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Chapter **Eleven**

Managing the New Product Development Process

frog[a]

frog is a global design firm with more than 1,600 designers, strategists and software engineers in thirteen studios around the world (Amsterdam, Austin, Bangalore, Boston, Johannesburg, Kiev, Milan, Munich, New York, San Francisco, Seattle, Shanghai, and Vinnitsa). frog designed such products as the Apple Macintosh computer, airline terminals for Lufthansa, and the groundbreaking Sony Trinitron television. frog has also applied its design methodology to corporate structure, treating the organization itself as a design object. frog works with clients in a range of industries that includes consumer electronics, retail, entertainment, finance, medical, automotive, software, and fashion, among others. frog's client list includes some of the most notable companies in the world, including Disney, Hewlett-Packard, GE, AT&T, Dell, Louis Vuitton, MTV, Sprint, Seimens, Yahoo!, and Microsoft. The company is known for its techno-hip style and its philosophy—articulated as "Form Follows Emotion"—of creating products with an aesthetic appeal that evokes an emotional response in the consumer.

More than an Industrial Design Firm

For frog, "design" meant more than creating new products—it meant helping firms plan their strategic directions for the future, sometimes "re-creating" themselves. As described by Mick Malisic, director of marketing, frog engaged in three kinds of activities:

- **"Evolving."** Reinvigorating a company's existing assets. For example, frog redesigned Lufthansa's first- and business-class cabins and lounges, reinvigorating products they already had and rethinking the customer experience for them.
- **"Expanding."** Identifying new products and services for existing and new markets. For example, when Disney expressed interest in developing its own line of consumer electronics products (rather than license the brand to a

third-party consumer electronics producer), frog developed a line of consumer electronics for Disney that included DVD players, televisions, walkie-talkies, cordless phones, and more. frog started by identifying features and cost points desired by retailers and worked backward to develop a line of products that became highly successful.

- **"Envision."** Rethinking the brand. For example, frog helped Motorola identify an opportunity to reinvent itself for the future by envisioning what kinds of products it could create in the future. A key aspect of this process was to identify a product revolution that was 5 to 10 years out, and then build the evolutionary product steps that would ease customers into a new way of using a product. In Motorola's case, this meant developing a concept design for a line of wearable wireless computing devices, including sunglasses with a miniature digital camera and a display inside the lens for reading e-mail, a watch with a two-way radio and smart phone capabilities, and an intelligent pen that stores a digital copy of your handwriting.

From a Tadpole . . .

In 1969, Hartmut Esslinger, a 30-year-old student at a German polytechnic university, won a student design competition that led to a commission to design a new television for German electronics giant Wega. This prompted Esslinger to found his own design studio, Esslinger Design, with two other students, Andreas Haug and George Spreng. The television design was a huge hit, and Esslinger ended up designing more than a hundred products for Wega. Wega was later bought by Sony, for whom Esslinger designed the landmark Sony Trinitron TV in 1978.

Esslinger's next big break came in 1981. Steve Jobs was hunting worldwide for the right design team for his next big project—the Macintosh computer. When Jobs found Esslinger, he knew he had found the team for the Macintosh. Jobs and Esslinger struck a multimillion-dollar deal that led to Esslinger's establishing a California office. In 1982, Esslinger Design was renamed frog design, and was by now synonymous with innovation and daring creative vision. Esslinger himself became a larger-than-life persona—high technology's first industrial design superstar.[b] In 1990, Esslinger appeared on *BusinessWeek*'s cover dressed in leather and astride a motorcycle, sealing his iconic status.

frog Teams

For each client project, frog assembled a multidisciplinary team that typically included visual designers, design analysts, business and brand strategists, and mechanical and software engineers. The design analysts tended to be dedicated permanently to the same team until the project was complete. Visual designers, on the other hand, often worked on multiple projects simultaneously. Business and brand strategists tended to be very heavily involved in the beginning of the project when the team was conducting design research and evaluating the market opportunities; mechanical engineers and design technologists tended to be very involved in the later project stages when designs had to be translated into physical realities. However, strategists, engineers, and technologists offered opinions and analysis throughout the project process to validate and shape the design. Each studio also had two creative directors that were responsible for helping navigate all of the projects through the various design and development stages. Creative directors had to be fluent in the technical language of all of the disciplines represented on the design team to ensure that the project's meaning and purpose remained coherent, and that frog's contribution could be communicated to the client.

The frog Process

frog's design process stretches from the idea stage through the sale of the product, often including product design, engineering, production, graphics, logos, and packaging. frog's approach emphasizes reaching customers at a deep, emotional level. As noted by Esslinger, "The magic is when both the manufacturer and the consumer get something good that they don't expect."

frog's process is organized in three phases: *discover, design,* and *deliver.*

Discover

In the discover phase, frog design team members do significant research to understand the client's business, market, brand, users, and technology. In this stage of the process, findings are synthesized to identify goals, opportunities, and critical success factors.

frog teams use a variety of activities to help them generate novel design solutions. These activities often include a facilitated brainstorming session that includes frog designers, members from the client's project team, and potential consumers. A "key facilitator" leads the group through a structured ideation session that could range from several hours to 5 days. The group is broken into smaller groups that are led through a variety of activities designed to help them connect aspects of their technology, brand, and consumer experience in new ways. The ideas are then harvested and analyzed in a process that relies heavily on intuition, subjectivity, and emotion, rather than empirical analysis. The discover phase often has considerable overlap with the design phase, with several activities from each phase occurring in parallel.

Design

During the design phase, the frog design team transforms intangible inspirations and ideas into tangible solutions that can be used and evaluated. Product concepts and opportunities are compared against production and marketing objectives and constraints. The design phase can include such activities as developing sketch renderings and basic three-dimensional models, conducting usability testing, and assessing project feasibility. Sometimes the design team uses *design charrettes*—an intense rapid design session in which multiple designers participate to create a design solution by drawing sketches, or crafting prototypes with basic materials such as foam core, tape, and glue.

The design process often relies heavily on multiple iterations with potential consumers, incorporating consumer design suggestions. For example, a designer might craft a simple three-dimensional model out of foam and ask consumers to handle the model and talk about how they would use it or how it could be modified to be more useful or appealing. frog Creative Director Valerie Casey noted that often the best feedback was obtained by letting consumers handle very simple, rudimentary models. Consumers, she noted, felt freer to suggest major changes when models were not yet well developed or refined. By contrast, more elaborate or detailed models tended to constrain consumers' suggestions for modification of the potential product. Casey also noted that frequent design iterations with consumers—often four or more per project as the design took form—not only resulted in better product designs but also saved a lot of time in the development process because they allow for early identification of design priorities and avoid costly rework.

frog design emphasizes rudimentary prototypes, sketches, and digital renderings rather than functional prototypes. Rudimentary prototypes or visual mock-ups are both more malleable than functional prototypes and far less expensive. For example, an "appearance prototype" (a prototype that looks like a functioning product but does not actually work) for something as simple as a coffeepot can cost as much as $60,000 to produce. Photo-realistic renderings, paper or foam mock-ups, or computer-aided-design can provide much of the same benefit at a small fraction of the cost.

Deliver

In the deliver phase, frog's design team refines and documents the chosen solutions. All of the product specifics, models, tools, and production details are turned over to the client. Training, testing, or manufacturing-partner support is conducted if necessary. For some clients, this meant just delivering specifications that the client would implement; for others it meant following the product all the way through manufacturing and distribution. For example, for Disney, frog worked closely with manufacturers and with Target to ensure that the products actually made it to Target's shelves. frog also had a relationship with contract manufacturing giant Flextronics that enabled it to take projects from start to finish, designing the electronic components, creating the "look and feel" of the finished product, and performing the manufacturing for the customer.

Discussion Questions

1. How do frog's activities affect its ability to (*a*) maximize the fit with customer needs, (*b*) minimize development cycle time, and (*c*) control development costs?
2. What are the advantages and disadvantages of involving customers fairly early in the design process?
3. What are the pros and cons of using computer-aided design/manufacturing (CAD/CAM) and photorealistic renderings instead of functional prototypes in the development process?
4. Would frog's approach be more suitable for some kinds of development projects than others? If so, what kinds would it be appropriate or inappropriate for?
5. Would frog's approach to product development be effective in a firm that primarily manufactured, marketed, and distributed its own products?

[a] Adapted from a New York University teaching case written by Prof. Melissa A. Schilling and Valerie Casey of frog design.
[b] P. Burrows, "frog design's New Lily Pad," *BusinessWeek Online*, August 13, 2004.

OVERVIEW

In many industries, the ability to develop new products quickly, effectively, and efficiently is now the single most important factor driving firm success. In industries such as computer hardware and software, telecommunications, automobiles, and consumer electronics, firms often depend on products introduced within the past five years for more than 50 percent of their sales. Yet despite the avid attention paid to new product development, the failure rates for new product development projects are still agonizingly high. By many estimates, more than 95 percent of all new product development projects fail to result in an economic return.[1] Many projects are never completed, and of those that are, many flounder in the marketplace. Thus, a considerable amount of research has been focused on how to make the new product development process more effective and more efficient. This chapter discusses some strategic imperatives for new product development processes that have emerged from the study of best—and worst—practices in new product development.

We will begin by looking at the three key objectives of the new product development process: maximizing fit with customer requirements, minimizing cycle time, and controlling development costs. We then will turn to methods of achieving these objectives, including adopting parallel development processes, using project champions, and involving customers and suppliers in the development process. Next we will look at a number of tools firms can utilize to improve the effectiveness and efficiency of the development process, including creating go/kill decision points with stage-gate processes, defining design targets with quality function deployment, reducing costs and development time with design for manufacturing and CAD/CAM systems, and using metrics to assess the performance of the new product development process.

OBJECTIVES OF THE NEW PRODUCT DEVELOPMENT PROCESS

For new product development to be successful, it must simultaneously achieve three sometimes-conflicting goals: (1) maximizing the product's fit with customer requirements, (2) minimizing the development cycle time, and (3) controlling development costs.

Maximizing Fit with Customer Requirements

For a new product to be successful in the marketplace, it must offer more compelling features, greater quality, or more attractive pricing than competing products. Despite the obvious importance of this imperative, many new product development projects fail to achieve it. This may occur for a number of reasons. First, the firm may not have a clear sense of which features customers value the most, resulting in the firm's overinvesting in some features at the expense of features the customer values more. Firms may also overestimate the customer's willingness to pay for particular features, leading them to produce feature-packed products that are too expensive to gain significant market penetration. Firms may also have difficulty resolving heterogeneity in customer demands; if some customer groups desire different features from other groups, the firm may end up producing a product that makes compromises between these conflicting demands, and the resulting product may fail to be attractive to any of the customer groups.

Numerous new products have offered technologically advanced features compared to existing products but have failed to match customer requirements and were subsequently rejected by the market. For example, consider Apple's Newton MessagePad, a relatively early entrant into the personal digital assistant market. The Newton was exceptional on many dimensions. It had a highly advanced ARM610 RISC chip for superior processing performance. Its operating system was object oriented (a feature that software programmers had been clamoring for), and Apple openly licensed the architecture to encourage rapid and widespread adoption by other vendors. Also, its weight, size, and battery life were better than many of the other early competitors. However, the Newton MessagePad was still much too large to be kept in a pocket, limiting its usefulness as a handheld device. Many corporate users thought the screen was too small to make the product useful for their applications. Finally, early problems with the handwriting recognition software caused many people to believe the product was fatally flawed.

Another example is Philips' attempt to enter the video game industry. In 1989, Philips introduced its Compact Disc Interactive (CD-i). The CD-i was a 32-bit system (introduced well before Sega's 32-bit Saturn or Sony's 32-bit PlayStation), and in addition to being a game player, it offered a number of educational programs and played audio CDs. However, Philips had overestimated how much customers would value (and be willing to pay for) these features. The CD-i was priced at $799, more than double the cost of Nintendo or Sega video game systems. Furthermore, the product was very complex, requiring a half-hour demonstration by a skilled sales representative. Ultimately, the product failed to attract many customers and Philips abandoned the product.

Minimizing Development Cycle Time

Even products that achieve a very close fit with customer requirements can fail if they take too long to bring to market. As discussed in Chapter Five, bringing a product to market early can help a firm build brand loyalty, preemptively capture scarce assets, and build customer switching costs. A firm that brings a new product to market late may find that customers are already committed to other products. Also, a company that is able to bring its product to market early has more time to develop (or encourage others to develop) complementary goods that enhance the value and attractiveness of the product.[2] Other things being equal, products that are introduced to the market earlier are likely to have an installed base and availability of complementary goods advantage over later offerings.

development cycle time
The time elapsed from project initiation to product launch, usually measured in months or years.

Another important consideration regarding **development cycle time** relates to the cost of development and the decreasing length of product life cycles. First, many development costs are directly related to time. Both the expense of paying employees involved in development and the firm's cost of capital increase as the development cycle lengthens. Second, a company that is slow to market with a particular generation of technology is unlikely to be able to fully amortize the fixed costs of development before that generation becomes obsolete. This phenomenon is particularly vivid in dynamic industries such as electronics where life cycles can be as short as 12 months (e.g., personal computers, semiconductors). Companies that are slow to market may find that by the time they have introduced their products, market demand has already shifted to the products of a subsequent technological generation.

Finally, a company with a short development cycle can quickly revise or upgrade its offering as design flaws are revealed or technology advances. A firm with a short development cycle can take advantage of both first-mover *and* second-mover advantages.

Some researchers have pointed out the costs of shortening the development cycle and rushing new products to market. For example, Dhebar points out that rapid product introductions may cause adverse consumer reactions; consumers may regret past purchases and be wary of new purchases for fear they should rapidly become obsolete.[3] Other researchers have suggested that speed of new product development may come at the expense of quality or result in sloppy market introductions.[4] Compressing development cycle time can result in overburdening the development team, leading to problems being overlooked in the product design or manufacturing process. Adequate product testing may also be sacrificed to meet development schedules.[5] However, despite these risks, most studies have found a strong positive relationship between speed and the commercial success of new products.[6]

Controlling Development Costs

Sometimes a firm engages in an intense effort to develop a product that exceeds customer expectations and brings it to market early, only to find that its development costs have ballooned so much that it is impossible to recoup the development expenses even if the product is enthusiastically received by the market. This highlights the fact that development efforts must be not only *effective,* but also *efficient.* Later in the chapter, ways to monitor and control development costs are discussed.

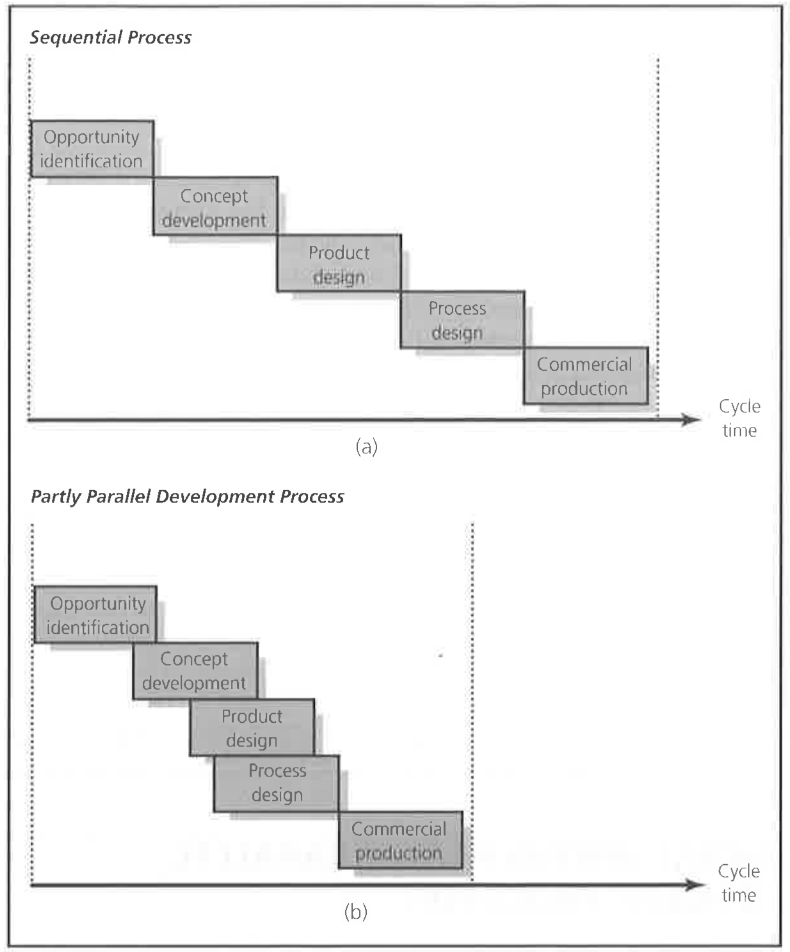
SEQUENTIAL VERSUS PARTLY PARALLEL DEVELOPMENT PROCESSES

partly parallel development process
A development process in which some (or all) of the development activities at least partially overlap. That is, if activity A would precede activity B in a partly parallel development process, activity B might commence before activity A is completed.

Before the mid-1990s, most U.S. companies proceeded from one development stage to another in a sequential fashion (see Figure 11.1a). The process included a number of gates at which managers would decide whether to proceed to the next stage, send the project back to a previous stage for revision, or kill the project. Typically, R&D and marketing provided the bulk of the input in the opportunity identification and concept development stages, R&D took the lead in product design, and manufacturing took the lead in process design. According to critics, one problem with such a system emerges at the product design stage when R&D engineers fail to communicate directly with manufacturing engineers. As a result, product design proceeds without manufacturing requirements in mind. A sequential process has no early warning system to indicate that planned features are not manufacturable. Consequently, cycle time can lengthen as the project iterates back and forth between the product design and process design stages.[7]

To shorten the development process and avoid time-consuming and costly iterations between stages of the development cycle, many firms have adopted a **partly parallel development process** (also sometimes called simultaneous engineering), as shown in Figure 11.1b.[8] Product design is initiated before concept development is complete, and process design is begun long before product design is finalized,

FIGURE 11.1
Sequential versus Partly Parallel Development Processes



enabling much closer coordination between the different stages and minimizing the chance that R&D will design products that are difficult or costly to manufacture. This should eliminate the need for time-consuming iterations between design stages and shorten overall cycle time.

Parallel development processes are not universally endorsed, however. In some situations, using a parallel development process can substantially increase the risks or costs of the development process. If, for example, variations in product design require significant changes to the process design, beginning process design before product design is finalized can result in costly rework of the production process. Such risks are especially high in markets characterized by rapid change and uncertainty.[9] Furthermore, once process design has commenced, managers may be reluctant to alter the product design even if market testing reveals that the product design is suboptimal. It is precisely these risks that the stage-gate* process (discussed later in the chapter) attempts to minimize.

*Note: Stage-Gate® is a registered trademark of Stage-Gate International Inc.

Theory in Action The Development of Zantac

In the 1970s, Glaxo Holdings PLC of Great Britain was one of the larger health care conglomerates in the world, known principally for its baby food, but it needed a new hit product to stimulate sales. While contemplating research possibilities, the head of Glaxo's research laboratory, David Jack, attended a lecture by James Black, a Nobel Prize–winning scientist and researcher for U.S.-based SmithKline Beecham. During the lecture, Black described a new possibility for treating ulcers that involved compounds called H_2 blockers that would inhibit gastrointestinal cells from secreting acid. Jack was intrigued. Ulcers were a common problem, and thus represented a large market opportunity for an effective solution. Jack began experimenting with different compounds in pursuit of a formula that would be safe and effective. Unfortunately, researchers at SmithKline Beecham beat Glaxo to the finish line, introducing Tagamet in 1977. Tagamet revolutionized ulcer treatment, and sales grew phenomenally.[a]

Discouraged but not thwarted, Jack's team kept working. Other companies (including Merck and Eli Lilly) were also developing their own ulcer treatments, and Jack believed that beating them to market might still give the company a shot at a significant share. In that same year, the team came up with a compound based on ranitidine (Tagamet was based on a compound called cimetedine) that achieved the desired objectives. However, Jack realized that if Glaxo was going to beat Merck and Eli Lilly to market, it would need to radically shorten the typical 10-year testing period required to secure regulatory approval and bring the product to market. To achieve this, Jack proposed the first parallel development process used in the pharmaceutical industry. Instead of following the typical sequence of testing (e.g., from rats to monkeys, and from short-term toxicity to long-term toxicity), Jack proposed doing all of the tests concurrently.[b] This intensified development process could potentially cut the cycle time in half—to five years—however, it would also be expensive and risky. If the development efforts increased the research costs substantially, it would be much harder to recoup those expenses through sales of the drug.

Fortunately for Jack's team, Paul Girolami, Glaxo's director of finance, chose to champion the project. Girolami argued that the company should be willing to risk its range of decently profitable products for one potentially sensational drug, stating, "Having all your eggs in one basket concentrates the mind because you had better make sure it is a good basket."[c] Not only was he able to convince the company that it was worth investing in the shortened development process, but he also insisted that the product be modified so that it could be taken once a day (Tagamet required twice-a-day use) and so that the product would have fewer side effects than Tagamet. These features would help differentiate Zantac as a superior product, and it was hoped they would enable Glaxo to take share away from SmithKline Beecham. The development process was successful, and the product was ready for launch in 1982. To recoup its development costs, Girolami chose a premium pricing strategy for the product (one-third higher than Tagamet), arguing that its advantages would warrant its additional cost. He also insisted that the product be launched globally in all major markets, and he set up a distribution alliance with Hoffman-LaRoche to speed up the product's penetration of the U.S. market.

Girolami's strategies were successful, and by the end of the year, Zantac was stealing about 100,000 patients a month from Tagamet. By 1987, Zantac sales had exceeded Tagamet's, and by 1991 Zantac became the world's No. 1 selling prescription drug and the first drug ever to achieve $1 billion in U.S. sales.[d] Both David Jack and Paul Girolami were knighted, and Sir Paul Girolami was appointed chairman of Glaxo.[e]

[a] A. Corsig, T. Soloway, and R. Stanaro, "Glaxo Holdings PLC: Zantac," in *New Product Success Stories*, ed. R. Thomas (New York: John Wiley & Sons, Inc., 1995), pp. 242–52.
[b] Ibid.
[c] C. Kennedy, "Medicine Man to the World," *Director* 46, no. 4 (1992), pp. 106–10.
[d] "Anti-Ulcer Drugs: Too Much Acid," *The Economist* 318, no. 7700 (1991), pp. 82–84.
[e] Corsig, Soloway, and Stanaro, "Glaxo Holdings PLC: Zantac."

PROJECT CHAMPIONS

A number of studies on new product development have suggested that firms should assign (or encourage) a senior member of the company to champion a new product development project.[10] Senior executives have the power and authority to support and fight for a project. They can facilitate the allocation of human and capital resources to the development effort, ensuring that cycle time is not extended by resource constraints, and help ensure that the project can sustain the necessary momentum to surmount the hurdles that inevitably will arise.[11] A senior project champion also can stimulate communication and cooperation between the different functional groups involved in the development process. Given that interfunctional communication and cooperation are necessary both to compress cycle time and to achieve a good fit between product attributes and customer requirements, the use of executive sponsors can improve the effectiveness of the development process. As of 2001, 68 percent of North American firms, 58 percent of European firms, and 48 percent of Japanese firms reported using senior managers to champion new product development projects.[12] An example of a successful use of project championing is described in the accompanying Theory in Action.

Risks of Championing

Vigorous project championing, however, also has its risks. A manager's role as champion may cloud judgment about the true value of the project. Optimism is the norm in product development—surveys indicate a systematic upward bias in estimates of future cash flows from a project.[13] In the role of champion, this optimism is often taken to extreme levels. Managers may fall victim to escalating commitment and be unable (or unwilling) to admit that a project should be killed even when it is clear to many others in the organization that the project has gone sour, or the factors driving the project's original value are no longer relevant. While it is common to read stories about projects that succeed against all odds because of the almost fanatical zeal and persistence of their champions, bankruptcy courts are full of companies that should have been less zealous in pursuing some projects. Managers who have invested their reputations and years of their lives in development projects may find it very difficult to cut their losses, in much the same way that individuals tend to hold losing stocks much longer than they should due to the temptation to try to recoup what they have lost. Though the champion's seniority is an asset in gaining access to resources and facilitating coordination, this same seniority may also make others in the firm unwilling to challenge the project champion even if it has become apparent that the project's expected value has turned negative.[14]

Firms may benefit from also developing "antichampions" who can play the role of devil's advocate. Firms should also encourage a corporate culture open to the expression of dissenting opinion, and champions should be encouraged to justify their projects on the basis of objective criteria, without resorting to force of personality.[15] The accompanying Research Brief describes five myths that have become widely accepted about project champions.

Research Brief Five Myths about Product Champions

Stephen Markham and Lynda Aiman-Smith argue that a number of myths have become widely accepted about new product champions. While Markham and Aiman-Smith believe that product champions are critical to new product development, they also argue that for product champions to be effective, their role in the development process must be completely understood. Markham and Aiman-Smith conducted a systematic review of the theoretical and empirical literature on product champions and identified five popular myths:

Myth 1: *Projects with champions are more likely to be successful in the market.* Markham and Aiman-Smith's review of the empirical data on use of project champions found that projects with champions were just as likely to be market failures as market successes. Markham and Aiman-Smith point out that while champions may improve the likelihood of a project being completed, the factors determining its market success are often beyond the champion's control.[a]

Myth 2: *Champions get involved because they are excited about the project, rather than from self-interest.* Markham and Aiman-Smith report that empirical evidence suggests champions are more likely to support projects that will benefit the champion's own department.[b]

Myth 3: *Champions are more likely to be involved with radical innovation projects.* Empirical evidence from multiple large sample studies indicates that champions were equally likely to be involved with radical versus incremental innovation projects.

Myth 4: *Champions are more likely to be from high (or low) levels in the organization.* Markham and Aiman-Smith argue that there are myths about both high-level and low-level managers being more likely to be product champions. Though stories abound featuring prominent senior managers supporting projects, as do stories featuring low-level champions fighting vigorously for a project's success, empirical evidence suggests that champions may arise from any level in the organization. (Note that this research does not indicate champions from all levels of the firm are equally effective.)

Myth 5: *Champions are more likely to be from marketing.* Markham and Aiman-Smith argue that while anecdotal evidence may more often emphasize champions who have marketing backgrounds, an empirical study of 190 champions found that champions arose from many functions of the firm. Specifically, the study found that 15 percent of champions were from R&D, 14 percent were from marketing, 7 percent were from production and operations, and 6 percent were general managers. Interestingly, 8 percent of champions were potential users of the innovations.[c]

[a] S. Markham, S. Green, and R. Basu, "Champions and Antagonists: Relationships with R&D Project Characteristics and Management," *Journal of Engineering and Technology Management* 8 (1991), pp. 217–42; S. Markham and A. Griffin, "The Breakfast of Champions: Associations between Champions and Product Development Environments, Practices, and Performance," The *Journal of Product Innovation Management* 15 (1998), pp. 436–54; and S. Markham, "Corporate Championing and Antagonism as Forms of Political Behavior: An R&D Perspective," *Organization Science* 11 (2000), pp. 429–47.

[b] Markham, "Corporate Championing and Antagonism as Forms of Political Behavior."

[c] D. Day, "Raising Radicals: Different Processes for Championing Innovative Corporate Ventures," *Organization Science* 5 (1994), pp. 148–72.

INVOLVING CUSTOMERS AND SUPPLIERS IN THE DEVELOPMENT PROCESS

As mentioned previously, many products fail to produce an economic return because they do not fulfill customer requirements for performance and price, or because they take too long to bring to market. Both of these problems can be reduced by involving customers and suppliers in the development process.

Involving Customers

Firms often make decisions about projects on the basis of financial considerations and level of production and technical synergy achieved by the new product proposal rather than on marketing criteria. This can lead to an overemphasis on incremental product updates that closely fit existing business activities.[16] The screening decision should focus instead on the new product's advantage and superiority to the consumer, and the growth of its target market.[17] The customer is often the one most able to identify the maximum performance capabilities and minimum service requirements of a new product. Including the customer in the actual development team or designing initial product versions and encouraging user extensions can help the firm focus its development efforts on projects that better fit customer needs.[18]

Many firms use *beta testing* to get customer input early in the development process. A "beta version" of a product is an early working prototype of a product released to users for testing and feedback. Beta versions also enable a firm to signal the market about its product features before the product reaches the commercial production stage. Other firms involve customers in the new product development process in even more extensive ways, such as enabling customers to "cocreate" the end product. OhMyNews, for example, is a South Korean online newspaper that publishes stories from "citizen reporters." Though the company employs a small writing and editorial team, most of its content comes from the more than 70,000 ordinary citizens that contribute stories. Contributors earn $2.00 for each accepted news story, with the potential for bonuses for stories that turn out to be especially popular. By 2009 the site was attracting 2.5 million page views a day.[19]

lead users
Customers who face the same general needs of the marketplace but are likely to experience them months or years earlier than the rest of the market and stand to benefit disproportionately from solutions to those needs.

Some studies suggest that firms should focus on the input of lead users in their development efforts rather than a large sample of customers. **Lead users** are those who face the same needs of the general marketplace but face them months or years earlier than the bulk of the market, and expect to benefit significantly from a solution to those needs.[20] According to a survey by the Product Development & Management Association, on average, firms report using the lead user method to obtain input into 38 percent of the projects they undertake. More detail on how firms use lead users is provided in the accompanying Theory in Action section.

Involving Suppliers

Much of the same logic behind involving customers in the new product development process also applies to involving suppliers. By tapping into the knowledge base of its suppliers, a firm expands its information resources. Suppliers may be actual members of the product team or consulted as an alliance partner. In either case, they can contribute ideas for product improvement or increased development efficiency. For instance,

Theory in Action The Lead User Method of Product Concept Development

Hilti AG, a European manufacturer of construction components and equipment, turned to the lead user method in its development of a pipe hanger (a steel support that fastens pipes to walls or ceilings of buildings). The firm first used telephone interviews to identify customers who had lead user characteristics (were ahead of market trends and stood to benefit disproportionately from the new solution). The lead users were invited to participate in a three-day product concept generation workshop to develop a pipe hanging system that would meet their needs. At the end of the workshop, a single pipe hanger design was selected as the one that best met all the lead users' objectives. The company then presented this design to 12 routine users (customers who were not lead users but who had a long, close relationship with Hilti). Ten of the 12 routine users preferred the new design to previously available solutions, and all but one of the 10 indicated they would be willing to pay a 20 percent higher price for the product. Not only was the project successful, but the lead user method was also faster and cheaper than the conventional market research methods the firm had used in the past to develop its product concepts. Hilti's typical process took 16 months and cost $100,000, but the lead user method took 9 months and cost $51,000.

Source: C. Herstatt and E. von Hippel, "Developing New Product Concepts via the Lead User Method: A Case Study in a Low-Tech Field," *Journal of Product Innovation Management* 9 (1992), pp. 213–21.

a supplier may be able to suggest an alternative input (or configuration of inputs) that would achieve the same functionality but at a lower cost. Additionally, by coordinating with suppliers, managers can help to ensure that inputs arrive on time and that necessary changes can be made quickly to minimize development time.[21] Consistent with this argument, research has shown that many firms produce new products in less time, at a lower cost, and with higher quality by incorporating suppliers in integrated product development efforts.[22] For example, consider Chrysler. Beginning in 1989, Chrysler reduced its supplier base from 2,500 to 1,140, offering the remaining suppliers long-term contracts and making them integrally involved in the process of designing new cars. Chrysler also introduced an initiative called SCORE (Supplier Cost Reduction Effort) that encouraged suppliers to make cost-saving suggestions in the development process. The net result was $2.5 billion in savings by 1998.

crowdsourcing
A distributed problem-solving model whereby a design problem or production task is presented to a group of people who voluntarily contribute their ideas and effort in exchange for compensation, intrinsic rewards, or a combination thereof.

Boeing's development of the 777 involved both customers and suppliers on the new product development team; United employees (including engineers, pilots, and flight attendants) worked closely with Boeing's engineers to ensure that the airplane was designed for maximum functionality and comfort. Boeing also included General Electric and other parts suppliers on the project team, so that the engines and the body of the airplane could be simultaneously designed for maximum compatibility.

Crowdsourcing

Firms can also open up an innovation task to the public through crowdsourcing. Crowdsourcing platforms such as InnoCentive, Yet2.com, and TopCoder present an innovation problem on a public Web platform, and provide rewards to participants who are able to solve them. Often individuals participate for the sheer excitement and challenge of solving the problem, or for social or reputational benefits, rather than because they anticipate earning large rewards. For example, Ben & Jerry's asked its customers to invent their new varieties of ice cream flavors—the submitters of the best flavors were given a trip to the Dominican Republic to see a sustainable fair trade cocoa farm. LG similarly used crowdsourcing to develop a new mobile phone, for a reward of $20,000.

TOOLS FOR IMPROVING THE NEW PRODUCT DEVELOPMENT PROCESS

Some of the most prominent tools used to improve the development process include stage-gate processes, quality function deployment ("house of quality"), design for manufacturing, failure modes and effects analysis, and computer-aided design/computer-aided manufacturing. Using the available tools can greatly expedite the new product development process and maximize the product's fit with customer requirements.

Stage-Gate Processes

As discussed in a previous section, escalating commitment can lead managers to support projects long after their expected value has turned negative, and the cost of pushing bad projects forward can be very high. To help avoid this, many managers and researchers suggest implementing tough **go/kill decision points** in the product development process. The most widely known development model incorporating such go/kill points is the stage-gate process developed by Robert G. Cooper.[23] The stage-gate process provides a blueprint for moving projects through different stages of development. Figure 11.2 shows a typical stage-gate process.

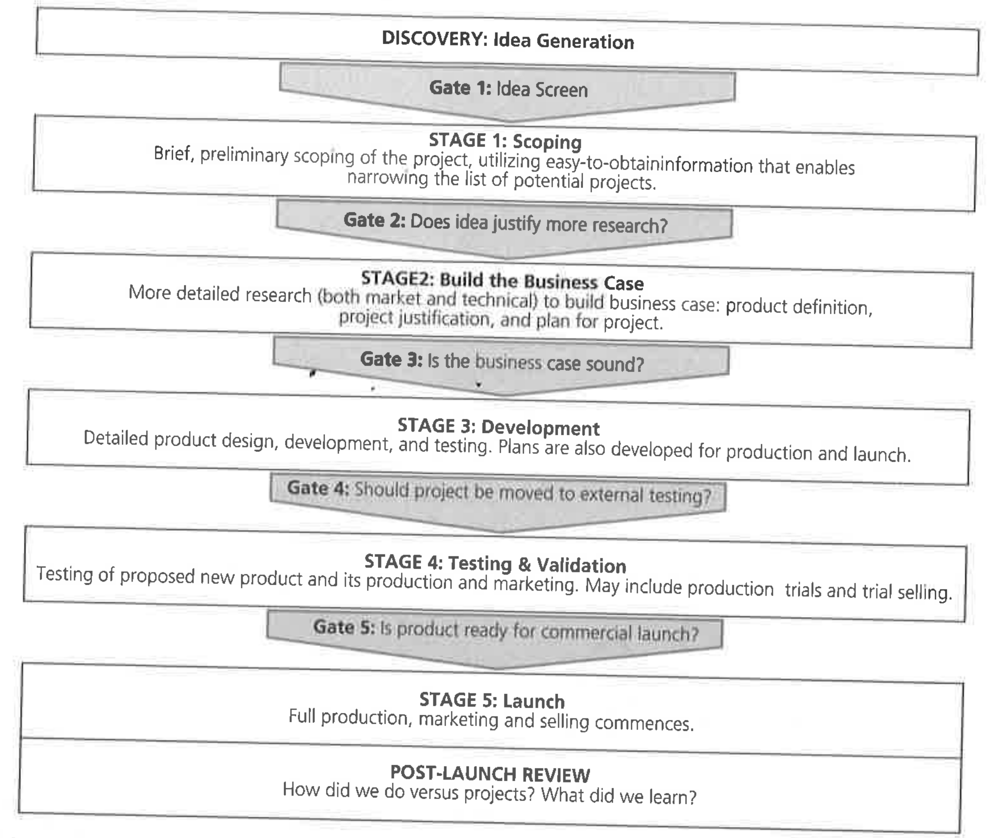
go/kill decision points
Gates established in the development process where managers must evaluate whether or not to kill the project or allow it to proceed.

At each stage, a cross-functional team of people (led by a project team leader) undertakes parallel activities designed to drive down the risk of a development project. At each stage of the process, the team is required to gather vital technical, market, and financial information to use in the decision to move the project forward (go), abandon the project (kill), hold, or recycle the project.

In Stage 1, the team does a quick investigation and conceptualization of the project. In Stage 2, the team builds a business case that includes a defined product, its business justification, and a detailed plan of action for the next stages. In Stage 3, the team begins the actual design and development of the product, including mapping out the manufacturing process, the market launch, and operating plans. In this stage, the team also defines the test plans utilized in the next stage. In Stage 4, the team conducts the verification and validation process for the proposed new product, and its marketing and production. At Stage 5, the product is ready for launch, and full commercial production and selling commence.[24]

Preceding each stage is a go/kill gate. These gates are designed to control the quality of the project and to ensure that the project is being executed in an effective and efficient manner. Gates act as the funnels that cull mediocre projects. Each gate has three components: *deliverables* (these are the results of the previous stage and are the inputs for the gate review), *criteria* (these are the questions or metrics used to make the go/kill decision), and *outputs* (these are the results of the gate review process and may include a decision such as go, kill, hold, or recycle; outputs should also include an action plan for the dates and deliverables of the next gate).

FIGURE 11.2
Typical Stage-Gate Process, from Idea to Launch



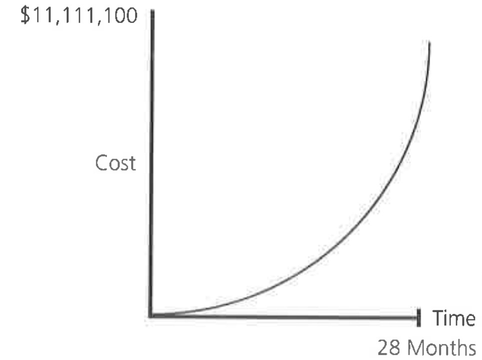
Source: R.G. Cooper, "Stage-Gate Idea to Launch System," *Wiley International Encyclopedia of Marketing: Product Innovation & Management* 5, B.L. Bayus (ed.), (West Sussex UK: Wiley, 2011).

Because each stage of a development project typically costs more than the stage preceding it, breaking down the process into stages deconstructs the development investment into a series of incremental commitments. Expenditures increase only as uncertainty decreases. Figure 11.3 shows the escalation costs and cycle time for each stage of a typical development process in a manufacturing industry.

Many companies have adapted the stage-gate process to more specifically meet the needs of their firm or industry. For example, while managers at Exxon were strong advocates of using a stage-gate process to track and manage development projects, they also felt that the standard five-stage system did not adequately address the needs of a company in which basic research was a primary component in generating innovations. Exxon managers created their own extended stage-gate system to include directed basic research. The resulting stage-gate system included two basic research stages (Stages A and B in Figure 11.4) and five applied research and development stages. In Stage A, the company identifies the potential business incentives and competitive advantages of an envisioned technology. The company then develops a basic research plan that establishes specific scientific deliverables, the methods of achieving

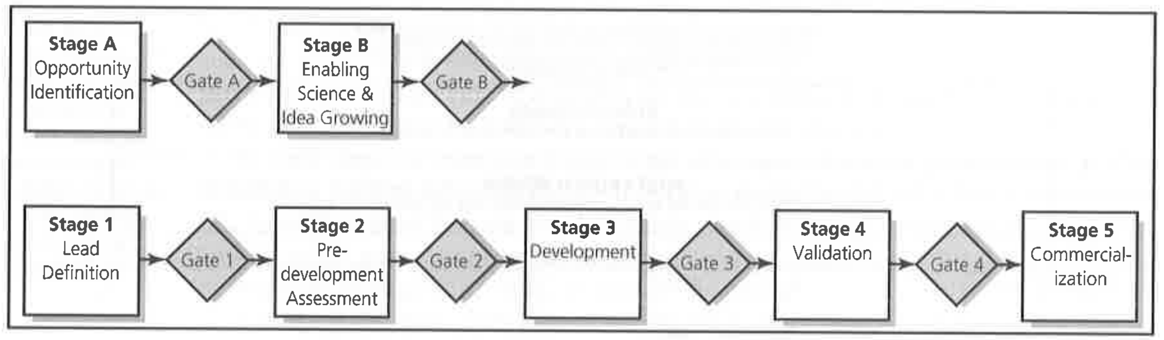
FIGURE 11.3
Escalation of Development Time and Costs by Stage

Stage	Time	Cost
0. "Here's an idea!"		
1. Formulate–describe and sketch	1 week	$100
2. Conduct preliminary investigations	2 weeks	$1,000
3. Design and define specifications	1 month	$10,000
4A. Develop prototype and test		
4B. Market research		
4C. Strategic fit evaluation and NPV risk analysis	2 months	$100,000
5A. Scale up, build pilot plant		
5B. Market test	8 months	$1 million
6A. Build plant		
6B. Promote, launch, market	16 months	$10 million



Source: From Frederick D. Buggie, "Set the 'Fuzzy Front End' in Concrete," *Research Technology Management*, vol. 45, no. 4, July–August 2002. Reprinted with permission of Industrial Research Institute.

FIGURE 11.4
Exxon Research and Engineering's Stage-Gate System



these deliverables, and the required resources. In Stage B, Exxon's research division begins to execute the plan developed in Stage A, using scientific methods to generate leads for addressing the business opportunity. Stage 1 then identifies the best leads, using "proof-of-principle" assessments to establish whether the leads are feasible.[25] Stages 2 through 5 proceed according to a typical stage-gate process.

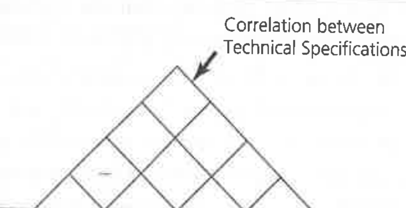
According to studies by the Product Development and Management Association, nearly 60 percent of firms (including IBM, Procter & Gamble, 3M, General Motors, and Corning) use some type of stage-gate process to manage their new product development process. Corning has made the process mandatory for all information system development projects, and Corning managers believe that the process enables them to better estimate the potential payback of any project under consideration. They also report that the stage-gate process has reduced development time, allows them to identify projects that should be killed, and increases the ratio of internally developed products that result in commercial projects.[26]

Quality Function Deployment (QFD)—The House of Quality

QFD was developed in Japan as a comprehensive process for improving the communication and coordination among engineering, marketing, and manufacturing personnel.[27] It achieves this by taking managers through a problem-solving process in a very structured fashion. The organizing framework for QFD is the "house of quality" (see Figure 11.5). The house of quality is a matrix that maps customer requirements against product attributes. This matrix is completed in a series of steps.

1. The team must first identify customer requirements. In Figure 11.5, market research has identified five attributes that customers value most in a car door: it is easy to open and close, it stays open on a hill, it does not leak in the rain, it isolates the occupant from road noise, and it protects the passengers in the event of crashes.
2. The team weights the customer requirements in terms of their relative importance from a customer's perspective. This information might be obtained from focus group sessions or direct interaction with the customers. The weights are typically entered as percentages, so that the complete list totals 100 percent.
3. The team identifies the engineering attributes that drive the performance of the product—in this case the car door. In Figure 11.5, four attributes are highlighted: the weight of the door, the stiffness of the door hinge (a stiff hinge helps the door stay open on a hill), the tightness of the door seal, and the tightness of the window seal.

FIGURE 11.5
Quality Function Deployment House of Quality for a Car Door



	Engineering Attributes	Importance	Weight of Door	Stiffness of Hinge	Tightness of Door and Seal	Tightness of Window Seal	Competitor A	Competitor B	Evaluation of New Design
Customer Requirements	Easy to Open	15	9	3			7	4	
	Stays Open on Hill	10	3	9			6	7	
	Does Not Leak	35			9	9	7	6	
	Isolates Occupant from Road Noise	20	1		9	9	4	7	
	Crash Protection	20	9				4	7	
Relative Importance of Each Engineering Attribute			365	135	495	495			
Design Targets									

4. The team enters the correlations between the different engineering attributes to assess the degree to which one characteristic may positively or negatively affect another. The correlations are entered into the matrix that creates the peaked roof of the house. In this case, the negative sign between door weight and hinge stiffness indicates that a heavy door reduces the stiffness of the hinge.
5. The team fills in the body of the central matrix. Each cell in the matrix indicates the relationship between an engineering attribute and a customer requirement. A number (in this example, one, three, or nine) is placed in the cell located at the intersection of each row (customer requirements) with each column (engineering attributes), which represents the strength of relationship between them. A value of one indicates a weak relationship, a three indicates a moderate relationship and a nine indicates a strong relationship. The cell is left blank if there is no relationship. The ease of opening the door, for example, is strongly related to the weight of the door and moderately related to the stiffness of the door hinge, but is not related to the tightness of the door seal or window seal.
6. The team multiplies the customer importance rating of a feature by its relationship to an engineering attribute (one, three, or nine). These numbers are then summed for each column, yielding a total for the relative importance of each engineering attribute. For example, the stiffness of the hinge influences how easy the door is to open, and whether the door stays open on a hill. Thus to calculate the relative importance of the stiffness of the hinge, the team multiplies the customer importance rating of how easy the door is to open by its relationship to the stiffness of the hinge ($15 \times 3 = 45$), then multiplies the customer importance rating of the door staying open on a hill by its relationship to the stiffness of the hinge ($10 \times 9 = 90$), and then adds these together for the total relative importance of the hinge stiffness ($45 + 90 = 135$). These scores indicate that the tightness of the door and window seals is the most important engineering attribute, followed by the weight of the door.
7. The team evaluates the competition. A scale of one to seven is used (one indicating a requirement is not addressed, and seven indicating a requirement is completely satisfied) to evaluate the competing products (in this case A and B) on each of the customer requirements. These scores go in the right-hand "room" of the house of quality.
8. Using the relative importance ratings established for each engineering attribute and the scores for competing products (from step 7), the team determines target values for each of the design requirements (for example, the door's optimal weight in pounds).
9. A product design is then created based on the design targets from step 8. The team then evaluates the new design that was created. The team assesses the degree to which each of the customer requirements has been met, entering a one to seven in the far right column of the house of quality, permitting it to compare the new design with the scores of the competing products.

The great strength of the house of quality is that it provides a common language and framework within which the members of a project team may interact. The house of quality makes the relationship between product attributes and customer requirements very clear, it focuses on design trade-offs, it highlights the competitive shortcomings

of the company's existing products, and it helps identify what steps need to be taken to improve them. The house of quality is used in settings as diverse as manufacturing, construction, police service, and educational curriculum design.[28] Advocates of QFD maintain that one of its most valuable characteristics is its positive effect upon cross-functional communication and, through that, upon cycle time and the product/customer fit.[29]

Design for Manufacturing

Another method of facilitating integration between engineering and manufacturing, and of bringing issues of manufacturability into the design process as early as possible, is the use of design for manufacturing methods (DFM). Like QFD, DFM is simply a way of structuring the new product development process. Often this involves articulating a series of design rules. Figure 11.6 summarizes a set of commonly used design rules, along with their expected impact on performance.

As shown in Figure 11.6, the purpose of such design rules is typically to reduce costs and boost product quality by ensuring that product designs are easy to manufacture. The easier products are to manufacture, the fewer the assembly steps required, the higher labor productivity will be, resulting in lower unit costs. DEKA Research makes a point of bringing manufacturing into the design process early, because as founder Dean Kamen points out, "It doesn't make sense to invent things that ultimately are made of unobtanium or expensium."[30] In addition, designing products to be easy to manufacture decreases the likelihood of making mistakes in the assembly process, resulting in higher product quality.

The benefits of adopting DFM rules can be dramatic. Considering manufacturing at an early stage of the design process can shorten development cycle time. In addition, by lowering costs and increasing product quality, DFM can increase the product's fit with customer requirements. For example, when NCR used DFM techniques to redesign one of its electronic cash registers, it reduced assembly time by 75 percent, reduced the parts required by 85 percent, utilized 65 percent fewer suppliers, and reduced direct labor time by 75 percent.[31]

FIGURE 11.6
Design Rules for Fabricated Assembly Products

Source: Adapted from M. A. Schilling and C. W. L. Hill, 1998, "Managing the New Product Development Process," *Academy of Management Executive*, vol. 12, no. 3, pp. 67–81.

Design Rule	Impact on Performance
Minimize the number of parts	Simplifies assembly; reduces direct labor; reduces material handling and inventory costs; boosts product quality
Minimize the number of part numbers (use common parts across product family)	Reduces material handling and inventory costs; improves economies of scale (increases volume through commonalty)
Eliminate adjustments	Reduces assembly errors (increases quality); allows for automation; increases capacity and throughput
Eliminate fasteners	Simplifies assembly (increases quality); reduces direct labor costs; reduces squeaks and rattles; improves durability; allows for automation
Eliminate jigs and fixtures	Reduces line changeover costs; lowers required investment

Failure Modes and Effects Analysis

Failure modes and effects analysis (FMEA) is a method by which firms identify potential failures in a system, classify them according to their severity, and put a plan into place to prevent the failures from happening.[32] First, potential failure modes are identified. For example, a firm developing a commercial aircraft might consider failure modes such as "landing gear does not descend," or "communication system experiences interference"; a firm developing a new line of luxury hotels might consider failure modes such as "a reservation cannot be found" or "guest experiences poor service by room service staff." Potential failure modes are then evaluated on three criteria of the risk they pose: severity, likelihood of occurrence, and inability of controls to detect it. Each criterion is given a score (e.g., one for lowest risk, five for highest risk), and then a composite risk priority number is created for each failure mode by multiplying its scores together (i.e., risk priority number = severity × likelihood of occurrence × inability of controls to detect). The firm can then prioritize its development efforts to target potential failure modes that pose the most composite risk. This means that rather than focus first on the failure modes that have the highest scores for severity of risk, the firm might find that it should focus first on failure modes that have less severe impacts, but occur more often and are less detectable.

FMEA was originally introduced in the 1940s by the U.S. Armed Forces and was initially adopted primarily for development projects in which the risks posed by failure were potentially very severe. For example, FMEA was widely used in the Apollo Space Program in its mission to put a man on the moon, and was adopted by Ford after its extremely costly experience with its Pinto model (the location of the gas tank in the Pinto made it exceptionally vulnerable to collisions, leading to fire-related deaths; Ford was forced to recall the Pintos to modify the fuel tanks, and was forced to pay out record-breaking sums in lawsuits that resulted from accidents).[33] Soon, however, FMEA was adopted by firms in a wide range of industries, including many types of manufacturing industries, service industries, and health care. A recent PDMA study found that firms report using FMEA in 40 percent of the projects they undertake.[34]

Computer-Aided Design/Computer-Aided Manufacturing

Computer-aided design (CAD) is the use of computers to build and test product designs. Rapid advances in computer technology have enabled the development of low-priced and high-powered graphics-based workstations. With these workstations, it is now possible to achieve what could previously be done only on a supercomputer: construct a three-dimensional "working" image of a product or subassembly. This enables product prototypes to be developed and tested in virtual reality. Engineers can quickly adjust prototype attributes by manipulating the three-dimensional model, allowing them to compare the characteristics of different product designs. Eliminating the need to build physical prototypes can reduce cycle time and lower costs as illustrated in the accompanying Theory in Action. Visualization tools and 3-D software are even being used to allow nonengineering customers to see and make minor alterations to the design and materials.

Computer-aided manufacturing (CAM) is the implementation of machine-controlled processes in manufacturing. CAM is faster and more flexible than traditional manufacturing.[35] Computers can automate the change between different product variations and allow for more variety and customization in the manufacturing process.

Theory in Action Computer-Aided Design of an America's Cup Yacht

Team New Zealand discovered the advantages of using sophisticated computer-aided-design techniques in designing the team's 1995 America's Cup yacht. The team had traditionally relied on developing smaller-scale prototypes of the yacht and testing the models in a water tank. However, such prototypes took months to fabricate and test and cost about $50,000 per prototype. This greatly limited the number of design options the team could consider. However, by using computer-aided-design technologies, the team could consider many more design specifications more quickly and inexpensively. Once the basic design is programmed, variations on that design can be run in a matter of hours, at little cost, enabling more insight into design trade-offs. Computer-aided design also avoided some of the problems inherent in scaling up prototypes (some features of the scaled-down prototype boats would affect the flow of water differently from full-scale boats, resulting in inaccurate results in prototype testing). The team would still build prototypes, but only after considering a much wider range of design alternatives using computer-aided-design methods. As noted by design team member Dave Egan, "Instead of relying on a few big leaps, we had the ability to continually design, test, and refine our ideas. The team would often hold informal discussions on design issues, sketch some schematics on the back of a beer mat, and ask me to run the numbers. Using traditional design methods would have meant waiting months for results, and by that time, our thinking would have evolved so much that the reason for the experiment would long since have been forgotten."

Source: M. Iansiti and A. MacCormack, "Team New Zealand," Harvard Business School case no. 9-697-040, 1997.

three-dimensional printing A method whereby a design developed in a computer aided design program is printed in three dimensions by laying down thin strips of material until the model is complete.

A recent incarnation of computer-aided manufacturing is **three-dimensional printing** (also known as additive manufacturing), whereby a design developed in a computer aided design program is literally printed by laying down thin horizontal cross sections of material until the model is complete. Unlike traditional methods of constructing a model, which typically involve machining a mold that can take several days to complete, three-dimensional printing can generate a model in a few hours. By 2011, three-dimensional printing was being used to create products as diverse as jewelry, solid-state batteries, and even titanium landing gear brackets for supersonic jets.[36] Biotechnology firms were even exploring using three-dimensional printing for use in creating organs by depositing layers of living cells onto a gel medium.[37] This method has recently begun rapidly replacing injection molding for products that are produced in relatively small quantities.

TOOLS FOR MEASURING NEW PRODUCT DEVELOPMENT PERFORMANCE

Many companies use a variety of metrics to measure the performance of their new product development process. In addition to providing feedback about a particular new product, such performance assessments help the company improve its innovation strategy and development processes. For example, evaluating the performance of its