

# The Product Family and the Dynamics of Core Capability

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INDIVIDUAL PRODUCTS ARE THE OFFSPRING OF PRODUCT PLATFORMS THAT ARE ENHANCED OVER TIME. PRODUCT FAMILIES AND THEIR SUCCESSIVE platforms are themselves the applied result of a firm's underlying core capabilities. In well-managed firms, such core capabilities tend to be of much longer duration and broader scope than single product families or individual products. The authors recommend a longer run focus on enhancing core capabilities, which includes identifying what they are and how they are applied and synthesized in new products. ♣

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Why is it that some firms introduce distinctive new products time and time again, when so many other firms are far less able to generate new products? More specifically, some firms, while strong in product design, fail to gain commercial reward, but their more successful counterparts exhibit the right mix of capabilities in implementation, manufacturing, and distribution as well as product design. Much current management thought addresses developing single products as rapidly as possible. Product development when seen from this perspective has two essential problems: redundancy of both technical and marketing effort and lack of long-term consistency and focus. We will argue for a broader approach to managing new products.

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 the vital issue. The benefit of examining elements shared by products within a family is that firms will then develop the foundation for a range of individual product variations. At an even broader level, one can examine relationships between product families themselves to achieve even greater commonality in both technologies and marketing. 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. Integration improves all products with-

in the family. Diversification can be achieved by building on and extending capabilities to build the foundations of new but related product families. For example, Hewlett-Packard built on a foundation of core capabilities in scientific instruments to create families of computers and peripherals, and also to enter into the medical systems business. Similarly, Canon built on its copier and facsimile machine platforms to create laser printer and scanner businesses.

Figure 1 portrays a set of products and their relationships over time that we believe is conducive to sustained success. Each generation of a product family has a platform used as the foundation for specific products targeted at different or complementary market applications ("Platform Development Family A," Products 1 through 4). Successive generations refresh older platforms with improved designs and technologies ("New Generation Platform Family A," Products 1 through 6). Starting work on the next product platform while completing specific products based on the current platform helps the company maintain product leadership. In terms of creating new businesses, new product families branch from existing ones, expanding on their technical skills, market knowledge, and manufacturing capabilities ("Platform Development Family B"). Thus, the development of new technologies is focused. Market extensions are related. High levels of customer recognition are

the cumulative effect of a robust product family. These factors all contribute to growth.

Deliberately building product families rather than single products requires management of a firm's core capabilities.<sup>1</sup> Quinn, Doorley, and Paquette view the firm as an intellectual holding company in which products and services are the application of the firm's knowledge assets. By targeting and focusing on the best of these assets, a firm can dominate its rivals.<sup>2</sup> Core capabilities cannot be divorced or viewed separately from the actual products that a company makes and sells on a daily basis. Core capabilities are the basis of products. Nondistinctive capabilities lead to nondistinctive products. Strong capabilities lead to strong product families because these capabilities are embodied in the people and assets applied to building a company's new products.

Our purpose in this article is to synthesize the two central concepts of the product family and core capabilities. Many managers with whom we have worked in the past have expressed a strong desire to understand better the evolution of their product families and leverage achieved from underlying architectures and designs. Many have also wanted to identify more clearly the core capabilities of their organizations and how these capabilities have also changed over time. To address both needs, we have developed a method to map product families and assess their embodied core capabilities. We will apply this method to three product families developed by a large corporation for the electronic imaging market and then use that application to more broadly consider how firms may better manage the development of new products.

## Defining the Product Family

What is a product family? What are those characteristics and properties shared by and therefore common to a series of related products grouped into a family?

The term "product platform" was used earlier in its common meaning: encompassing the design and components shared by a set of products. A robust platform is the heart of a successful product family, serving as the foundation for a series of closely related products. For example, Chrysler has just released three new lines of cars, the Chrysler Concorde, Eagle Vision, and Dodge Intrepid, based on a common platform in which all share the same basic frame, suspension, and drive train. New products are refinements or extensions of the platform. For example, Chrysler's forthcoming upscale New Yorker model will be based on a longer version of the new platform.

We will call products that share a common platform but have specific features and functionality required by different sets of customers a product family. A product family typically addresses a market *segment*, while specific products or groups of products within the family target *niches* within that segment. The commonality of technologies and markets leads to efficiency and effectiveness in manufacturing, distribution, and service, where the firm tailors each general resource or capability to the needs of specific customer groups.

The technology embodied in a product family has two key parts: the design and the implementation of the design. Design groups dedicated to new product platform research create basic designs, standard components, and norms for subsystem integration. Implementation teams create different product models, integrating component technologies to achieve specific product goals.<sup>3,4</sup>

To illustrate the ideas of the product family, platforms, and extensions of platforms as products, consider Sony's Walkman. Sanderson and Uzumeri catalogued all products introduced in the portable tape cassette segment.<sup>5</sup> Sony introduced more than 160 variations of the Walkman between 1980 and 1990. These products were based on a platform that Sony refreshed with four major technical innovations.<sup>6</sup> The company combined these major innovations with incremental improvements to achieve better functionality and quality, while lowering production costs. Sony's trademark is virtually synonymous with the portable cassette player.

Black & Decker's power tool business pursued a deliberate strategy to share major elements of product platforms across different product families.<sup>7</sup> In 1970, the company had hundreds of products. The products used more than thirty different motors, sixty different motor housings, and dozens of different operating controls. Further, each of the hundreds of power tool products had its own unique armature. Management determined that, in order to remain competitive, it would have to decrease its cost of goods sold by about a third in the coming decade. Black & Decker created a plan to design and manufacture product families based on shared components and modules. Nearly \$20 million was allocated to the effort. First, the company developed a hexagonal, copper-wire-wrapped motor field with standard electrical plug-in connections that would serve all its power tools.<sup>8</sup> Engineers designed standard motor housings and controls as well as a more standardized, adhesive-bonded armature. The company tackled each product family in succession (drills, jigsaws, sanders, etc.). The results were dramatic: product costs were reduced by 50 percent,

market share rose from 20 percent to a dominant share, and the number of competitors declined from more than twenty to three. The case also shows the extent to which product families can share technical designs and components, an understanding of market requirements, and production capabilities.

## Mapping Product Families

Individual products are therefore the offspring of product platforms that are enhanced over time. Product families and their successive platforms are themselves the applied result of a firm's underlying core capabilities. In well-managed firms, such core capabilities tend to be of much longer duration and broader scope than single product families or individual products.

We believe that the product family can be used as a basis for assessing the dynamics of a firm's core capabilities, in other words, how these capabilities grow, decline, and integrate with one another over extended periods of time. The first step is to *map* the chronology of a product family. The following pages will describe our method as we applied it to three product families in a large corporation engaged in the electronic imaging business.

Figure 2 shows a product family map. The general application of the products shown has been to reproduce computer screen images onto various presentation media. We refer to them as a *horizontal market* application in that they are general-purpose solutions for different customer groups in different industries that nonetheless have a common need.

In order to map this product family, we assembled a study group of ten people, all actively involved in the family development for many years and representing business, technology, and marketing functions. Producing the map required several intensive meetings. The top half of Figure 2 is the summary, and the bottom half the detail, showing the market introduction and termination date for each product. The product family is represented in four hierarchical levels:<sup>9</sup>

- The product *family* itself. Figure 2 shows one product family.
- *Platforms with a family* are encapsulated in large rectangles in the top half of Figure 2. There were four basic product platforms in that family: two platforms generated internally (one analog, the other digital) and two acquired from vendors as private-labeled products ("OEM Initiatives").
- *Product extensions* are denoted by oval forms starting at the beginning of the research and ending with the cessation of active marketing of platform-based products.

"Skunk works" projects, having no commercial product offspring, can be the first iteration of a product platform and provide important technological and market knowledge for subsequent platform extensions. The first product platform in Figure 2 has had two successive platform extensions.

- Specific *products* (numbered here to disguise real product names) are placed at and numbered in order of their market introduction dates and, in the bottom half of the figure, extend out to the date of marketing termination.

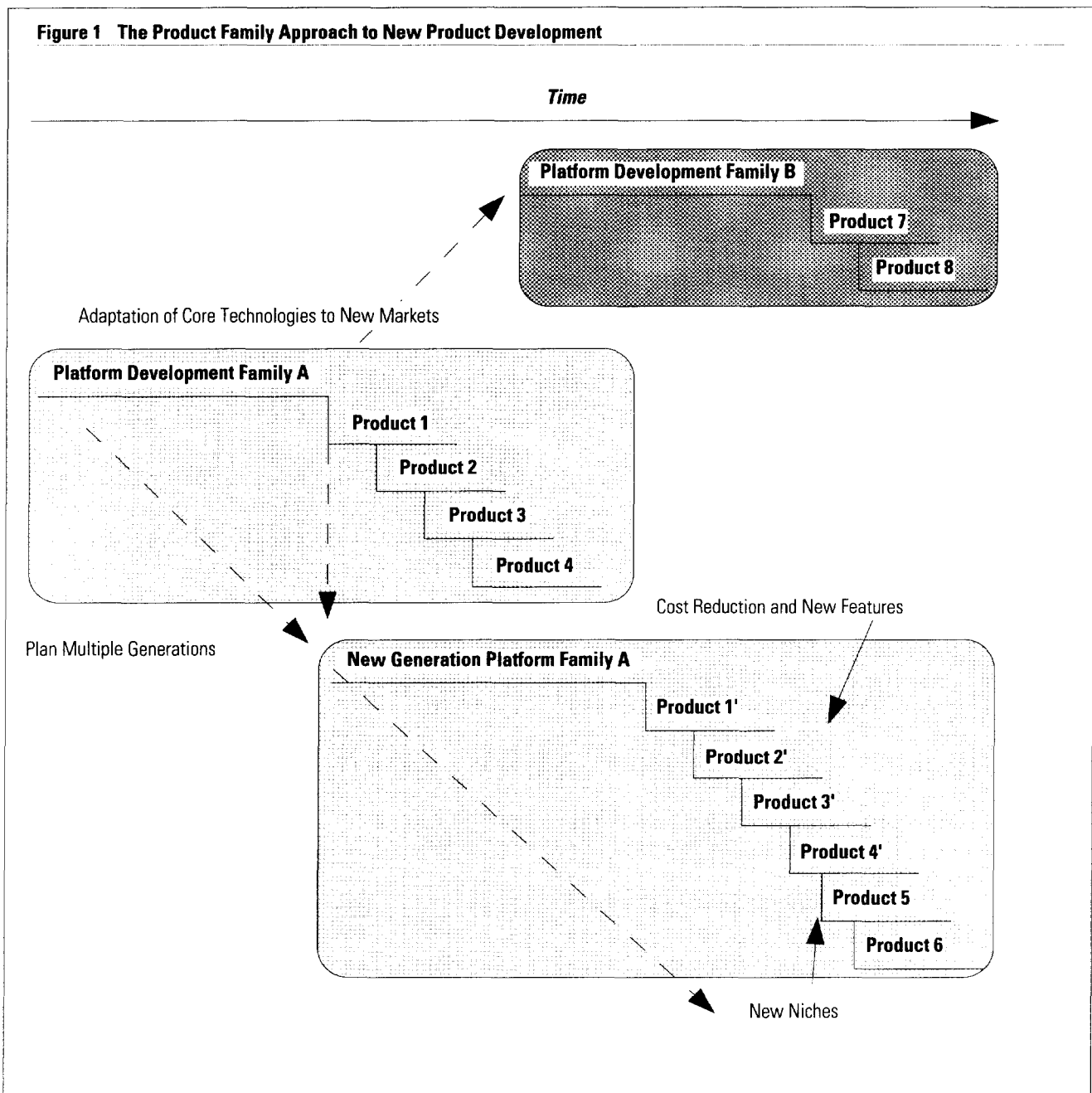
Product family maps convey a sense of continuity or the lack thereof in product development. For example, in Figure 2, there have essentially been three overlapping streams of development: analog architecture products, products resold from other vendors (called OEM initiatives), and the current digital architecture products. All have been carried forward by different groups in the company. The original development team chose not to abandon its initial analog platform in favor of the newer digital platforms being introduced by competitors. Its products became obsolete. Seeing that this was happening, management tried to short cut its lack of effective products with two private-label initiatives that were early digital systems. Meanwhile, two product champions resurrected the company's internal technical initiative by recruiting engineers from corporate research to create a new digital platform. The result, after four years of determined technical effort and marketing development, has been the delivery of what many would call world-class products.

Figure 3 includes the product family map described above as well as maps for two other, related businesses in the same company that addressed different areas of electronic imaging. Family A is a turnkey system made for a specific industrial vertical market. It is sold primarily through the company's own direct salesforce and requires systems integration at the customer's site. Family B contains the horizontal electronic imaging applications described above. The company sells these products through distribution channels. Family C consists of peripherals and components sold through a number of different channels; they have been aimed at both industrial and consumer market segments. Management selected these three families for us to study because they represented different points along the spectrum from making components to building turnkey systems and therefore provided a good test of mapping product families and assessing core capabilities.

## Assessing Core Capability

The product family idea serves as a basis for assessing

**Figure 1 The Product Family Approach to New Product Development**



the evolution of a firm's core capabilities. Figure 4 presents a detailed core capability assessment for Family B. Figure 5 represents a summarization of that detail. We generated similar charts for the other two families. The charts have four basic parts:

- The product family map as a legend is plotted against time in both charts. Key product events serve as anchors for subsequent data gathering and analysis.<sup>10</sup>
- In Figure 4, the product family team's strengths are assessed in relation to existing competition for specific core capabilities within four basic dimensions: product technology, understanding of customer needs as reflected

by products sold at that time, distribution, and manufacturing.<sup>11</sup> The solid line running across the measurement strips is a mean of responses from team members, the details of which will be described shortly.

- Figure 5 summarizes the means for responses for the core capabilities within the four basic dimensions.
- Figure 5 also shows a final summary of core capability strength as embodied within the product family.

All four parts show the ebb and flow of core capabilities over time for the product family.

The process of gathering data started with a group meeting of the product family team members.<sup>12</sup> At this

initial meeting, the team defined the product families, groups, generations, and specific products under a product scope established earlier by the study's executive sponsors. This process required several iterations, using recollections of product histories and archived project documents to create product maps. We also noted key products events, some made by the company itself and others by its competitors. These served as anchors for gathering information and then presenting it.

The study team was then reconvened in a second series of meetings to identify the general product technologies, the major customer segments, the distribution channels used over time, and the key manufacturing processes required for the product.<sup>13</sup> These are the specific core capabilities embodied in a product family and constitute the vertical legend running down the left side of Figure 4.

Our model posits that *generic* core capabilities in any product family exist in product technology, market understanding, and so on; the team defines the specific core capabilities within each of these areas. For example, the respondents who provided data for Family B developed a consensus that three basic technical capabilities were central to their products. These technologies were higher-level groupings of more numerous individual technologies. Participants must determine the appropriate level of grouping using their understanding of the technologies employed in a product family. Examples of technological core capability categories from this company and others where we have applied the method include "PC graphics hardware," "signal processing" or "circuit packaging" or "networked computing," and "applications software development." Since the purpose of the study is to facilitate *managerial* analysis and action, too much detail will obfuscate major trends in the past and a firm's needs in the future.

Figure 4 also shows that Family B had one major industrial customer group. The company sold the products through independent dealers and original equipment manufacturers. The team felt most comfortable combining specific manufacturing processes into one "internal manufacturing" core capability, and relationship management with suppliers and manufacturing subcontractors into an "external subcontractors" capability.<sup>14</sup>

We produced blank survey forms for each product family. These forms appeared exactly as shown in Figure 4 but with the measurement strips left empty for respondents to complete. Each measurement strip has five levels. These levels represent the degree of capability (from best in class to worst in class) *relative to competi-*

*tors at that time*, for each of the years in the product family's history as perceived by respondents.<sup>15</sup> This assessment method can be further anchored by having participants identify competitors that at different points in time represented "best in class" or close to it for each area of core capability. Competitors' names are simply inserted at the appropriate point along each capability measurement strip. (We could not include the names of best-in-class competitors for Family B in Figure 4 and still keep the case adequately disguised.)

Measurement strips can be extended into the future to learn a team's expectations. In fact, in other firms where we have applied the method, managers have included new areas of core capability that a product family will require in the future or, in other words, that appear as measurement strips starting in 1994 or 1995.

Respondents then completed the survey forms, using the same response scale for all core capabilities. We instructed them to indicate levels of strength relative to existing competitors for capabilities for only those years when they had worked on the product family. We also asked respondents to assess capability strength for the key product anchor points and then fill in the intervening years for which they had knowledge. Figure 4 shows average responses.<sup>16</sup>

Figure 5 summarizes the company's capabilities with unweighted means.<sup>17</sup> The bottom of Figure 5 shows a grand average of these capabilities.

Figure 6 shows the core capability assessments for all three product families in the study. We use the width of line and shading to represent levels of strength in core capability, so the reader can more quickly and clearly surmise meaning. The core capability embodied in Family A has gradually increased over the years to a moderate level of strength. Family B experienced strong initial strengthening, then a strong decline, and, more recently, an even stronger rebound in its embodied core capabilities. The company has yet to build significant core capability in Family C.

This method for identifying and assessing core capabilities is flexible. As noted above, each firm will identify those areas of core capability most important for each product family studied. Further, while the managers in Families A, B, and C chose to treat each area of core capability as equal in importance, other companies may wish to assign different weights to different capabilities for computing averages. These weights can be adjusted to accommodate changes in the relative importance of core capabilities over time. Further, we have used the same survey forms with long-term customers, which provides a way to validate a team's self-assessments and

to gain new perspectives on benchmarking its competencies.

## Core Capabilities and Performance

Higher levels of core capability should be associated with sustained success, be it in terms of product development effectiveness, financial performance, or learning and employee satisfaction.<sup>18</sup>

We asked divisional management of the sponsoring company to provide their assessment of the *success of the product family over its history relative to other new business developments undertaken by the company at that time*. Using a scale representing levels of performance, six senior vice presidents completed a measurement strip chart for each product family, basing their assessments on financial return.<sup>19</sup> We asked them to assess product families only for those years in which they had actively monitored and otherwise participated in the management of the product family. We plotted an average of these responses in Figure 7.<sup>20</sup>

Data for core capabilities and performance are compared in Figure 8, using width of line and shading to convey degree. Higher levels of core capability have tended to precede and then coincide with higher levels of performance. For example, Family B gained moderate levels of core capability in 1985, and better performance came in 1987. The obsolete analog platform in Family B for the two-year period between 1987 and 1989 did not significantly depress performance because customers were not quick to abandon the familiar product. However, participants indicated that the new digital platform arrived just in time in 1990. By 1991, the product family achieved very high levels of performance. Family A achieved moderate levels of overall core capability in 1988; better performance followed in 1989. Family C's levels of embodied core capability and performance have also been closely matched, i.e., poor, over the course of ten years. The history of these three product families appears to support a cause-and-effect relationship between core capability and performance.<sup>21</sup>

Achieving high levels of capability can be expected to have less impact in declining markets. We have recently completed a similar analysis for an electronic capital equipment company where, despite continuously growing core capability in its traditional mainstream product line, declining market conditions (slower growth and more competitors) have nonetheless yielded poorer performance relative to prior years. This company must find new market applications for its core technologies.

Market dynamics temper the relationship between

core capability and performance. We asked each family study team to indicate changes in the rate of market growth,<sup>22</sup> the level of competition,<sup>23</sup> and the effective product life cycle for their product families.<sup>24</sup> Figure 9 shows the results for Family B. For all three product families, market growth rates in target markets are now moderate to fast, and competition has intensified. Product life cycles have also shortened.

## Using Core Capability Assessment to Improve a Product Family

A company must continue to invest in renewing product platforms, particularly for markets with accelerating rates of product introduction and competitive intensity. For example, if management does not continue to invest to renew Family B's platform, the "dip" experienced before will probably occur again.

How is management to choose which requests to satisfy fully, or whether the resources requested are indeed sufficient? Many, if not most, firms allocate resources by individual product effort on an annual basis. Further, allocation requests tend to be summarized by functional area (R&D versus marketing versus manufacturing). Single-product funding impedes the development of a core for product families and therefore inhibits creation of the type of leverage that we have discussed throughout this paper.

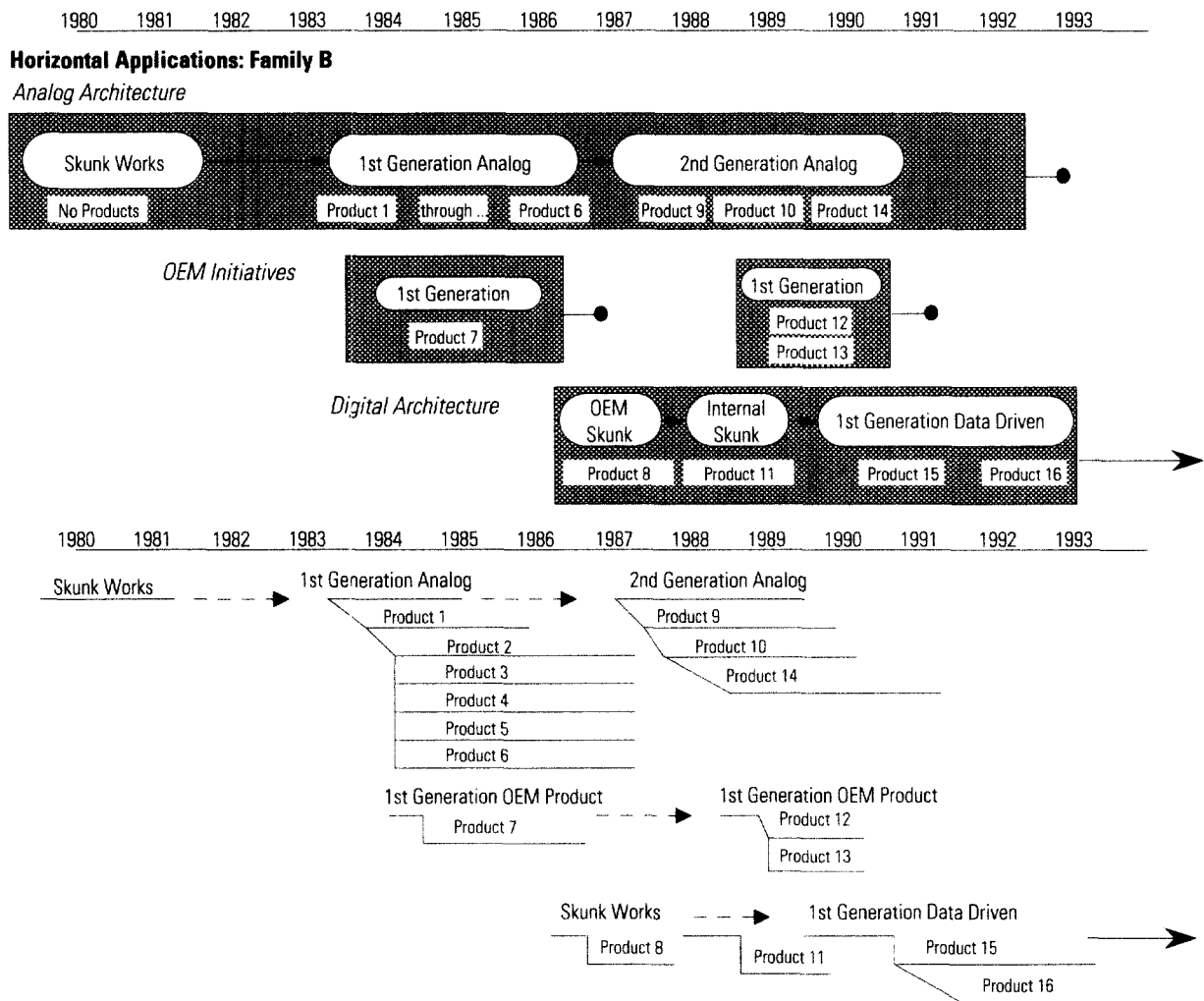
What does a firm need to do to achieve best-in-class status in technology, market knowledge, distribution, manufacturing, and service? Product family maps combined with core capability assessment may be useful in this regard.

For example, Figure 10 shows the core capability assessments for product technologies in Family A. While the first two technologies have risen above the industry average, the third (applications software development) continues to be well below par. The company must address this area of weakness to be more successful. Specific areas of need in the other product families also emerged from these more detailed core capability assessment charts.

## Explaining the Ebb and Flow of Core Capabilities

Core capabilities are inherently dynamic. They result from the efforts of individuals and are thus affected by the organization of teams, the selection of products and markets, and the nature and quality of those markets. Once gained, competence can be readily lost. Ill-considered

**Figure 2 Product Family Map — Two Alternate Representations**



ered managerial policies and approaches can destroy hard-won capabilities, impede learning, hurt the effectiveness of product development, and ultimately, damage the profitability of the company. Our work suggests this and illustrates what managers intuitively know and feel.

Four fundamental inhibitors of core capability creation have emerged as common themes in our work.

- **Lack of Patience.** Using unrealistic, short time horizons for the development of new businesses invariably leads promising technical and marketing development efforts to be killed before capability, visible on the horizon, is realized and exploited. How long should it take to achieve excellence in the relevant core capabilities in a new area?

A visual presentation of a product family powerfully conveys the nature of the embodied core capabilities,

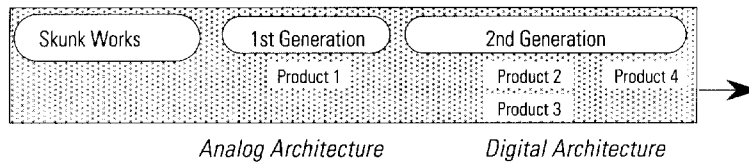
how painstakingly they may be gained, and how quickly lost. Of the three product families studied, the company achieved competitive levels of capability in only one family, and in that case, only after approximately ten years. This experience is by no means atypical. Other studies have produced time ranges from seven to twenty years.<sup>25</sup>

- **Failure to Adopt Innovations and New Architecture.** Technological discontinuities can quickly make a company's products obsolescent.<sup>26</sup> Radical technological innovation in an industry can make any given capability irrelevant. In fact, companies often get trapped in their earlier successes.<sup>27</sup> Thomas Edison dramatically improved the efficiency and reliability of carbon filaments in light bulbs when his business was attacked by more efficient but expensive metal filaments. Later, he was

**Figure 3 Three Product Family Maps**

1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993

**Turnkey Systems: Family A**

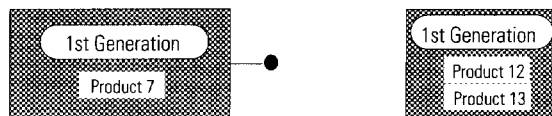


**Horizontal Applications: Family B**

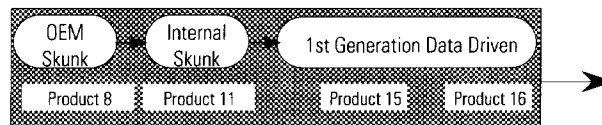
*Analog Architecture*



*OEM Initiatives*

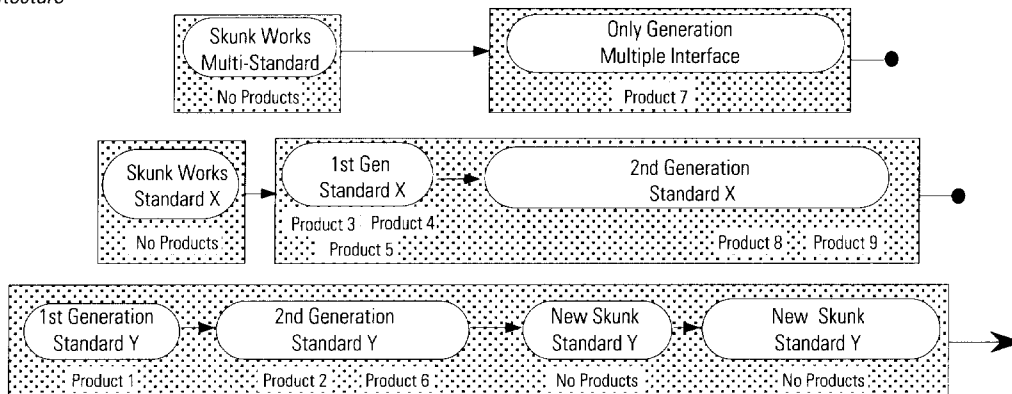


*Digital Architecture*



**Peripherals: Family C**

*Analog Architecture*

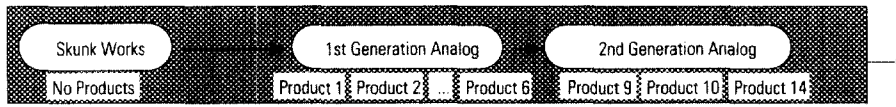




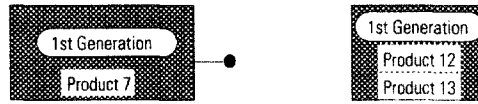
**Figure 4 Core Capability Assessment for Family B**

**Family B**

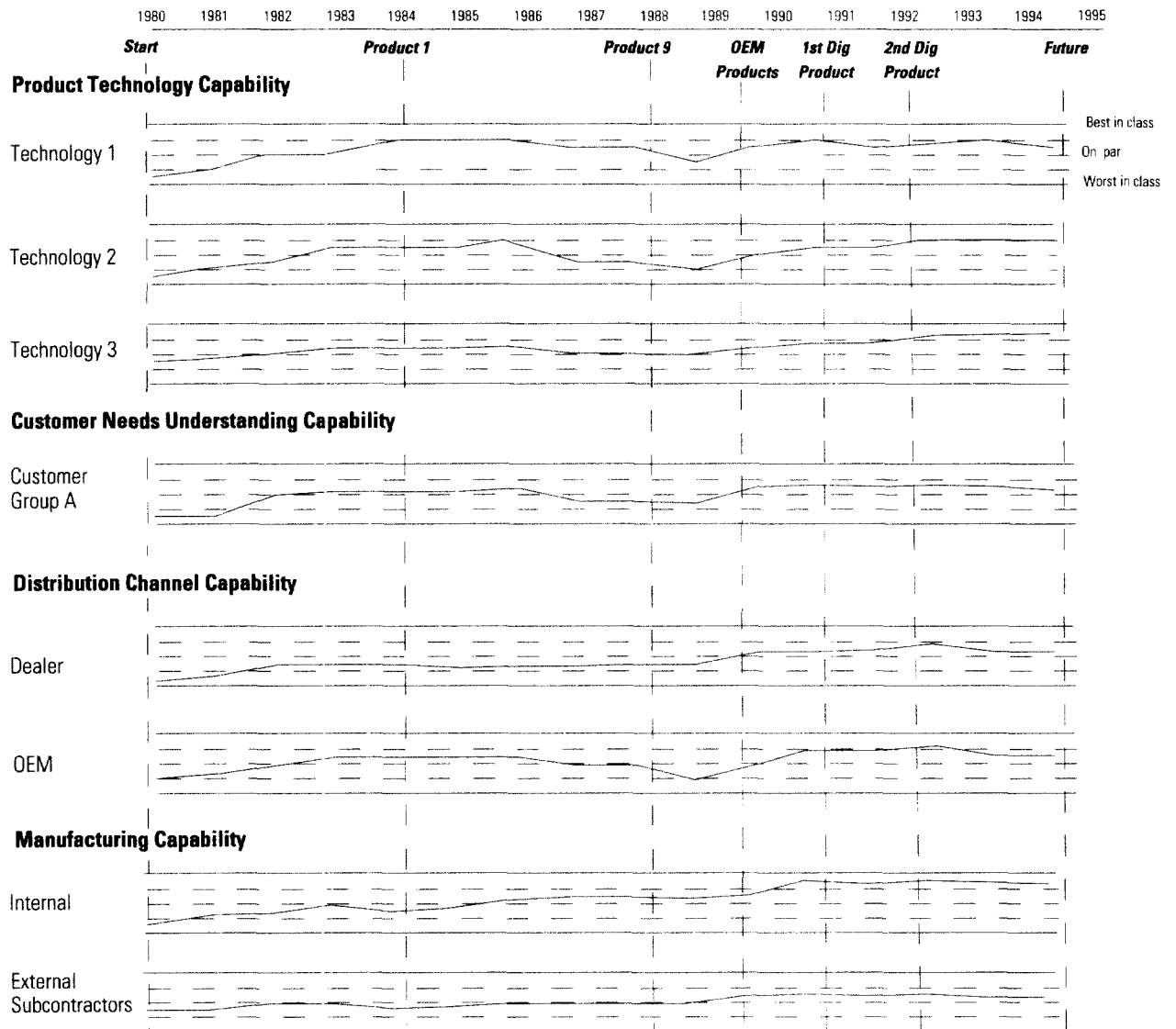
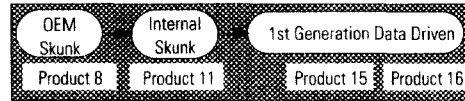
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*OEM Initiatives*



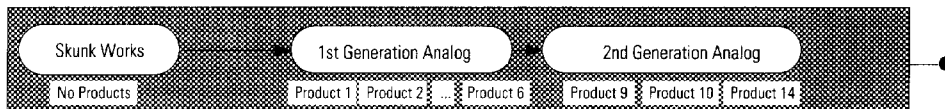
*Digital Architecture*



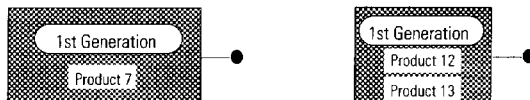
**Figure 5 Summary Core Capability Assessment for Family B**

**Family B**

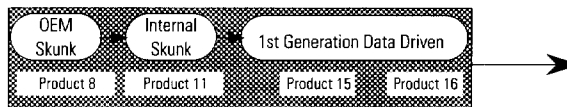
*Analog Architecture*



*OEM Initiatives*



*Digital Architecture*

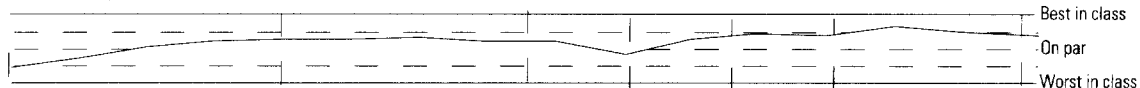


**Summary**

1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995

**Start**                      **Product 1**                      **Product 9**                      **OEM Products**                      **1st Dig Product**                      **2nd Dig Product**                      **Future**

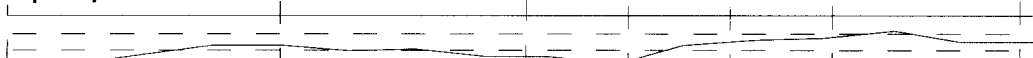
**Product Technology Capability**



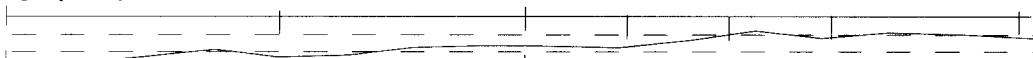
**Customer Needs Understanding Capability**



**Distribution Capability**



**Manufacturing Capability**



**Grand Summary**

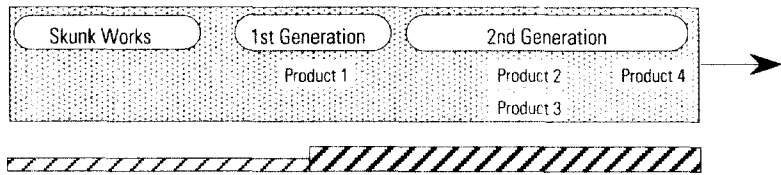


**Figure 6 Core Capability Assessments for Three Product Families**

1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993

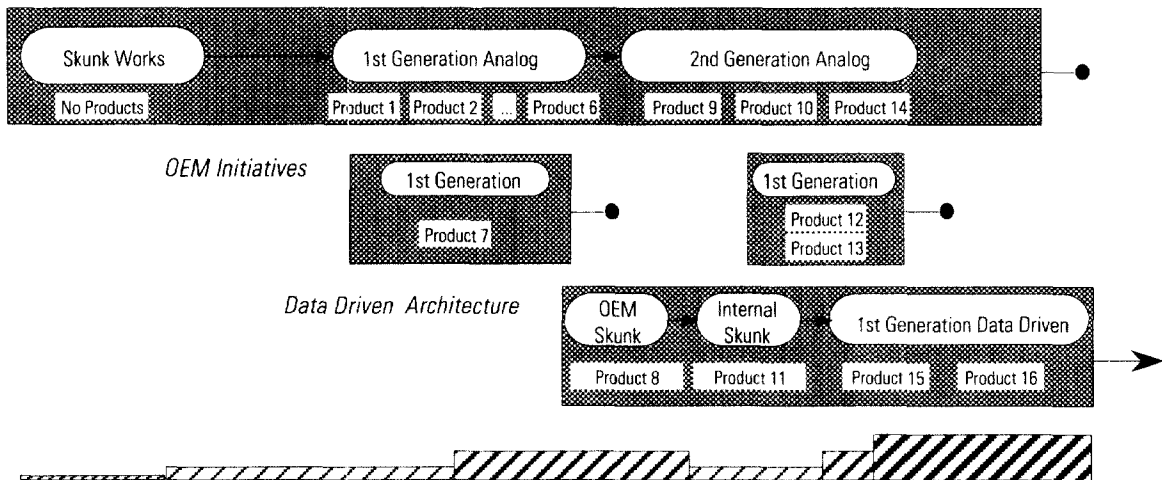
**Family A**

Core Capability  
as Assessed by  
Product Family Teams



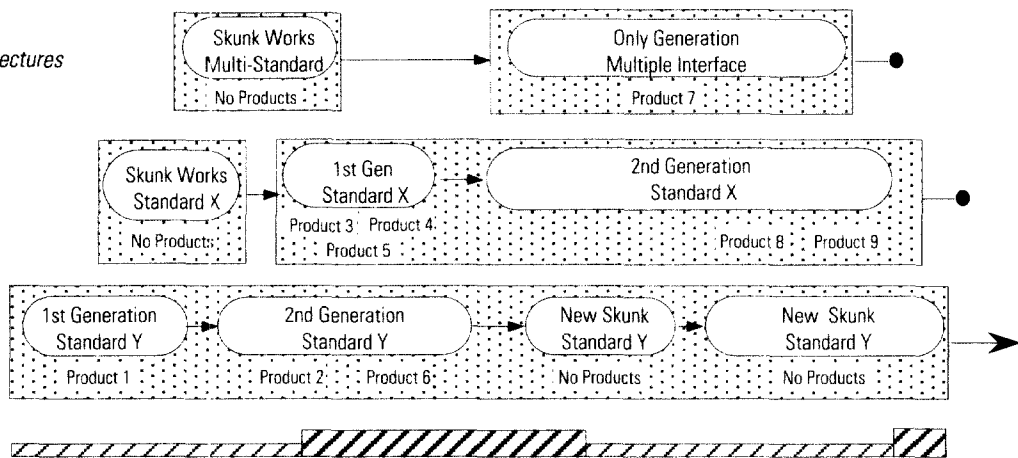
**Family B**

*Analog Architecture*



**Family C**

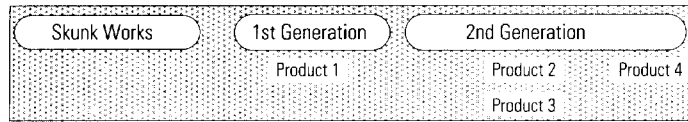
*Analog Architectures*



**Figure 7 Performance Assessments for Three Product Families**

1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993

**Family A**



Performance as Assessed by Senior Management

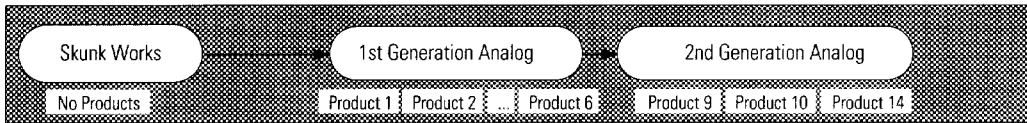


Among best new-business performance

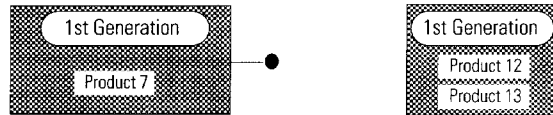
Among worst new-business performance

**Family B**

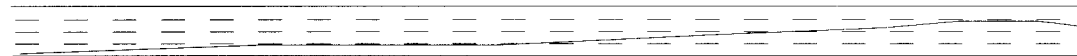
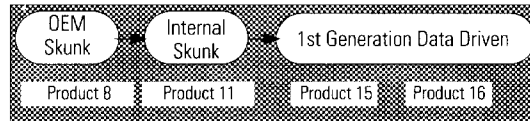
*Analog Architecture*



*OEM Initiatives*

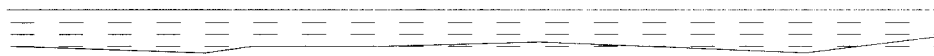
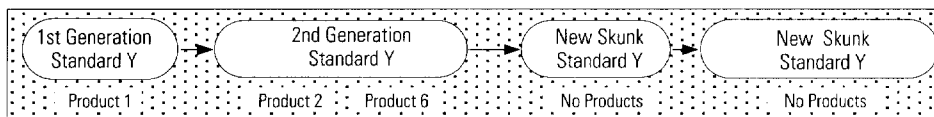
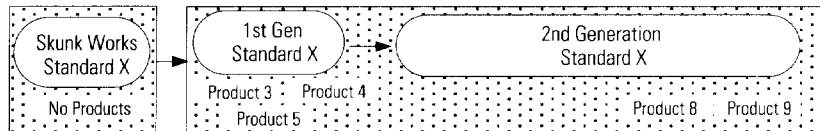
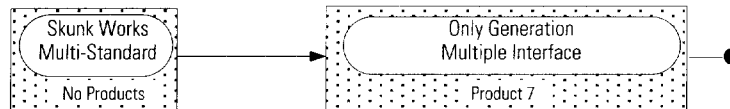


*Data Driven Architecture*

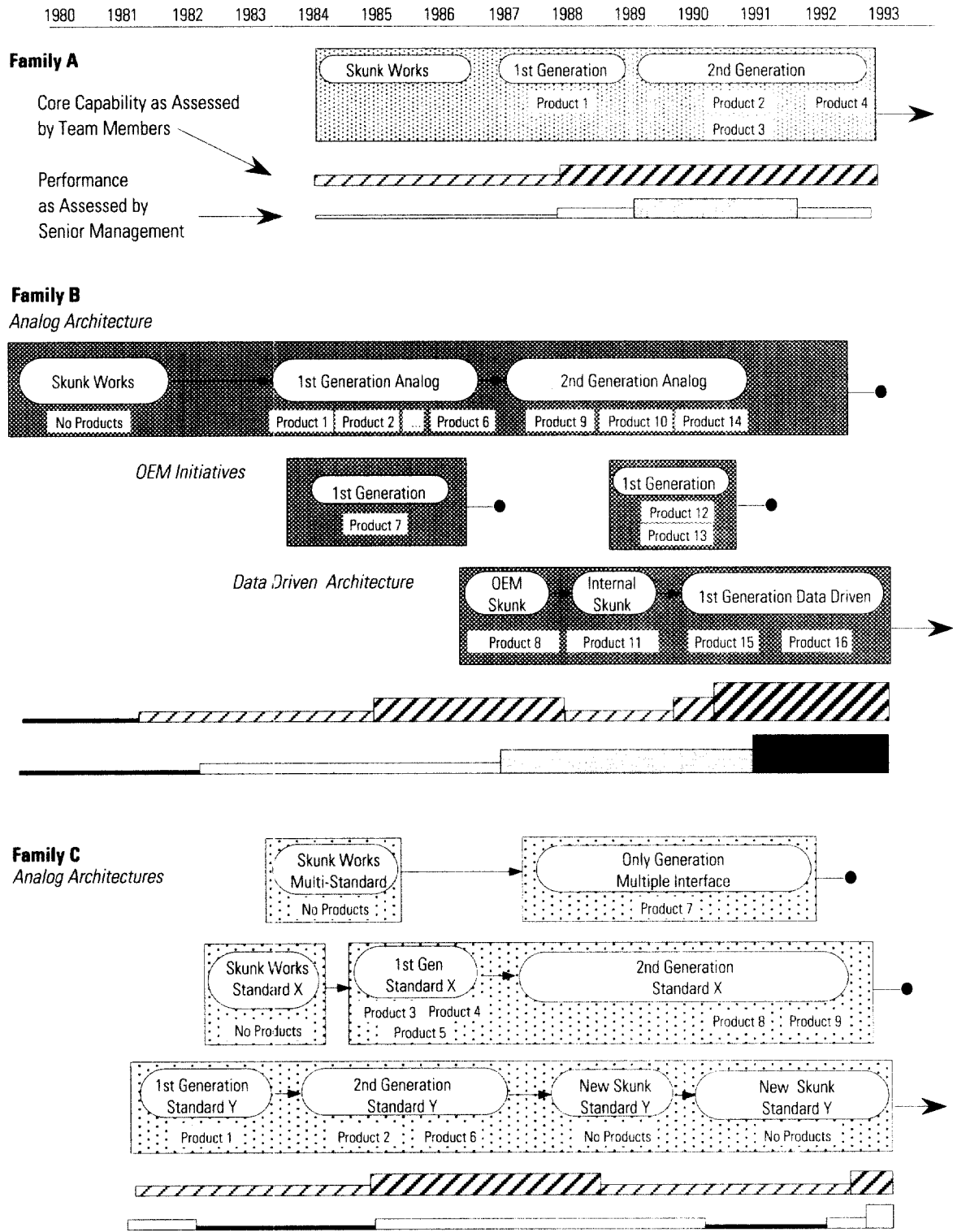


**Family C**

*Analog Architectures*



**Figure 8 Core Capability and Performance for Three Product Families**

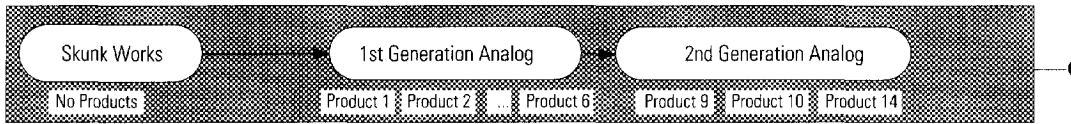


**Figure 9 Core Capability, Performance, and Market Assessments for Family B**

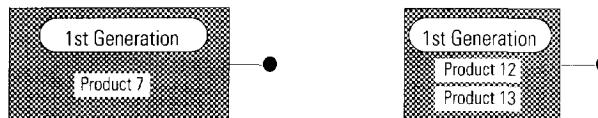
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993

**Family B**

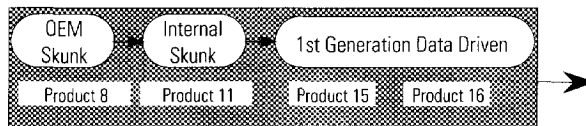
*Analog Architecture*



*OEM Initiatives*



*Data Driven Architecture*



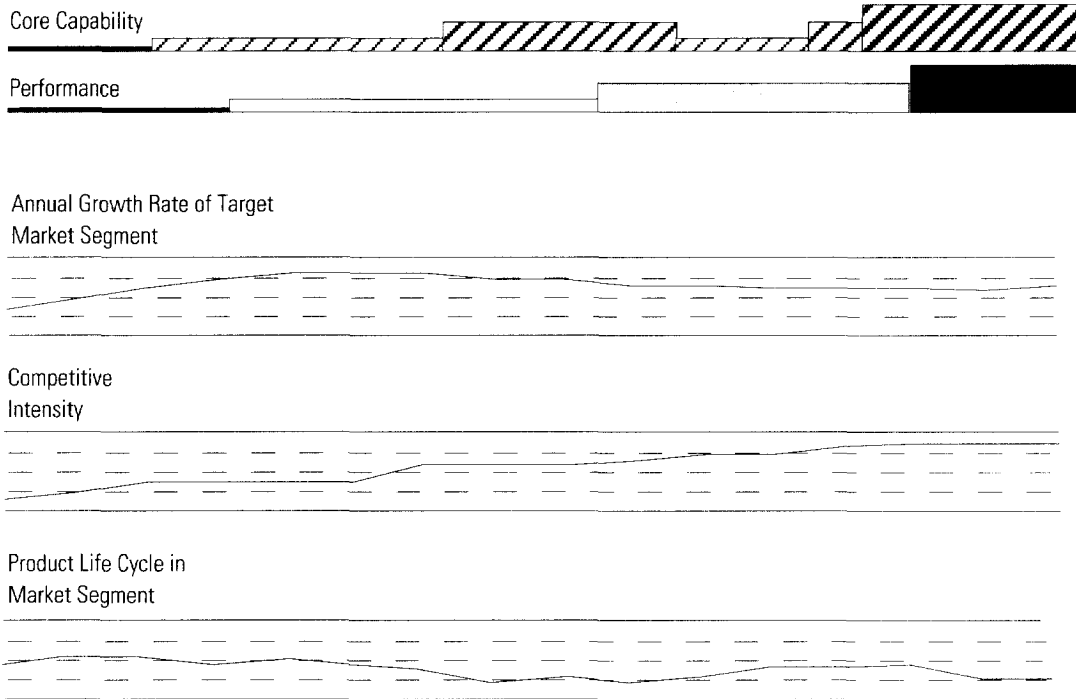
Core Capability

Performance

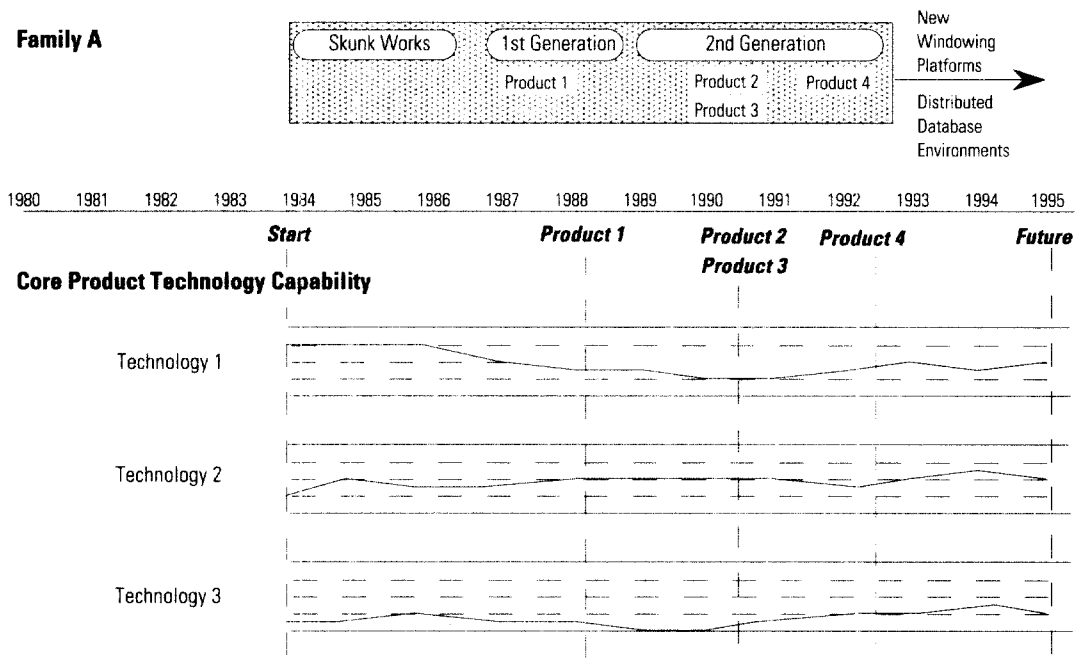
Annual Growth Rate of Target Market Segment

Competitive Intensity

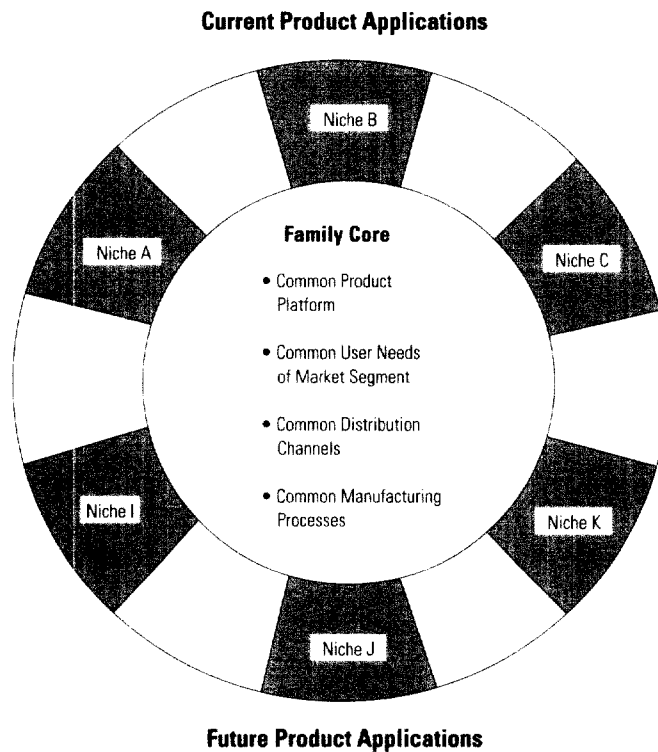
Product Life Cycle in Market Segment



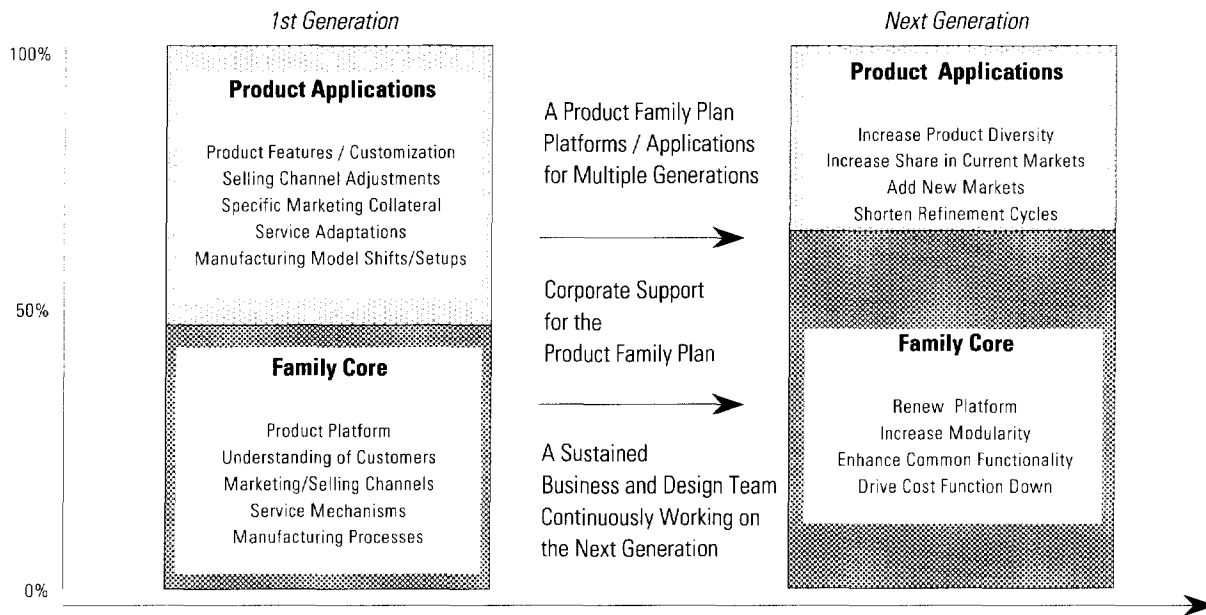
**Figure 10 Identifying Problems in Family B's Product Technology Capabilities**



**Figure 11 The Product Family: Core and Product Applications**



**Figure 12 The Product Family Infrastructure and Product Applications**



- Increase the Contribution of the Platform and Other Core Elements to Individual Products
- Improve Quality
- Product Refinement Cycle Time Continuously Shortened
- Marketing Emphasizes Good Products Today, Better Ones Tomorrow

forced to spend large sums to license metal filament technology from these same competitors to replace his own carbon filament capability and create a new light-bulb platform for his company. Other firms have consistently looked forward. In workstations, for example, Sun Microsystems abandoned more quickly than its competitors complex instruction set processing (CISC) to embrace a simpler, more elegant, reduced instruction (RISC) architecture.

Planned renewal of product platforms combined with sustained development of core capabilities is a defense against technological surprises and obsolescence. We have observed that early planning and development of new product platforms must also be coupled with high levels of modularity in designs and emphasis on layering technologies within an overall product architecture. Modularity in designs allows a firm to more readily focus on critical areas of proprietary technology to advance internally. Modularity also allows a firm to upgrade components with newer and better variations from suppliers.

• **Coasting on Success.** Management can dissipate the firm's capabilities by failing to invest in product and

manufacturing technology required to maintain competitive distinctiveness. Members of our study groups called this the *coast mentality*. Once a product family reaches high levels of success, management allocates only maintenance-level resources and shifts resources to other product families in earlier stages of development. Maintenance is a strategy prone to disaster.

The coast mentality is probably more a result of a portfolio management approach to new product development than anything else: diversify, spread risk, and invest by stage of maturity. Portfolio management leads large corporations to have too many irons in the fire. Rather than produce many successful products, the portfolio approach yields many mediocre products.<sup>28</sup> Strategic focus and aggressive reinvestment are essential to rapidly changing markets with high levels of technological change.

• **Breaking up Design Teams.** The staffing of business and technical teams has a strong bearing on the development of core capabilities. Surely core capabilities cannot be developed or maintained if key individuals do not have the chance to work with one another in a concentrated way for extended periods of time. In many



companies, while management brings multifunctional "hit teams" together to design and complete a product, once that product is finished, management disbands the team and assigns its personnel to other high-priority product efforts.

Perhaps there is another way. Is it possible for firms to keep the heart of a multifunctional design team together for at least a generation of a product family? Momentum would then build behind a product platform that meets customers' needs and is amenable to effective manufacturing and sales. At the same time, management can rotate people into the development effort more frequently to implement the product platform and create specific variations using the latest skills and techniques.

### Managing toward a Better Future

Companies can manage toward a better future by thinking in terms of the product family, product platforms, and the policies required to enrich core capabilities. Management must fashion planning horizons and financial commitments toward periods longer than current practice in many companies. Management must also have multifunctional design teams stay together longer than current practice. The more diverse a corporation's various businesses, the greater will be the pressure not *to do these things*.

The common understanding of product platforms focuses on technology and designs. We propose a broader definition (see Figure 11). A successful product family requires a clear and deep understanding of target customers' need for the product, how they will use it, and how the customer will integrate the product within their technical and business infrastructures.<sup>29</sup> Further, while product technology and market understanding are usually most important, in some situations, competences in manufacturing or distribution or service will explain success more than other factors.<sup>30</sup> For example, in a paper pulp manufacturer, the rate of new product introduction is low. However, within its long-lived product family of pulp variations, the rate of continuous improvement in manufacturing quality and costs can be high, making its manufacturing core capabilities the keys to success. Similarly, a large retailer might well find its capabilities in logistics, selling, and customer service the levers of competitiveness since it neither creates nor manufactures its own products.

The idea that a product family requires a multi-dimensional core is summarized in a framework for managing successive development efforts in Figure 12.

Product families consist of cores on which products are based to address specific market niches. Different functional aspects of the core undergo substantial improvements on a periodic basis. Platforms are improved. New manufacturing processes are used. The firm may implement new techniques and technologies to improve service. It can improve or add new channels of distribution. All such improvements to the family's core raise the effectiveness of the individual products within the family. If a company can enhance the capabilities undergirding the current family core, the result should be better products. Conversely, if core capabilities dissipate, families will lose their competitive edge and their products will fare poorly. Ideally, the percentage of the platform's contribution to individual products should increase from generation to generation based on the principles of modularity and technology layering in design.

For the product family idea to have impact, we believe that the firm must consider several basic steps. First, management must transform product planning into product *family* planning that includes, over several generations, ways in which its platforms and other aspects of its core must change in the form of specific product variations and their market applications. Second, management must adapt its budgeting to multi-year planning for related products. In many companies, individual new product efforts compete for resources. To our way of thinking, a company must try to consolidate these individual efforts into basic product families. Each family management requests *multiple year* commitments from senior management based on its plans; one major part is for core development, and the other major part is for the completion and marketing of specific products.

A disciplined approach to developing and extending product families presents a compelling basis for achieving rapid delivery cycles in the creation of new products. If one adopts this approach to making new products, then a strategy for "speed management" emerges. A company must be patient and forward thinking in developing product platforms and other dimensions of the family core. The completion of a strong platform then facilitates the far more rapid development of specific product variations. In fact, rather than release a single new product, the firm may simultaneously introduce many products, each aimed at a specific market niche. Concurrently, the company must begin designing the product platform for the next generation of the family and consider changes to its basic manufacturing, selling, and service capabilities.

Product obsolescence is inescapable. The issue is who

takes control of the process. Winning companies retire their own products rather than let competitors do it for them. Methods such as ours will help management see its past activities more clearly and to better plan the future. ♦

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The authors wish to thank the Center for Innovation Management Studies at Lehigh University and MIT's Leaders for Manufacturing Program and International Center for Research on the Management of Technology for their support of the research reported in this article.

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3. Sanderson posited that "virtual designs" serve as the basis for a series of "product realizations" within particular generations of a product family. See: S. Sanderson and V. Uzumeri, "Cost Models for Evaluating Virtual Design Strategies in Multicycle Product Families" (Troy, New York: Rensselaer Polytechnic Institute, Center for Science and Technology Policy, 1991, and forthcoming in *Journal of Engineering and Technology Management*.
4. R. Henderson and K. Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Administrative Science Quarterly* 35 (1990): 9-30.
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6. The four major innovations were miniature stereo headphones, miniature super flat motors, disk drive mechanisms, and small, rechargeable Ni-Cd batteries.
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8. By simply varying the length of the motor field, power from 60 to 650 watts could be achieved.
9. Wheelwright and Clark employ a similar framework in their new book on product development. See: S.C. Wheelwright and K.B. Clark, *Revolutionizing Product Development* (New York: Free Press, 1992).
10. Events and years to anchor data gathering and analysis over a span of time have been used to study and illustrate that successful R&D teams pursue a number of alternative technical solutions before arriving at final solutions. See: T.J. Allen, *Managing the Flow of Technology* (Cambridge, Massachusetts: MIT Press, 1977), pp. 13-26.
11. A fifth basic dimension, service, has been made part of our research with other companies.
12. For Family A, seven individuals participated in the study; for Family B, ten individuals; for Family C, nine.
13. We settled on these four dimensions of core capability based on the literature. We are also examining core capabilities for data gathering and analysis.
14. In our work with other firms, managers have chosen to identify

specific manufacturing processes as core capabilities for data gathering and analysis.

15. The metric used to assess capability was as follows:
  5. Best in class — industry leadership
  4. Above par
  3. On par
  2. Below par
  1. Worst in class
16. The underlying databases for these studies can be quite large. For example, over a thousand data points were gathered for the horizontal application family alone. We computed standard deviations to examine the variance in responses among participants for each core capability. These have been left out of this article to simplify the presentation.
17. In our work for other firms, participants have requested that we weight certain core capabilities more heavily than others to reflect their importance in the products studied.
18. Prahalad and Hamel (1990); and Quinn, Doorley, and Paquette (1990).
19. The scale for performance was:
  5. Among the most successful new business development efforts in the company
  4. Above par
  3. On par
  2. Below par
  1. Among the least successful new business development efforts in the company
20. In another study at the same company, we have gathered data on individual product performance for recent years. Grouping individual products into their respective families provided a cross-check on the validity of the executives' relative assessments. Cross-checks for earlier years were not feasible because performance data for individual products were not recorded.
21. We are presently applying this method to a number of other product-developing firms in order to gather sufficient data to generalize the finding reported here with meaningful statistics.
22. The scale for market growth was:
  5. >25% per year: rapid growth
  4. >10% and <25%: fast growth
  3. >5% and <10%: moderate growth
  2. >=0% and <5%: slow growth
  1. <0%: contracting market
23. The scale for level of competition was:
  5. Many competitors, with several dominant firms
  4. Many competitors, but no dominant firms
  3. A few large competitors
  2. A few small competitors
  1. No competitors
24. The scale for effective product life cycle was:
  5. Five or more years
  4. Four years
  3. Three years
  2. Two years
  1. One year
25. Sony spent approximately twenty years in basic research for the development of its video camera products. See: M. Cusumano, Y. Mylonadis, and R. Rosenbloom, "Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta" (Cambridge, Massachusetts: MIT Sloan School of Management, International Center for Research on the Management of Technology, Working Paper 40-91, 1991).

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Reprint 3432