation of manufacturing methods, sourcing methods, and design methods from other products within the company, competitive products, and particularly consumer goods led to large-scale cost reductions.

A new computer-based project management system was implemented during the A2 project to help manage project logistics. This new methodology provided a structured way to schedule, plan, and control project details, and resulted in an improved slip rate of 10% compared with previous slip rates of 50-60%. This may have helped alleviate the problem of changes in leadership, which were a particular problem with this project team: the project leader was changed three times over the course of the project.

As time progressed, cost moved lower on the objective list. Performance and time to market became higher priorities as production time neared. It was indicated that this was due to expectations in the marketplace and from the marketing representatives. Furthermore, resources were limited, especially since this low-cost project had relatively low priority from the perspective of upper management.

The A2 group was especially creative and assertive in its development and design processes. The engineers were eager to gain insight from other divisions within their company, their competitors, and, surprisingly, industry outsiders. Cost reduction ideas were processed thoroughly for feasibility from both a marketing and manufacturing standpoint, again displaying an extraordinary use of cross-functional teams. For example, consumer products were investigated, and the material cost for plastic in many items was estimated to be significantly lower per unit than the plastic in the current A1 product. Manufacturing engineers confirmed that a lower grade of plastic would indeed suffice for most of the plastic required for the planned A2 product. However, marketing representatives were also included in the decision-making to ensure that the consumers would still perceive an acceptable price/value mix with the proposed reduction in "touch and feel" quality of the product. In one consensus, the team decided that a lower-grade plastic would be acceptable resulting in a significant reduction of material cost.

3.1.2 Group B Process

The project objectives for both project teams S and T were determined by committees in upper management. The two teams began their work independently, in a direction that most likely would have resulted in extensions to the B25/20 and B10 families. However, a serious engineering resources shortage resulted in an initiative to increase efficiency and decrease engineering demands within the group. The project managers met with each other, engineers, manufacturing representatives, and marketing representatives. The two product lines were broken into components, and projected costs and engineering hours were tabulated. Customer expectations and expected price points were taken into account when trying to find areas for possible homologation between the two product lines. A collaborative effort resulted in the decision to share one of the more complex, costly subsystems between both the low-end and high-end products.

Since the common subsystem was shared by two product groups, both groups were involved in the decision-making. The S group consistently sought ways to minimize the cost of the back end, while the T group focused on meeting all of the needs of the high-end customer. For example, the S group replaced one component of the shared subsystem with a component based on a different technology. The new component cost one sixth as much as the old one, but retained all of the functionality desired by the high-end group. It was through this collaborative effort that the shared subsystem achieved both the functionality goals of the high-end group and the cost objectives of the low-end group.

The low-end group used several methods to reduce the costs of its components. Each engineer was given design objectives for both functionality and cost. Engineers were then empowered to varying extents to make the trade-offs between cost and function. Cost data was published on a regular basis to all team members. Pareto charts were commonly used to display cost information. Production representatives were moved beside the design engineers. Cost savings idea contests were used to encourage a shift in thinking towards cost reduction, with small incentives such as free dinners. Various seminars were conducted to explain the costs of different types of designs and manufacturing methods, such as surface mounting.

This team regularly dismantled competitive products, comparing their advantages and disadvantages. The S team tried to estimate costs of various competitive designs, searching for ways to reduce its own costs. The two major competitors each had over 50% more research and development resources than this group, so it was critical to understand each new model quickly. There did not, unfortunately, seem to be a structured method of organizing this information.

3.2 Product Architecture

Many theories suggest that by optimizing product architecture, a company can reap great benefits. Two of these theories are Design for Manufacturing and the Product Family Concept. Design for Manufacturing consists of using techniques to minimize the manufacturing costs of a product. The Product Family Concept promotes the use of base product platforms which can then be modified to create product variations at a lower cost than designing products in isolation from one another. Strong evidence of the effectiveness of both of these practices was found during the course of this study.

3.2.1 Design for Manufacturing

The design for manufacturing (DFM) methodology, when used effectively, can help a development team minimize manufacturing costs of a product while maintaining a desired product quality level. Profit margin is directly related to manufacturing cost. A lower manufacturing cost can allow a company to offer lower prices while maintaining a constant profit margin.

There are many training courses, seminars, books, and technical papers available on the DFM methodology. For this discussion, the basic methodology as defined in Product Design and Development will be used as a reference (Eppinger, Ulrich, 1995). The DFM methodology consists of five parts: (1) Estimation of manufacturing costs, (2) Reduction of component costs, (3) Reduction of assembly costs, (4) Reduction of supporting production costs, and (5) Consideration of the impact of DFM decisions. In order to implement this methodology, cross-functional teams, or at least cross-functional information, is critical. A wide range of information must be gathered and analyzed, including: drawings, product specifications, design alternatives, production and assembly capabilities, estimated manufacturing costs, volumes, and a target manufacturing cost; this information usually comes from many different areas within a company such as finance, marketing, production, and product development areas. Once product specifications are somewhat refined, a bill of materials list with estimated costs is useful. Since many factors are interdependent, such as product specifications and manufacturing costs, this is an iterative process. Furthermore, conflicts often arise between functions when the prioritization of objectives is unclear.

All three groups studied used DFM techniques to reduce the cost of their product. Cross-functional teams were also used in all three groups. These teams consisted of members from finance, marketing, production, and engineering. Cost information availability and visibility was an integral part of cost reduction in all three groups. Production engineers worked closely with the design engineers throughout the project. Group B found it helpful to relocate the production engineers adjacent to the design engineers.

Group A, in particular, was very successful in implementing DFM techniques to their advantage. The manufacturing costs were decreased significantly from A1 to A2, although the product configuration was very similar. Some of the inspirations for these production cost reductions included:

- The use of a single type of screw by the Japanese Automotive Industry.
- The use of break-away plastic parts from a single mold in plastic toy models.
- The low cost of components used in large volume production-- i.e. taking advantage of this by utilizing identical components.
- Subsystem designs in mass-produced consumer products that were similar in concept but lower in cost compared with subsystems contained in A's product.
- Low-cost packaging methods used in consumer products.

As a result of the implementation of these and other cost-savings ideas, the direct materials cost was reduced by approximately 50% per unit while the the labor cost remained at about the same rate per unit from A1 to A2. For A1, direct materials represented about 93% of the total actual cost, while for A2 direct materials represented only 85% of the total actual cost. Figure 3-1 illustrates the difference in materials and labor costs from A1 to A2. Figure 3-2 illustrates the difference between materials and labor costs for A2 compared with three competitive products, X, Y, and Z. Cannibalization of A1 by A2 is actually a desireable effect. Due to the tremendous reduction in manufacturing cost discussed previously, the absolute dollar amount of profit margin on A2 is actually higher than for A1.

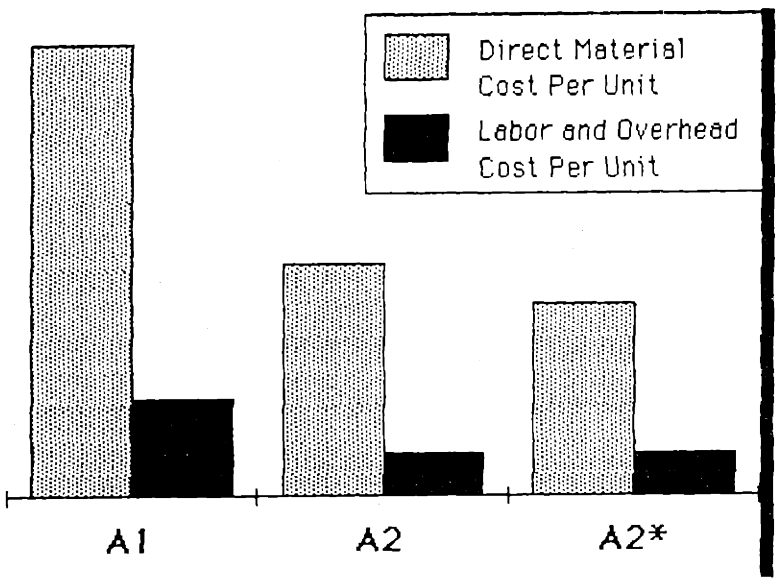


Figure 3-1. Comparison of Manufacturing Costs of A1, A2, and A2*.

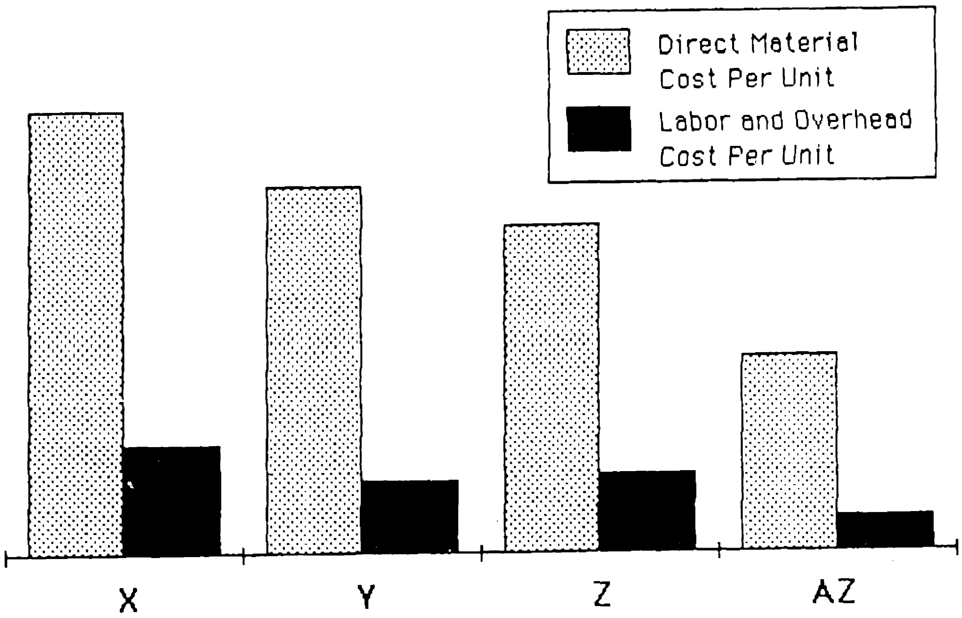


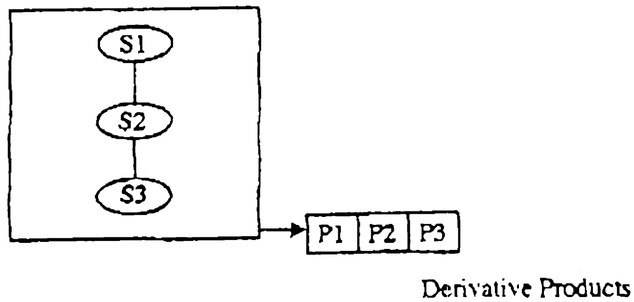
Figure 3-2. Comparison of Manufacturing Costs for A2 and Competitive Products X, Y, and Z.

Although cost was a top objective for all three groups, the team members were not following a specific DFM methodology. Many of their methods fell into the realm of DFM, but it is possible that a better-defined methodology could have helped their process. For example, Group A searched extensively in other industries and products for alternative solutions to their component and subsystem designs. Group A indirectly learned and copied several DFM methods, inlcluding part standardization and global material sourcing, from studying other companies rather than following the systematic, comprehensive DFM methodology. Group Group B, on the other hand, appeared to be looking for the lowest-cost alternative only from readily available optoions. In future projects, increased awareness of DFM techniques may be helpful, in addition to the utilization of DFM guidelines to direct the overall product development process.

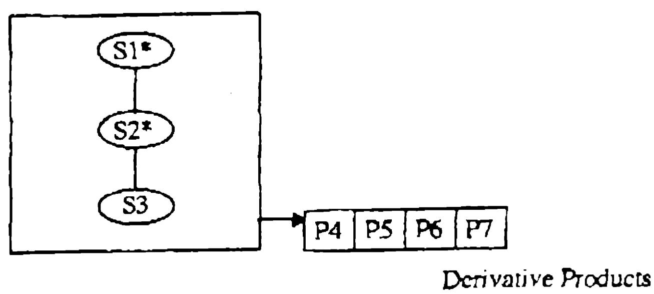
3.2.2 The Product Family Concept

There have been several works which explore the topic of product families. (Christensen, 1992, Clark and Wheelwright, 1992; Meyer and Utterback, 1993). Figure 3-3 shows a figure excerpted from one such paper that clearly illustrates the product family concept (Meyer, Tertzakian, and Utterback, 1995). Well-planned and well-executed product platforms can offer fundamental improvements across a broad range of performance dimensions. Product derivatives use the basic platform with incremental improvements such as cost-reduced parts, add-ons or enhancements, or a manufacturing process change. Platforms provide a better system solution across market segments. A platform should reach a core market segment, with relatively simple adaptation into derivatives by adding, substituting, or removing features. Sony is an extreme example of the potential success of using such a strategy. With their "hyper-variety" strategy, its 200 Walkman models are based on only three platforms (Clark and Wheelwright, 1992).

Initial Platform Architecture: Common Subsystems and Interfaces for Multiple Products



Platform Extensions: A new generation where number and types of subsystems and interfaces remain contant, but where subsystems and interfaces are enhanced.



Platform Renewal: A New Architecture, where subsystems and interfaces from prior generations may be carried forward and combined with new subsystems and interfaces in the new design.

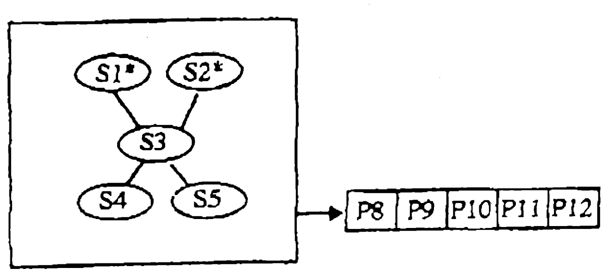


Figure 3-3. Product Family Concept Overview
Source: Meyer, Tertzakian, and Utterback, 1995

According to Meyer and Utterback, "concentrating at the level of the product family, and more specifically on the development and sharing of key components and assets within a product family, is a vital issue...for an existing product family, renewal is achieved by integrating the best components in new structures or proprietary designs to better serve evolving customer needs", (Meyer and Utterback, 1993). All three groups in this study seemed to keep this philosophy in mind as they developed their products. Before embarking on this study, I was very curious about the practical implementation of such a philosophy. How do you determine and optimize modules of a product? How do you optimize a module for all derivative products, especially when you might not know future derivatives? How does integration work? How much planning is necessary? I found some very interesting answers to my questions.

The breakdown of products into modules seemed relatively simple. A schematic drawing showing subsystems and interfaces of the current product was the starting point for both Groups A and B. For Group C, they used the design of their other printer products as an initial baseline. Optimization of the modules came primarily from design for manufacturing techniques and continuous improvement suggestions. In some cases, DFM methods allowed several components to be combined, shrinking the number of parts within a subsystem. Subsystems were substituted with similar designs from other products within the same company or with lower-cost designs from an external company. By sharing a subsystem between its two main platforms, T and S, Group B was able to offer a broader range of price/value combinations in their new product line.

Group B originally had two separate platforms, one for the B20/B25 line and another for the B10. In their low-cost initiative, they were able to base their new product line on a single platform. The T and S platform were designed side by side, with the same number and type of subsystem and interfaces. Therefore, T could be considered a single platform, and S could be considered a platform extension. S and T share one identical subsystem and various components. Although the other subsystems are of the same type, they were designed separately to meet two distinct market groups, the high-end and the low/medium-end. It was the shared subsystem that allowed the S platform to be upscalable from the low-end to the medium-end, which was not the case with the B10. By standardizing and sharing a complex subsystem, cost per value was reduced for each group. However, tradeoffs did exist. The new shared subsystem had higher manufacturing costs than other options available to the low-end S group. The new shared subsystem was not quite as extravagant as the high-end group may have liked. On the bright side, development costs overall for both groups were lower for this subsystem, and will continue to be less costly in future generations for a single subsystem rather than two subsystems.

How do you optimize a module, or a platform, for that matter, when future derivatives are unclear? Well, the answer depends on who you ask. Those working on low/medium end projects seemed to believe that the base module or platform should be positioned somewhere in the middle, with cost as a top priority. The high-end engineers, on the other hand, were primarily interested in developing top-of-the-line subsystems, incorporating the newest technology and setting trends in the industry. Professor Marc Meyer of Northeastern University has promoted a low-end base platform, which is then "upscalable". He conjectures that it is more practical to add-on features to create derivatives rather than to reduce costs de facto. (Meyer, MIT lecture, 1995). A basic diagram of Meyer's Upscalable Platform framework is shown in figure Figure 3-4.

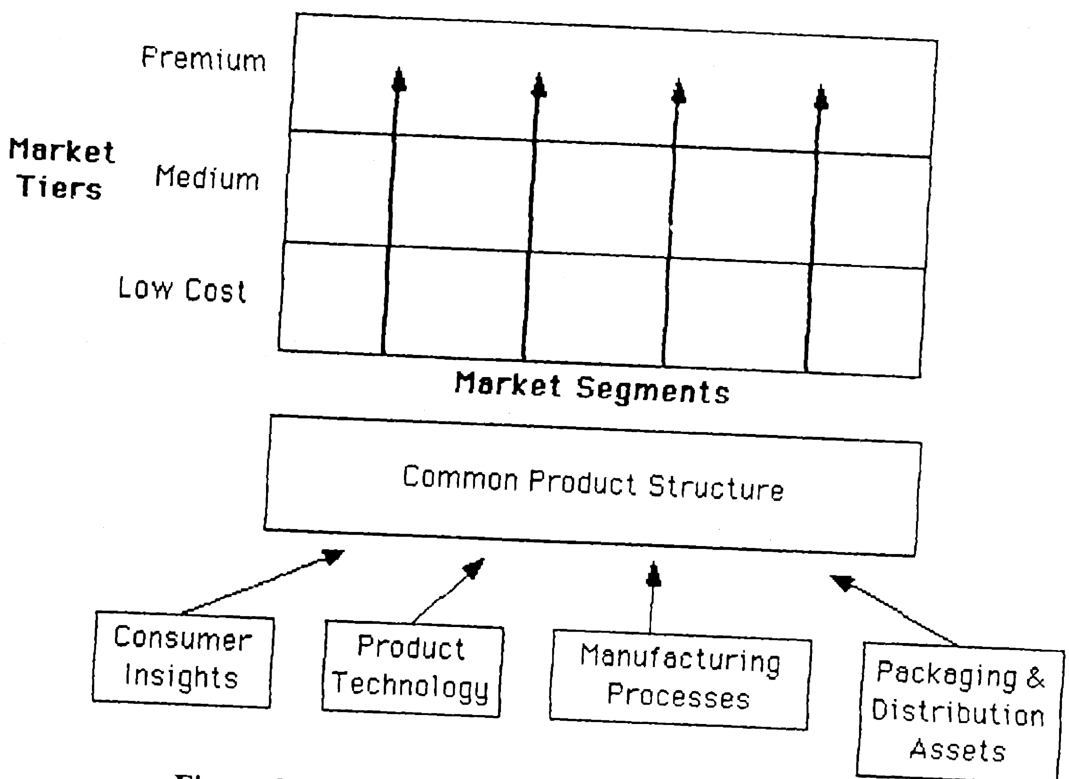


Figure 3-4. Meyer's Low Cost Platform Framework
* Source: Lecture by Professor Marc Meyer at MIT on November 16, 1995

This model could be used as a generalization of the platform positioning used by The DeskJet group. They orginal DeskJet was designed with cost as the number one priority. Since then, they have been able to upscale their platform to produce many derivatives at varying prices. Figure 3-5 illustrates the platform positioning within the other two groups. Essentially, platforms were either high-end and downscalable, or low-end and upscalable. As in the case of the B25 and the B20, there was minimal difference in cost from the high-end model to the downscaled medium-end model. The new S product for group B did not meet Meyer's ideal platform positioning either, but at least the cost could be downscaled or upscaled with product features.

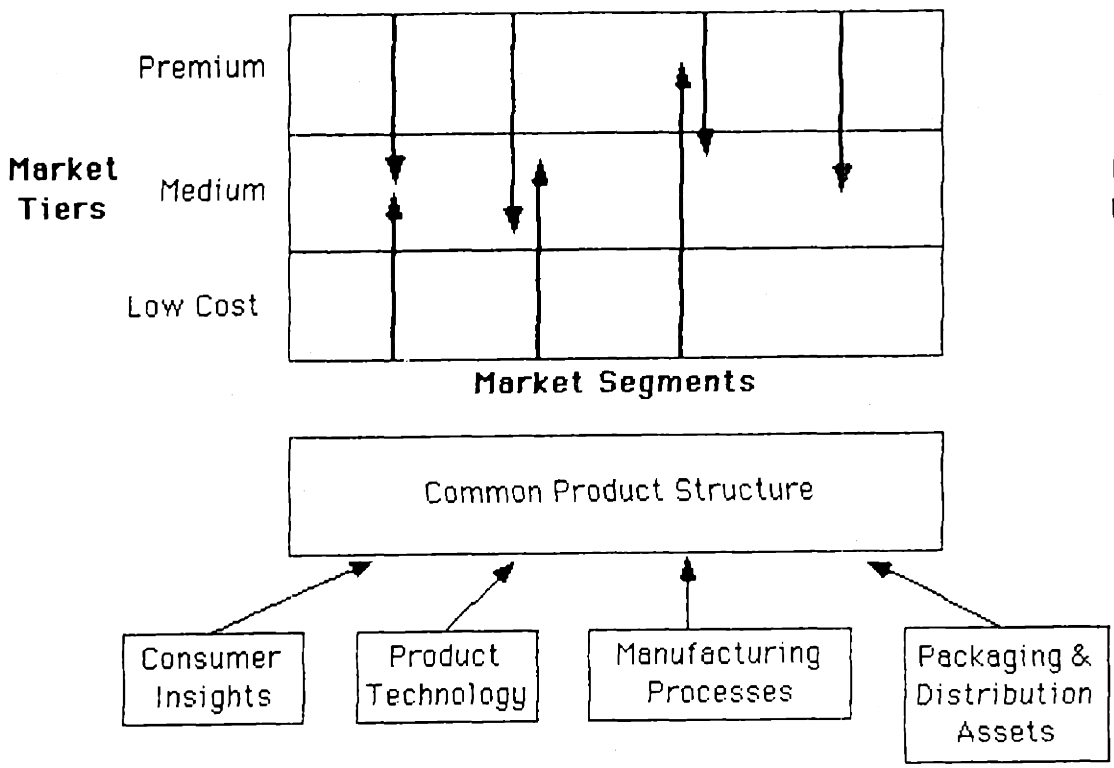


Figure 3-5. Meyer's Platform Framework in Practice -- Groups A & B.
* Source: Lecture by Professor Marc Meyer at MIT on November 16, 1995

Engineers in groups A and B both felt that it was easier to design for the high-end and then downscale, rather than vice versa. They believed the product specifications of the high-end model were critical in the initial design, so that the appropriate interfaces, such as packaging space or processor memory capacity, would be put into place in the core platform design. Unfortunately, as we saw with the S and T groups, engineers working on high-end design often place unecessary costs into the design. Furthermore, since these engineers had historically worked on high-end products, they had become accustomed to creating state-of-the-art products with every imagineable feature. A change in culture and a shift towards standardization of interfaces may make the low-end upscalable plaform more feasible in the future for these groups. By defining critical needs rather than all-inclusive wish lists of the high-end market segment, marketing can play a leadership role in the product specification decision-making process.

Integral, Inc., a consulting company, believes that "many companies systematically underinvest in [platforms]. The reasons vary, but the most common is that management lacks an awareness of the strategic value of platforms and fails to create well-thought-out platform projects. To address this problem, companies should recognize explicitly the need for platforms and develop guidelines for making them central part of an aggregate project plan." (Clark, HBR 1992) These three product groups did not plan their platforms extensively from the beginning. The HP DeskJet Group did have a modular, low-cost design, so it was relatively easy for them to extend their platform and to create multiple product derivatives. Group A was looking at producing a single product with a significantly reduced cost, but they did not take a big picture view of the product family concept. Group B was originally planning on developing their two core platforms in two separate tunnels, and were driven by unusual resource restraints to combine them under a single platform. Platforms require substantial advance planning and the involvement of R&D, marketing, manufacturing, and senior management. The DeskJet Group has certainly mastered the ability to modify and extend a core platform to create multiple products for a low-cost. Groups A and B, on the other hand, may be able to gain significant value from taking a step back, perhaps from a divisional standpoint, and developing a long-term family planning strategy.

Chapter 4: The Culture.

Within Company ABC, each division is run as a single business unit, but it is also somewhat affected by the performance of other divisions within the company. Furthermore, other divisions' success with low-cost development was well communicated to the members within this team. However, team priorities seemed to be driven by project specific goals in both of these groups.

Group A's particular division is small, with less than 1,000 employees. Thus, communication among functions has been relatively frequent, and teamwork between functions has always been present. The design engineers were provided with the objectives, and then empowered to make tradeoffs as necessary between aspects such as performance, cost, and time to market. Some engineers did not agree with the initial positioning of cost as the first three objectives, however, explaining that quality should have higher priority. Expectations of a group may also drive the culture. The following table compares the magnitude of the resources and expectations for the development of A1 versus A2:

	A1	A2
Project Priority	#1	#7
Budget	$2X	$X
Number of Engineers	7Y	Ranged from Y to 3Y
Time to Market	(5/8)Z	Z

A1 was #1 on the project priority list on a divisional level compared with #7 for A2. Clearly, A2 had a significantly lower budget and resources priority than A1. For example, the project manager changed three times and a period of time elapsed when there was no project leader on the A2 project.. However, the A2 team was provided with significantly less stringent time to market objectives, defined as the time from initial development to shipping.

Within Group B's division, a new vice president was pushing for low cost initiatives. Although all project teams working within this division were aware of the low-cost initiatives, those involved in "high-end" T product continued to focus on functionality, performance, and form, without much consideration for cost. Those working on the "low-cost" S product focused on adding functionality only when cost effective. The S and T teams held joint meetings to discuss any new developments on common components. Members from T often wanted to add features, wanting their product to be the best in the market. Members from S would counteract with lower cost alternatives or veto the feature altogether. Again, members from the S team were able to add essentially identical functionality for one sixth of the cost of a feature proposed by the T team. It is interesting that S's enthusiasm and success with cost reduction did not seem to rub off onto the T team members. On the other non-shared T subsystems, T members were not consistently trying to produce low cost designs. Again, the engineers were trying to reach their specific project goals, which did not include profitability. The teams seemed to have a high level of project loyalty and team spirit rather than a company-wide loyalty.

The culture at Hewlett-Packard and within the DeskJet group was found to be quite similar to these two groups. Cross-functional teams were used with an extraordinary effectiveness to reduce costs while meeting customer needs.

4.1. General Findings.

Well-defined goals provided measurement and promoted accomplishment. Goals set a clear definition for success, providing a focus for daily work tasks. Goals provided a shared method for evaluation in the product feature decision-making process, where conflicts were common between functions.

"Pushing the envelope" facilitated unexpected results. By setting goals that are seemingly unrealistic, i.e., Group A's goal of 70% cost reduction, can enable out-of-the-box thinking and drive extraordinary performance. Continuous improvement efforts can be very successful in raising expectations and deliverables of individuals and teams.

Cross-functional teamwork was critical. Key skills included both the willingness to share information across functions and the willingness to learn and integrate important factors from each functional area. Managers and engineers who had a working knowledge of cost drivers, manufacturing processes, and customer needs were better able to meet their cost reduction goals while still producing satisfactory products.

Learning helped employees reach their goals faster. The types of learning included, building prototypes, models, examining external products and subsystems, and talking with others within the company. For example, by studying other companies, Group A found that global materials sourcing and parts standardization could result in dramatic cost reductions.

Direct monetary incentives were not used by any of the groups studied. Although an individual's compensation was somewhat related to meeting their objectives on a performance-review basis, there was no direct bonus or product-specific profit sharing used to encourage cost reduction in any of the three groups. Some employees from Groups A and B thought that this might be a good idea, while others preferred their lower risk, more diversified company-wide profit sharing incentive plan.

Chapter 5: Summary and Conclusion.

The case study and the literature corroborated the general hypotheses stated at the beginning of this study. Specifically, that in order to transition successfully to the low-end market, companies must: 1) redesign their product lines en masse and revisit the core building blocks of these product lines, including product architectures, manufacturing processes, and distribution channels, and 2) adopt new talents and skills to accomplish (1).

The product teams studied dissected their products into modules, optimized these modules, and then created a range of products; these products were able to profitably fill the needs of a wider spectrum of market segments, particularly the lower-end markets. Most of the cost reductions came from changes in the product design or manufacturing processes that reduced the production cost. Distribution channels, as we saw in the case of the DeskJet group, were also adapted to target these newer market segments with different buying patterns than previous customers.

New talents and skills were developed to reach these goals. Engineers came to better understand marketing and finance, and vice-versa. Design engineers and production engineers worked together rather than "over the wall" to develop low-cost solutions. Core capabilities such as design skills and the ability to understand the customer were manipulated using creativity and flexibility to push the groups' products into new market tiers. Finally, management came to understand that sharing ideas, concepts, and product modules among product lines and functional areas can reduce costs and secure success in the marketplace.

5.3 General Approach

Several of the methods observed during the course of this study may help other product development teams who are attempting to transition to low-cost product development. These include:

- The use of modules in product design and long-term product family planning to best leverage these modules.
- The use of Design for Manufacturing methodologies which include, but are not limited to: cost estimation, cost reduction, parts standardization, and part count reduction.
- The use of cross-functional teams.
- Flexibility in market segmentation and distribution methods.
- High awareness of cost information throughout all functions.
- Setting well-defined, overly optimistic goals.
- Encouraging strong leadership and individual empowerment.

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