1 Fuzzy Front End: Effective Methods, Tools, and Techniques

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The innovation process may be divided into three areas: the fuzzy front end (FFE), the new product development (NPD) process, and commercialization, as indicated in Figure 1-1.[1] The first part—the FFE—is generally regarded as one of the greatest opportunities for improvement of the overall innovation process.[2] Many companies have dramatically improved cycle time and efficiency by implementing a formal Stage-Gate™ (Cooper 1993) or PACE® (McGrath and Akiyama 1996) approach for managing projects in the NPD portion of the innovation process. Attention is increasingly being focused on the front-end activities that precede this formal and structured process in order to increase the value, amount, and success probability of high-profit concepts entering product development and commercialization.

The purpose of this chapter is to provide the reader with the most effective methods, tools, and techniques for managing the FFE.[3] The chapter begins with a brief discussion of the literature and the rationale for developing the new concept development (NCD) model. The next section describes the NCD model. The remaining sections provide a description of the most effective methods, tools, and techniques to be used in each part of the NCD model.

LITERATURE REVIEW AND RATIONALE FOR DEVELOPING THE NCD MODEL

Best practices are well known at the start (Khurana and Rosenthal 1998) and within the NPD portion (Brown and Eisenhardt 1995; Cooper and Kleinschmidt 1987; Griffin and Page 1996) of the innovation process. Similar research on best practices in the FFE is absent. Many of the practices that aid the NPD portion do not apply to the FFE. They fall short, as shown in Table

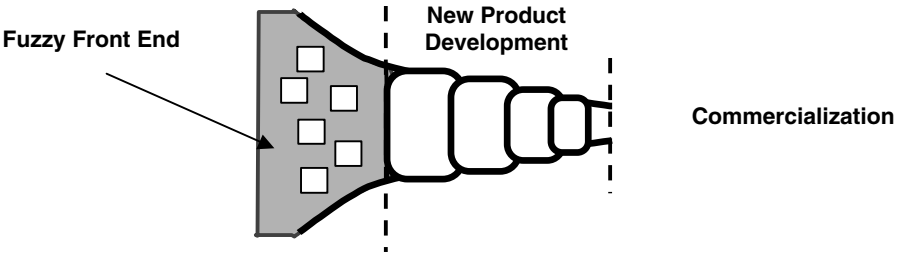

FIGURE 1-1. The entire innovation process may be divided into three parts: fuzzy front end (FFE), new product development (NPD), and commercialization.
The division between the FFE and the NPD is often less than sharp, since technology development activities may need to be pursued at the intersection.

1-1, because the nature of work, commercialization date, funding level, revenue expectations, activities, and measures of progress are fundamentally different.

Lack of research into best practices made the FFE one of the most promising ways to improve the innovation process. An Industrial Research Institute multicompany project team began studying the FFE in the middle of 1998 to describe and share best practices.[4] However, our work was stymied at first due

TABLE 1-1.
Difference Between the Fuzzy Front End (FFE) and the New Product Development (NPD) Process

	Fuzzy Front End (FFE)	New Product Development (NPD)
Nature of Work	Experimental, often chaotic. "Eureka" moments. Can schedule work—but not invention.	Disciplined and goal-oriented with a project plan.
Commercialization Date	Unpredictable or uncertain.	High degree of certainty.
Funding	Variable—in the beginning phases many projects may be "bootlegged," while others will need funding to proceed.	Budgeted.
Revenue Expectations	Often uncertain, with a great deal of speculation.	Predictable, with increasing certainty, analysis, and documentation as the product release date gets closer.
Activity	Individuals and team conducting research to minimize risk and optimize potential.	Multifunction product and/or process development team.
Measures of Progress	Strengthened concepts.	Milestone achievement.

to the difficulty of comparing FFE practices across companies. The comparison was complicated because there was a lack of common terms and definitions for key elements of the FFE. Without a common language and vocabulary, the ability to create new knowledge and make distinctions between different parts of the process may be impossible (Krough, Ichijo, and Nonaka 2000). Knowledge transfer is ineffective or unlikely if both parties mean different things, even when they are using the same terms. These insights led us to believe that we could improve understanding of the FFE by describing it using terms that mean the same thing to everyone.

To address this shortcoming, we developed a theoretical construct, the NCD model (Koen et al. 2001). It is intended to provide insight and a common terminology for the FFE. Typical representations of the front end consist of a single ideation step (Cooper 1993). However, the actual FFE is more iterative and complex. To create the model, participants provided in-depth reviews of the FFE experience in their companies. Factors common to FFE activities at all companies were identified next. Differences in both terminology and content among FFE activities were then discussed and resolved. We argued with intensity for a long time trying to devise a sequential FFE model similar to the traditional Stage-Gate™ process. All of us had demonstrated success with Stage-Gate™ processes for NPD and assumed that a similar sequential process would work for the FFE. Our argument made us realize that a sequential process model was not appropriate. This important realization allowed us to move from a sequential process model to a nonsequential relationship model.

This chapter presents our understanding of effective tools and techniques in the FFE using the NCD model. The methods, tools, and techniques discussed were determined from the best practices within our companies, an extensive search of the literature, and a review of techniques utilized by consulting firms and our colleagues. In addition, all of the authors have considerable personal experience with the FFE.

The remaining sections start with an overview of the NCD model. Following that, each part of the model is described along with the methods, tools, and techniques that the authors believe are effective.

DEFINITIONS

Opportunity: *A business or technology gap, that a company or individual realizes, that exists between the current situation and an envisioned future in order to capture competitive advantage, respond to a threat, solve a problem, or ameliorate a difficulty.*

Idea: *The most embryonic form of a new product or service. It often consists of a high-level view of the solution envisioned for the problem identified by the opportunity.*

Concept: *Has a well-defined form, including both a written and visual description, that includes its primary features and customer benefits combined with a broad understanding of the technology needed.*

NEW CONCEPT DEVELOPMENT MODEL

The NCD model shown in Figure 1-2 consists of three key parts:

- The engine or bull's-eye portion is the leadership, culture, and business strategy of the organization that drives the five key elements that are controllable by the corporation.
- The inner spoke area defines the five controllable activity elements (opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition) of the FFE.
- The influencing factors consist of organizational capabilities, the outside world (distribution channels, law, government policy, customers, competitors, and political and economic climate), and the enabling sciences (internal and external) that may be involved.[5] These factors affect the entire innovation process through to commercialization. These influencing factors are relatively uncontrollable by the corporation.

Several characteristics of the model are worth noting. The inner parts of the NCD are called elements, as opposed to processes. A process implies a struc-

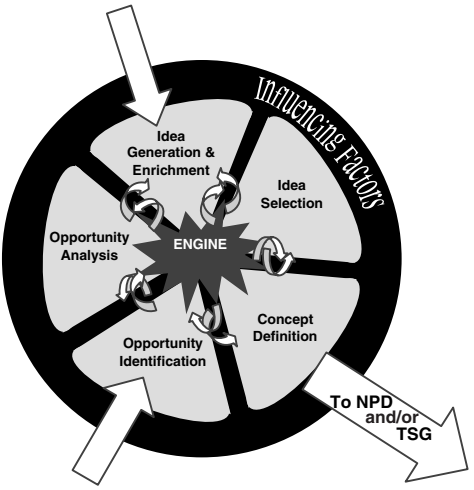

FIGURE 1-2. The new concept development (NCD) construct is a relationship model, not a linear process.
It provides a common language and definition of the key components of the fuzzy front end (FFE). The engine, which represents senior- and executive-level management support, powers the five elements of the NCD model. The engine and the five elements of the NCD model are placed on top of the influencing factors. The circular shape of the NCD model is meant to suggest that ideas and concepts are expected to iterate across the five elements. The arrows pointing into the model represent starting points and indicate that projects begin at either opportunity identification or idea generation and enrichment. The exiting arrow represents how concepts leave the model and enter the new product development (NPD) or technology stage gate (TSG) process.

ture that may not be applicable and could force the use of a set of poorly designed controls to manage FFE activities. In addition, the model has a circular shape, to suggest that ideas are expected to flow, circulate, and iterate between and among all the five elements. The flow may encompass the elements in any order or combination and may use one or more elements more than once. This is in contrast to the sequential NPD or Stage-Gate™ process, in which looping back and redirect or redo activities are associated with significant delays, added costs, and poorly managed projects. Iteration and loop-backs are part of FFE activities. While the inherent looping back may delay the FFE, it typically shortens the total cycle time of product development and commercialization. Clearer definition of market and technical requirements, sources of risk and a well defined business plan for the new product may enable more effective management of the development and commercialization stages with fewer 'redo' or 'redirect' activities. In contrast, the overall project cycle time and costs grow exponentially whenever there is redo activity as the project moves downstream through the NPD or Stage-Gate™ process (Wheelwright and Clark 1992).

An example of looping back and iteration took place when Spence Silver at 3M first identified the strange adhesive that was more tacky than sticky and which later enabled the development of the 3M Post-it notepads. Initially there were no product ideas for this concept—though Silver visited most of the divisions at 3M in order to find one. The initial idea was to develop a bulletin board coated with the tacky adhesive, to which people would attach plain-paper notices. This concept was never realized, and a new concept, which eventually became 3M Post-its, was later proposed by looping back into opportunity identification and opportunity analysis from idea generation and enrichment. Constant iteration and flow within the FFE is a hallmark of activities in this stage of the product development process.

Even though the key elements of the FFE will be discussed in a clockwise progression, they are expected to proceed nonsequentially, as shown by the looping arrows between the elements. Further, the separation between the influencing factors (i.e., environment) and the key elements is not rigid. Interactions and intermingling between the influencing factors, the five key elements, and the engine are expected to occur continuously.

The following sections discuss influencing factors, the engine, and each of the five key elements in more detail. Methods, techniques, and tools utilized will be indicated. Two examples—one market-driven and one technology-driven—highlight the characteristics of each part of the model.

EXAMPLES

The market-driven example is the development of nonfat potato chips using a fat substitute (a substance that provides the same flavor as fat but is not absorbed in the body). The technology-driven example is the development of 3M Post-it notepads (Nayak and Ketteringham 1994).

INFLUENCING FACTORS (THE ENVIRONMENT)

The FFE exists in an environment of influencing factors. The factors are the corporation's organizational capabilities, customer and competitor influences, the outside world's influences, and the depth and strength of enabling sciences and technology. Sustained successful product development can occur only when FFE activities can be accomplished with the company's organizational capabilities. Organizational capabilities determine whether and how opportunities are identified and analyzed, how ideas are selected and generated, and how concepts and technologies are developed. Organizational capabilities can also include organized or structured efforts in acquiring external technology. Electronics and pharmaceutical companies have a long history of augmenting their product development efforts with external licensing, joint development agreements, and the development of testing methodologies and protocols (Slowinski et al. 2000). These capabilities exert influence and give the organization the ability to deal with the influencing factors.

Enabling science and technology is also critical, since technology typically advances by building upon earlier achievements. Science and technology become enabling when they can be used repeatedly in a product or service. "Enabling" is not the same as "mature," which is defined on a technology trend line or penetration curve. It is the point when the technology is developed enough to build it into a manufactured product or regular service offering. Enabling technologies usually provide some degree of enhanced utility, cost avoidance, value, or quality improvement for the customer. Technologies typically become enabling early in their life cycle.

The outside world, government policy, environmental regulations, laws concerning patents, and socioeconomic trends all affect the FFE as well as the new product development or Stage-Gate™ part of the innovation process. Some of these factors are indicated in Porter's "five force" model (1987). Porter's model evaluates the relative power of customers, competitors, new entrants, suppliers, and industry rivalry—a power relationship that determines the intensity of competition and often inspires innovation.

Complementors are companies that are not direct competitors, that serve to help grow one's industry, and should be considered a sixth force (Grove 1999). For instance, complementors to Microsoft are Intel and Dell. Each of these companies complements the others in building an industry. Government law and policy should be considered a seventh force, because of their impact on the use of and profit from a technology.

These factors, constantly influencing people's thoughts and actions, are primary contributors to "serendipitous discovery" of new ideas. Just as a healthy marine environment is essential for a healthy population of aquatic species, so is a supportive climate essential for a productive FFE. These influencing factors are largely uncontrollable by the corporation. However, the response by the engine (corporate culture, leadership, and strategy) greatly affects the NCD's five activity inner elements. The response may also impact the organizational capabilities of the company—internal development as well

EXAMPLES

The influencing factors in the nonfat potato chip example would be the increasing consumer desire for nonfat products and cholesterol reduction, the regulatory environment for food, awareness that a competitor was beginning research efforts on fat substitutes that could be used in a nonfat potato chip, and the company's organizational capabilities (from product design, market evaluation, and distribution of potato chip products) in understanding this marketplace.

The influencing factors for 3M Post-it notepads were the organizational capabilities and enabling science in adhesives.

as external access through joint development or licensing—although these capabilities usually change much more slowly than the response by the engine.

Effective Methods, Tools, and Techniques

The ability to execute the strategy or plan of action when changes occur is a key tool for addressing influencing factors. For example, Corning enjoyed huge success in developing the successful ceramic substrate for catalytic converters. That success was a direct result of senior executives' early awareness of the Clean Air Act's requirement for reduced emissions and of the huge potential of the business. These factors were so compelling that Corning, in 1970, directed hundreds of scientists and engineers to focus on this single challenge. The resulting product has been used in more than three hundred million automobiles.

New alliances and partnerships may provide the capabilities needed for addressing influencing factors. Examples may be found in the automotive and automotive materials industries. Energy conservation and the drive to improve the quality of life and reduce pollution motivated people in these industries to establish research alliances, industry consortia, and industry-government collaborative R&D ventures. U.S. automakers and their suppliers, government labs, and several universities formed the U.S. Council for Automotive Research (USCAR), an alliance to generate and develop concepts such as a highly fuel-efficient (over eighty miles per gallon) vehicle. This new spirit of collaborative research changed the way the automakers accepted new processes and techniques. Alternative materials such as aluminum, polymers, and composites were able to show their advantages in safety, fuel economy, and vehicle performance.

When the global steel industry sensed a competitive threat, they reacted in turn. Steel industry leaders thought USCAR members could develop new structures and materials that might displace steel. In response to the challenge, more than thirty-five steel producers from around the world formed the Ultra Light Steel Auto Body research consortium. That consortium contracted research to generate and develop new ways to use steel in cars. They developed concept vehicles and built prototypes to show how vehicles and individual components made out of steel can be as much as 40 percent lighter than conventional com-

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Ability to execute the strategy or plan effectively and quickly when the environment changes.

ponents with no cost penalty. They accomplished this through novel architectures, new manufacturing techniques (e.g., hydroforming instead of stamping and welding of parts, tailor-made blanks, laser welding for assembly), and advanced new steel formulations (e.g., complex microstructures to provide for ultrahigh strength combined with light weight and good formability to address engineering and styling demands).

The influencing factors at work on the automakers and their suppliers are inspiring approaches to innovation that bring together the best attributes of multiple materials and organizations' technologies. Overall, the materials innovations are helping produce automobiles that are safer and more fuel-efficient, with longer service lives, adding to customer value.

Ability to execute the strategy or plan depends on quickly and effectively communicating influencing factors throughout the entire organization. Effective communication of the presence and impact of influencing factors and the gathering and organizing of quality information are critical to early foresight. Early foresight in turn provides early warning that gives decision makers time to decide and act. Capacity and time to decide and act are the most valuable resources to have when there are significant shifts in the influencing factors. This is because developing new, enabling technology for new products or services requires a time investment. The Corning, steel, and aluminum industry examples teach us that the impact of influencing factors can be changed favorably by communicating about them in a way that improves foresight and triggers action.

THE ENGINE (LEADERSHIP, CULTURE, AND BUSINESS STRATEGY)

The element of leadership, culture, and business strategy sets the environment for successful innovation. Proficiency in this element distinguishes highly innovative companies from less innovative ones (Koen et al. 2001). Continuous senior management support for innovation has been shown in numerous studies to be critical to new product development success (Cooper and Kleinschmidt 1995; Song and Parry 1996; Swink 2000). In their study of breakthrough projects, Lynn, Morone, and Paulson (1996) indicate that the huge success of Corning's optical fiber, GE's computerized axial tomography scanners, and Motorola's cellular phone—all of which had long gestation periods—were possible only because "senior management persisted because these opportunities made strategic sense. They fit the strategic focus of the business." The entire innovation process (including both FFE and NPD) needs to be aligned with

business strategy to ensure a pipeline of new products and processes with value to the corporation.

Culture in the FFE fundamentally differs from that in the NPD and operations parts of the organization (Buckler 1997). The FFE is experimental, ambiguous, and often chaotic, with a great deal of uncertainty. In contrast, an efficient NPD or Stage-Gate™ part of the innovation process is disciplined and goal-oriented, following a clearly defined process. Successful operations are predictable, have a strong financial orientation, are committed to the established businesses, and are often reluctant to change. In their study of thirteen highly innovative companies, Zein and Buckler (1997) identified seven factors that set these companies apart:

- Leaders demonstrating in every decision and action that innovation is important to their company
- Encouraging purposeful evolution and encouraging employees to try new things (for example, 3M employees may spend a percentage of their time on their own projects)
- Developing real relationships between marketing and technical people (for example, Sony requires all managers to spend two or three years in marketing, R&D, manufacturing, and finance)
- Generating customer intimacy by encouraging their employees to interact closely with customers
- Engaging the whole organization in understanding that innovation is the fundamental way that the company brings value to its customers
- Continuing to value the individual and set an environment that is conducive to high motivation
- Telling powerful stories that reinforce the principles and practices of innovation

Isaksen, Dorval, and Treffinger (1994) describe nine dimensions of climate for creative problem solving. Prather (2000), based on his work at DuPont, indicated that five of these dimensions are most important for shaping an environment of innovation:

- A compelling challenge that will allow people to become committed emotionally to the project.
- An environment that allows risk taking. To what degree is it acceptable to not meet expectations when trying something new?
- Trust and openness that allow people to speak their minds and offer differing opinions.
- Sufficient time for people to think ideas through before having to act.
- Availability of funding resources for new ideas.

Business strategy focuses the FFE activities toward survival, opportunistic, or growth goals. Both McGrath and Akiyama (1996) and Cooper (2000) highlight the importance of developing an overarching product vision and strat-

EXAMPLES

The engine for the nonfat potato chip example would be the CEO's desire to develop such a product when she became aware that a competitor was moving in the same direction and that this product would cannibalize their existing high-fat potato chip market.

The engine for the 3M Post-it notepads was a culture that allowed the inventor of this unusual adhesive to champion his new technology for many years in spite of the fact that no recognized application or customer need existed.

egy for new product development. Khurana and Rosenthal (1998), in their study of eighteen business units within twelve companies, concluded that business and product strategy were well integrated in the FFE of successful companies.

In contrast, Collins and Porras (1994), in their classic study of eighteen visionary companies, found that the highly successful companies expressed the essential and enduring tenets of their purpose in a core ideology that went beyond making money. Employees in these visionary companies may suggest new ideas and concepts that may not be consistent with corporate or product strategy, but they may not breach the company's core ideology. Thus a consistent product strategy may not be as important to breakthrough projects as other enablers. A recent study by Swink (2000) indicated that senior management involvement in highly innovative projects may not be beneficial. The real issue may be constancy of purpose. An unpublished multiyear study by the company of one of this chapter's authors found that the leaders in the majority of their highly successful projects showed a constancy of purpose that never wavered, combined with aggressive, focused goals. Amabile (1998) indicated how management could damage the environment for creativity by "constantly changing goals."

Effective Methods, Tools, and Techniques

A culture that encourages innovation and creativity is a key enabler. Two well-developed instruments may be used to assess the climate for creativity by measuring the culture. The first is the Situational Outlook Questionnaire published by the Creative Problem Solving Group.[6] It measures the climate for innovation along nine scales: challenge and involvement, freedom, idea time, idea support, playfulness and humor, interpersonal conflicts, debates on issues, trust and openness, and risk taking. The other is KEYS, developed by the Center for Creative Leadership.[7] KEYS measures six dimensions that encourage creativity and two that thwart it. The six encouragers are organizational encouragement, supervisory encouragement, work group supports, resource availability, challenging work, and freedom. The two inhibitors are organizational impediments and workload pressure.

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- A culture that encourages innovation and creativity.
  - Several well-tested instruments are available (see discussion above).
- Early involvement of a business-executive champion (The business or executive champion denotes the person who has direct or indirect influence over resource allocation and uses this power to channel resources to new projects. This is different from the product champion researched by Markham and Griffin (1998) and Markham (1998) and discussed later in the concept definition section.).
- A collaborative culture that encourages knowledge creation. Methods for enhancing this are:
  - Communities of practice (McDermott 1999, 2000; Wenger and Snyder 2000)
  - Information technology tools that enable people-to-people contacts
  - Collaborative work space
- Leaders maintaining constancy of purpose.
- Setting aggressive goals.

OPPORTUNITY IDENTIFICATION

In this element the organization identifies opportunities that it might want to pursue. Business and technological opportunities are explicitly considered so that resources will be allocated to new areas of market growth, operating effectiveness, and efficiency. This element is typically driven by the business goals. For example, the opportunity may be a near-term response to a competitive threat, a "breakthrough" possibility for capturing competitive advantage, or a means to simplify operations, speed them up, or reduce their cost. It could be an entirely new direction for the business or an upgrade to an existing product. It could also be a new product platform, a new manufacturing process, a new service offering, or a new marketing or sales approach. Overall opportunity identification defines the market or technology arena the company may want to participate in.

The essence of this element is the sources and methods used to identify opportunities to pursue. The company may have a formal opportunity identification process that is aligned with the influencing factors. Alternatively, there may be informal opportunity identification activities, including ad hoc sessions, water cooler or cyberspace discussions, individual insights, or edicts from senior management. Opportunity identification in many cases precedes idea genera-

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Opportunity identification occurred in the nonfat potato chip example when the food company recognized the need to develop low-fat products to respond to developing consumer trends and the competitive threat in this area.

Opportunity identification in the 3M example occurred when Silver, the inventor of the unusual glue, recognized that he had created something truly unique—a glue that was more tacky than adhesive.

tion and enrichment. It also may enable linking unanticipated notions to business or marketplace needs that were not previously known. Opportunity identification may occur from a single person recognizing an unmet customer need or previously undetected problem.

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Effective enablers for this element involve methods of envisioning the future so that opportunities may be chosen for further analysis. Principal methods utilized for assessing the uncertain future are roadmapping, technology trend analysis and forecasting, competitive intelligence analysis, customer trend analysis, market research, and scenario planning. Roadmaps capture the driving forces of the business in graphical form in order to enhance communication and insight. The key value of roadmaps is not the documents but the mapping process. The mapping process provides an invaluable forum for sharing the collective wisdom of the project team's resources, capabilities, and skills. In addition, it is one of the few tools that can easily convey the complexity of real-world projects to people who are not part of the project team.

Willyard and McClees (1987) from Motorola first introduced the roadmapping process. Since then, practitioners have mapped key technologies (Koen 1997) and products for a wide variety of applications, including catalysts (Jackson 1997), optical memory (Capron 1997), and health care (Varnado et al. 1996).

Use of competitive intelligence methods and activities for transforming disaggregated competitor information into relevant and strategic knowledge about competitors' position, size, efforts, and trends is now well developed in many companies. This new discipline refers to the broad practice of collecting, analyzing, and communicating the best available information on competitive trends occurring outside one's own company. This is not just about information gathering; rather, it is a structured process for producing actionable findings. The reader is referred to the seminal books by Fuld (1994) and Kahaner (1998), and to the Society for Competitive Intelligence Professionals.[8]

Scenario planning provides a disciplined approach for imagining and preparing for the future (Schoemaker 1995). It stimulates decisions that one would otherwise ignore, and it confronts the prevailing mind-set. The challenge for the company is to use scenario development methods to create multiple views of the future. The multiple views will yield insight into the future environment. Such foresight helps organizations better determine which opportunities to pursue.

GE's Jack Welch had his managers envision how the future of hypothetical Internet businesses could hurt them by having each business unit prepare a plan that, if implemented by an Internet competitor, could erode GE's customer base. He called this exercise "Destroy Your Business." As an example, GE reevaluated how appliances are shipped, and developed an alliance with Home Depot

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- Create more opportunities by envisioning the future through:
  - Roadmapping
  - Technology trend analysis
  - Customer trend analysis
  - Competitive intelligence analysis
  - Market research
  - Scenario planning

to sell GE appliances in its stores without Home Depot carrying the inventory. GE would deliver the appliances directly from its own warehouses. Using this new strategy, GE is on schedule to move 45 percent of its $2.5 billion appliance sales to the Internet, opening whole new segments while decreasing overall transaction costs. Envisioning a new future through the eyes of competition triggered this new strategy.

OPPORTUNITY ANALYSIS

In this element, an opportunity is assessed to confirm that it is worth pursuing. Additional information is needed for translating opportunity identification into specific business and technology opportunities. This involves making early and often uncertain technology and market assessments. Extensive effort may be committed for focus groups, market studies, and/or scientific experiments. However, the effort expended will depend on the value of the information associated with reducing uncertainties about the attractiveness of the opportunity, the expected size of the future development effort given the fit with the business strategy and culture, and the decision makers' risk tolerance.

Opportunity analysis may be part of a formal process or may occur iteratively. Business capability and competency are assessed in this element, and sponsorship for further work will be determined. However, despite all of the effort, significant technology and market uncertainty will remain.

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Opportunity analysis occurred in the nonfat potato chip example when the food company examined the trends in more detail. Did consumers really want a low-fat product, or did they want one that was low-calorie and/or low-cholesterol? How much taste would consumers give up? Was the market mainly a small niche? What were the regulatory issues? In this element the food company also examined the value of such an effort to their portfolio and the competitive threats if they did not develop such products.

Opportunity analysis in the 3M case took place when Silver attempted to find an opportunity for this strange adhesive. Silver visited every division at 3M in his quest to find a business opportunity for this new technology.

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Many of the same tools used in opportunity identification are used in this element as well. Roadmapping, technology trend analysis, competitive intelligence analysis, customer trend analysis, and scenario planning are all employed in this element. In opportunity identification, these tools were used to determine if an opportunity existed. In this element, considerably more resources are expended, providing more detail on the appropriateness and attractiveness of the selected opportunity. A typical analysis for a large-scale opportunity would include:

- *Strategic framing*. A determination of how this opportunity fits within the company's market and technology strengths, gaps, and threats.
- *Market segment assessment*. A detailed description of the market segment, showing why it represents a great opportunity. Market size analysis, growth rates, and market share of competitors are determined. Economic, cultural, demographic, technological, and regulatory factors that impact the market segment are also evaluated. Often companies will only evaluate opportunities in markets greater than a certain size (such as those with revenue greater than $100 million and growing at 10 percent per year.)
- *Competitor analysis*. Determines who the major competitors are in the identified market segment. Determines the type of new products needed in order to achieve competitive advantage. Evaluates the competitors' strategies and capabilities and the status of recent patents in this area.
- *Customer assessment*. Determines what major customer needs are not being met by current products.

An effective practice in this element for a large-scale opportunity is to assign a specific, multifunctional team whose members work full time to perform the opportunity analysis. The size and makeup of these teams depend on the size, scope, and complexity of the effort and the culture of the organization. Teams typically number three to five people and usually contain a marketing and R&D person. The team effort should begin with a project charter that provides a clear set of expectations, committing resources and outlining the expected outcome. Without such a charter the team will often squander their efforts by evaluating opportunities outside their focus. The content of the project charter is similar to the product innovation charter discussed by Crawford and Di-Benedetto (2000) but is focused on identifying new opportunities instead of new products. The team will also benefit from a clear analytical framework for assessing opportunities and the assistance of an experienced analyst. One example of an analytical framework for assessing technical opportunities is the context graph of historical performance, benchmarks, and theoretical and engineering limits that has been used by Alcoa (Turnbull et al. 1992).

An opportunity analysis for a large-scale opportunity may take approximately sixty to ninety days. Shorter efforts result in assessments from mostly

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- Same methods, tools, and techniques used to determine future opportunities, but the effort would be expanded in considerably more detail
- Assignment of a full-time specific multifunctional team of three to five people for large projects
  - Creating a charter for the team that points them in the right direction

secondary sources and lack the richness of an in-depth competitor and customer assessment. The level of detail should minimize technical, market and commercial risk and state assumptions used in the opportunity analysis to support the conclusions. This element of NCD is used for identifying the right customer and market segments or for identifying an area of significant technical potential. Further effort in the concept definition element will provide more detail about the opportunity. The desire for great detail in this element must be balanced against the knowledge that the opportunity analysis project will stall if the information collection effort becomes so exhaustive that the project never moves forward.

In many cases the team will loop back to opportunity analysis as new features and constraints are identified in the concept definition stage. Will these new features increase the market, and if so, by how much? If the project cannot deliver on these features, what is the impact? In some cases the team may loop back to opportunity identification to identify entirely new opportunities that were not envisioned at the start of the project. However, the new opportunities should be pursued only if they remain consistent with the team's charter, which should have been defined prior to the start of opportunity analysis.

IDEA GENERATION AND ENRICHMENT

The element of idea generation and enrichment concerns the birth, development, and maturation of a concrete idea. Idea generation is evolutionary. Ideas are built up, torn down, combined, reshaped, modified, and upgraded. An idea may go through many iterations and changes as it is examined, studied, discussed, and developed in conjunction with other elements of the NCD model. Direct contact with customers and users and linkages with other cross-functional teams as well as collaboration with other companies and institutions often enhance this activity.

Idea generation and enrichment may be a formal process, including brainstorming sessions and idea banks so as to provoke the organization into generating new or modified ideas for the identified opportunity. A new idea may also emerge outside the bounds of any formal process—such as an experiment that goes awry, a supplier offering a new material, or a user making an unusual request. Idea generation and enrichment may feed opportunity identification, demonstrating that the NCD elements often proceed in a nonlinear fashion, advancing and nurturing ideas wherever they occur.

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Idea generation and enrichment occurred in the nonfat potato chip example when several methods of delivering nonfat potato chips were identified. Some ideas involved reducing the total fat content; others were about the development of a fat substitute that could provide the same flavor as fat but would not be absorbed in the body.

Idea generation and enrichment in the 3M example occurred when several product ideas were identified, such as the sticky bulletin board and notepads.

Ideas may be generated by anyone with a passion for a particular idea, problem, need, or situation. Ideas may be generated or enriched by others through the efforts of a key individual or "champion" (Markham 1998; Markham and Griffin 1998). Once the idea is identified, many different creativity techniques can be applied to generate and expand upon it.[9] Those techniques can be used either by individuals or by a team in a brainstorming meeting or other idea-generation session.

Effective Methods, Tools, and Techniques

Understanding the customer and market needs is a consistent theme for successful product development in studies by Bacon and colleagues (1994), Song and Parry (1996), and Cooper (1999). There are many creativity and brainstorming techniques for enriching the idea stream. Other methods for enriching the idea stream utilize TRIZ, the Russian acronym for Theory of Inventive Problem Solving, which is a systematic way for solving problems and creating multiple-alternative right solutions. TRIZ is a methodology that enhances creativity by getting individuals to think beyond their own experience and to reach across disciplines to solve problems using solutions from other areas of science (Altshuller, 1999). Some of the most effective tools and techniques include:

- An organizational culture that encourages employees to spend unscheduled time testing and validating their own and others' ideas.
- A variety of incentives (e.g., awards, peer recognition, performance appraisal) to stimulate the generation and enrichment of ideas.
- A Web-enabled idea bank with easy access to product or service improvements, including linkages to customers and suppliers.
- A formal role for someone to coordinate ideas from generation through assessment.
- A mechanism to handle ideas outside (or across) the scope of established business units.
- A limited number of simple, measurable goals (or metrics) to track idea generation and enrichment. These could include: number of ideas retrieved and enhanced from an idea portfolio, number of ideas generated/enriched over a period of time, percentage of ideas commercialized,

value of ideas in a idea portfolio (or idea bank), percentage of ideas that entered the NPD process, percentage of ideas that resulted in patents, and percentage of ideas accepted by a business unit for development.

- Frequent job rotation of engineers (Harryson 1997), scientists, and inventors to encourage knowledge sharing and extensive networking.
- Mechanisms for communicating core competencies, core capabilities, and shared technologies broadly throughout the corporation.
- Inclusion of people with different cognitive styles on the idea enrichment team (Leonard and Straus 1997; Prather 2000).

However, many of these techniques do not lead to breakthrough ideas. Von Hippel (1986) indicated that the actual first user of a product develops over 75 percent of breakthrough inventions. This occurs because the tacit knowledge stays with the user. Von Hippel (1998) refers to this knowledge as "sticky" since it is difficult to transfer from the lead user to others. One method for better understanding the tacit knowledge of the customer utilizes lead user methodology, which involves working with lead and analog[10] users (von Hippel, Thomke, and Sonnack 1999). 3M has utilized the lead user process to develop a way to prevent infections that is less costly and more effective than

Most Effective Methods, Tools, and Techniques

- Methods for identifying unarticulated customer needs include:
  - Ethnographic approaches
  - Lead user methodology
- Early involvement of customer champion
- Discovering the archetype of your customer. (Archetype[12] research identifies the unstated "reptilian" or instinctive part of the brain)
- Market and business needs and issues continuously interspersing with the technology advances
- Identifying new technology solutions
  - Increasing technology flow through internal and external linkages.
  - Partnering
- An organizational culture that encourages employees to spend free time testing and validating their own and others' ideas
- A variety of incentives to stimulate ideas
- A Web-enabled idea bank with easy access to product or service improvements, including linkages to customers and suppliers
- A formal role for someone (i.e., process owner) to coordinate ideas from generation through assessment
- A mechanism to handle ideas outside (or across) the scope of established business units
- A limited number of simple, measurable goals (or metrics) to track idea generation and enrichment
- Frequent job rotation to encourage knowledge sharing and extensive networking
- Mechanisms for communicating core competencies, core capabilities, and shared technologies broadly throughout the corporation
- Inclusion of people with different cognitive styles on the idea enrichment team

EXAMPLES

Idea selection occurred in the nonfat potato chip example when a particular fat substitute molecule was chosen.

Idea selection occurred in the 3M example when the notepad idea was selected for continued development.

traditional surgical drapes. The company has successfully tested the lead user methodology in eight of its fifty-five divisions. Ethnographic approaches involve methods for gaining intimate knowledge of the customer by becoming part of their habitat (Burchill and Brodie 1997).[11] Michaels (2000) notes that Motorola employed anthropological observation to develop two-way pagers for the rural Chinese market.

IDEA SELECTION

In most instances, the problem is not coming up with new ideas. Even when businesses are being downsized, there is no shortage of new ideas. The problem for most businesses is in selecting which ideas to pursue in order to achieve the most business value. Making a good selection is critical to the future health and success of the business. However, there is no single process that will guarantee a good selection. Most idea selection involves an iterative series of activities that are likely to include multiple passes through opportunity identification, opportunity analysis, and idea generation and enrichment, often with new insights from the influencing factors and new directives from the engine.

Selection may be as simple as an individual's choice among many self-generated options, as formalized as a prescribed portfolio management method, or as complex as a multistage business process. Formalized decision processes in the FFE are difficult due to the limited information and understanding that are available early in product development. Financial analyses and estimates of future income for ideas at this early stage are often wild guesses. Idea selection is expected to be less rigorous in FFE than in the NPD portion, since many ideas must be allowed to grow and advance. Additional effort will be invested to define the concept after the idea has been selected.

Effective Methods, Tools, and Techniques

Idea selection often begins as individual judgment, which may occur subconsciously. Often early personal judgments are made at an emotional or "gut" level, with little more than the idea itself to consider. Idea selections within an individual's own mind are almost always the initial part of the selection process.

Although there may not be a single most effective practice for idea selection,

our experience has shown that without some formal decision process to commit business resources (time, funding, and people), most new ideas disappear into a kind of black hole. In the authors' experiences, formal processes work as long as there is visible support from management and there is a process owner facilitating the activity.[13] Many people who submit ideas into a suggestion box or other collection process never hear any follow-up. As a result, they are less likely to submit their next new idea, and the stream of new ideas dries up. For this reason, communicating to the originator about what is happening with his or her idea (or simply that it has been shelved) is critical to the process. The process should provide prompt feedback to idea generators on the status of their ideas and periodic reviews of the ideas in the idea bank. The need to have a formal process is consistent with the radical innovation hub suggested by Leifer and colleagues in their book *Radical Innovation* (2000). Their hub would link ideas, opportunity evaluators, and key people in the corporate and operating units.

Most formal processes begin with some person or group looking at a very limited amount of information about an idea (Figure 1-3). They will probably require a number of stages before a final decision to commit significant resources can be reached. In some cases the process may begin with no more than a one-line description of the idea. If the idea is considered attractive, the next step is usually to gather more information. This could be requested of the originator or assigned to someone else. The originator may have a great deal of energy and/or ownership for his or her idea and wish to pursue it further. If further work is assigned to someone else, the originator might feel that his or her idea is being taken away. On the other hand, the originator may not have the time or inclination to do more work on the idea and may view additional work as a burden. Any idea selection process needs to address these possibilities. Once additional information has been gathered and analyzed, the idea usually goes through another decision process. Roles and responsibilities of the

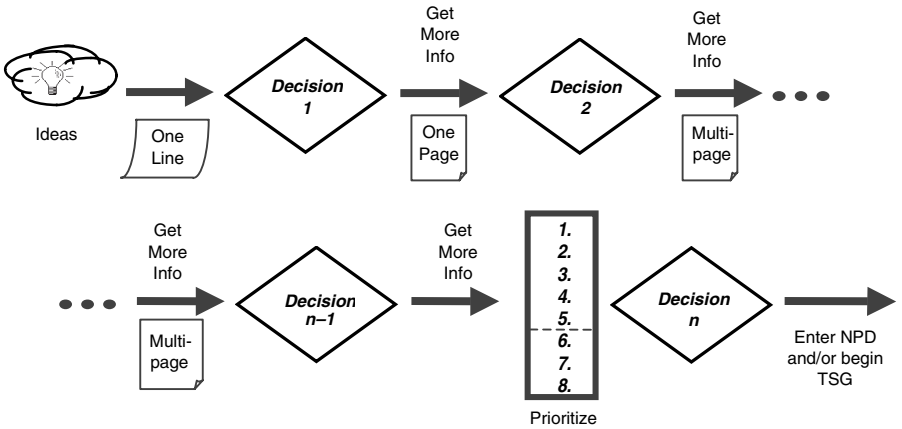

FIGURE 1-3. A typical idea selection process.
In many cases the total number of decisions may be reduced to two.

people involved, and the assumptions and expectations of the process, need to be clearly known and understood by those who own the process and those who rely on it.

In idea selection, decision makers need to adopt a positive attitude rather than to approach the task as a filtering out of less attractive ideas. Decision makers need to ask how an idea can be helped to move forward or how an idea can be modified to make it more attractive, rather than how to determine which ideas to kill. Screening should be done in a way that encourages creativity and should not be so restrictive as to stifle new ideas.

Having decided which ideas are worth further attention, the next step is to prioritize the attractive ideas and select the best ones. Usually a business has many more ideas that it wants to work on than it has resources. It therefore must find a way to determine which ideas are most attractive. Traditional financial measurements, such as sales and profit forecasts and traditional discounted cash flow calculations, are well suited to incremental, short-term product and process development serving well-characterized customer and market needs. However, as the idea becomes novel and the time to commercialization becomes longer and/or more uncertain, metrics such as net present value or internal rate of return break down.

In contrast to the formal people-intensive process discussed above, Nortel has developed an electronic performance support system that allows idea generators the ability to screen their own ideas using an "expert" system—thus eliminating the need for people to screen every submitted idea (Montoya-Weiss and O'Driscoll 2000). Once the idea makes it through each of the three phases (idea qualification, concept development, and concept rating), then a decision maker will electronically receive a standardized form. The overall idea is evaluated based on sixteen dimensions equally divided among marketing, technical, human, and business factors.

In lieu of traditional financial measures, Boer (1999) first suggests considering an idea's "terminal value" (assumed cash flow beyond the finite time horizon of the typical discounted cash flow calculation). He notes that the terminal value may account for 75 percent or more of the value of long-range developments such as new drugs. Second, traditional discounted cash flow metrics burden the project with the total cost of developing and maintaining the business after product launch. Reliance on these metrics contradicts the intention of making small investments of finite duration to encourage rapid screening of ideas and then building the worthwhile ones into business concepts. Third, Boer (2000) indicates that conventional discounted cash flow calculations do not properly treat the dependency of value on risk (beyond that captured by the discount rate or cost of capital). Methods to capture risk are also needed. Cooper, Edgett, and Kleinschmidt (1998) describe numerous examples of techniques used by companies to assess technical and commercial factors that capture "unique risk."

Assessing risk using options theory is yet another approach. Market risk, which options theory represents by the probability distribution of the cash flow stream or its independent revenue and cost components (Angelis 2000), actually

enhances the option's value. Three recent articles elaborate on applying options theory assessment with examples in the chemical and pharmaceutical industries (Boer 2000; Angelis 2000; McGrath and MacMillan 2000). While these methods offer tremendous potential, their power can be unleashed only when the innovator thinks critically about the assumptions that determine the idea's business value.

When selecting ideas to consider for further development, it is important to consider Bower and Christensen's (1995) assertion that most businesses will reject "disruptive technologies."[14] Thus, any idea selection process may be fundamentally flawed, since a disruptive idea will be unable to garner resources against the existing business. Bower and Christensen assert that the disruptive idea should be the basis for creating a small organization separate from the mainstream during its initial formative development.

Stevens, Burley, and Divine (1998, 1999) indicate that individuals with high Myers-Briggs preferences for intuition and thinking will make better project selections and generate ninety-five times more profit when compared to similar individuals with low Myers-Briggs preferences for intuition and thinking. Surprisingly few studies have directly examined the role of personality on NPD performance in large corporations. In contrast, the new business entrepreneurial literature has extensively investigated the personality differences between entrepreneurs and nonentrepreneurs—though with often conflicting results (Shaver and Scott 1991).

In summary, idea selection should be done in a formal process where prompt feedback is provided to the idea generators. However, the criteria for selecting the "right" idea for highly novel projects are just emerging. Traditional financial methods, for other than incremental products and services, have been recognized as being unsuitable for these cases. Other methods, such as options theory and risk assessment, are just beginning to emerge, with no consensus as

Most Effective Methods, Tools, and Techniques

- Portfolio methodologies based on multiple factors (not just financial justification) using anchored scales*
  - Technical success probability
  - Commercial success probability
  - Reward
  - Strategic fit
  - Strategic leverage
- Formal idea selection process with prompt feedback to the idea submitters
  - Enhancement of methodology with electronic performance support systems
  - Web-enabling of the process
- Use of options theory to evaluate projects

*Anchored scales are ordinal measures that utilize numeric indicators, each of which is associated with a set of words that help the respondent "anchor" his or her evaluation. The use of anchored scales remove much of the subjectivity when assigning a value to the project. Examples may be found in Ajamian and Koen 2002 and Davis et al. 2001.

to the "best" method to use. Further, companies need to determine how to prevent the rejection of disruptive ideas, which may eventually destroy the company's existing business. Finally, certain personality types may be more likely to make better decisions.

CONCEPT DEFINITION

Concept definition is the final element of the new concept development model. This element provides the only exit to the NPD or technology stage gate (TSG). In order to pass through the gate, the innovator must make a compelling case for investment in the business or technology proposition. Some organizations refer to this as a "win statement." Others call it a "gate document." The investment case consists of both qualitative and quantitative information, which the gatekeepers use to make a determination. Most companies specify guidelines for gatekeepers, who make decisions at the outset of the development process. These may address:

- Objectives
- Fit of the concept with corporate and/or divisional strategies
- Size of opportunity, such as financial impact
- Market or customer needs and benefits
- A business plan that specifies a specific win/win value proposition for value chain participants
- Commercial and technical risk factors
- Environmental, health, and safety "showstoppers"
- Sponsorship by a receiving-group champion
- A project plan including resources and timing

Information requirements and criteria vary depending on the nature and type of concept as well as the decision makers' attitudes toward risk. For example, numerous companies specify market, financial, and timing hurdles for NPD and improvements. Many companies expect their NCD teams to build technology ideas into business concepts. If the investment case is not compelling, the concept may return to NCD rather then proceeding to the NPD Stage-Gate™ or TSG process. This provides an opportunity to revise and strengthen the concept. Alternatively, the concept may become dormant. It is a knowledge management challenge to keep these dormant concepts alive in a way that allows them to receive consideration once the environment changes.

Formality of the business case varies because of several factors:

- Nature of the opportunity (e.g., new market, new technology, and/or new platform)
- Level of resources
- Organizational requirements to proceed to NPD
- Business culture (e.g., formal, informal, or hybrid)

EXAMPLES

In the final element, concept definition, a scientific program in the nonfat potato chip example was started and supported to develop the selected fat substitute molecule.

In the 3M example, an entirely new manufacturing process to attach a "nonsticking" adhesive to paper was developed.

Developing a business plan and/or a formal project proposal for the new concept typically represents the final deliverable for this element as the concept moves into NPD and/or TSG.

Effective Methods, Tools, and Techniques

Both Crompton Corporation and Rohm and Haas employ a formal goal deliberation process prior to investing significant resources in the concept. Members of the cross-functional team define the business goal(s) or outcome(s) of the proposed product, process, business, or technology development. The team deliberates responses to questions regarding market, customer, competitor, technology, product, manufacturing, regulatory, supply chain, delivery, service, and other issues. They define a set of necessary and sufficient objectives in specific, measurable terms. For example, the team would quantify target performance properties of a new polymer and specify the methods by which they would carry out the measurements. Participants define boundary conditions that, if unfulfilled, could result in project termination. These boundaries could include the range of technical approaches that the team will utilize, cost ranges, timing and resource limits, and other sources of technical and commercial risk that could alter the outcome. The process owner plays an essential role in goal deliberation. He or she facilitates the discussion to clear away the "technical smoke" and reveal any implicit, unstated assumptions behind disagreements. If conducted effectively, goal deliberation yields solid commitment, including resources, from all stakeholders.

Many companies have also developed evaluation criteria that help innovators determine if the opportunity is attractive. An example of such a matrix is indicated in Table 1-2. Having a set of objective criteria that are utilized by the screening committee and communicated for understanding by everyone in the organization has also been found important in both the idea generation and enrichment element and the idea selection element.

Having a product champion is usually required for many ideas to survive the gauntlet of barriers found at most companies (Markham and Aiman-Smith 2001; Markham 2002).[15] However, research by Markham and Griffin (1998) and Markham (1998) indicates that having a product champion is not correlated with overall project success. Product champions advocate both good and bad projects. Adding more rigor to the idea selection process and defining the

TABLE 1-2.
Example of Evaluation Criteria that Provide Guidance in Concept Selection

Factors	Specific Issues	Attractive	Unattractive
Market	Market size	>$100 million	<$10 million
	Market growth	>20%	<5%
	Market drivers	Satisfy all	Meets at least one
	Market access	Existing business	Needed
	Potential market share	>20%	<5%
Competency	Business infrastructure	In place	Needed
	Customer familiarity	Current base	Few
	Core competency	Recognized	None
Competitive Issues	Proprietary position	Yes	No
	Leadership position	#1 by year 5	No lead
	Cost position	Lowest	Highest
	Key competitive advantage	Proprietary	None
	Sustainability of position	High	Low
Time Factors	Time to sales	<2 years	>5 years
	Full commercialization	<5 years	>5 years
	Competitive time advantage	>2 years	<1 year
	Operating at break-even	<3 years	>5 years
Technology	Technology availability	In place	Needed
	Technology readiness	Proven	Discovery still needed
	Technology skill base (people and time)	Available	Needed
Financial	After-tax operating income	>12%	<8%
	Maximum cash hole	<$20 million	>$50 million
	Revenue stream	>1 product line	1 product
	Business potential	>$100 million	<$20 million

criteria for what a good product looks like (i.e., Table 1-2) should reduce the ability of a great champion/salesman to promote his or her bad project.

Alcoa uses a method supporting rapid evaluation of high potential process and product innovations (Smith, Herbein, and Morris 1999). Short proposals requesting funding to test a specific technical hurdle are reviewed by an experienced innovation assessment team. Potential business value, the nature of the innovation, a plan to quickly test the highest-risk element of the concept, and the identification of potential sponsors for the project are evaluated. Resources are often provided to rapidly test a high-risk aspect of a high-potential concept in order to help determine if the project is sufficiently compelling for further investments.

When there are significant technical uncertainties, some companies use a technology stage-gate (TSG) process (Eldred and McGrath 1997; Ajamian and

Most Effective Methods, Tools, and Techniques

- Goal deliberation approaches
  - Time spent on carefully defining the project goals and outcomes
- Setting criteria for the corporation that describe what an attractive (in terms of financials, market growth, market size, etc.) project looks like
- Rapid evaluation of high-potential innovations
- Rigorous use of the TSG for high-risk projects
- Understanding and determining the performance capability limit of the technology (Foster 1986)
- Early involvement of the customer in real product tests
  - Involvement of the customer even before product is completed
  - Staff up high-potential projects while still in FFE
- Partner outside of areas of core competence
- Focus (in contrast to spreading too thin)
- Pursue alternative scientific approaches
- Employ product champions if adequate funds are unavailable

Koen 2002). The TSG process may be completely inside, partially outside, or completely outside the NCD. Technology projects that explore fundamental scientific relationships, scout, or evaluate new technology platforms are usually unstructured at the earlier phases and thus are part of the NCD. As the effort escalates, technology risk is reduced to justify further investment. More resources are utilized, and the decisions become more structured, resulting in the later portions of the TSG moving out of the NCD and into the NPD portion. In some cases, the TSG would be completely external to the NCD if the technology activities were mostly structured and with few risks, or if there was a business decision to specifically pursue a particular technology. In contrast, the TSG would remain inside the NCD if these factors were reversed.

CONCLUSIONS

Methodologies, tools, and techniques used in the NPD portion of the innovation process often will not work in the FFE because the FFE is fundamentally different. As a result, the FFE is one of the weakest areas of the innovation process—and so presents one of the biggest opportunities for improvement. There are four significant differences between NPD and FFE. First, FFE work is not structured, but is experimental and often involves individuals instead of multifunctional teams. Second, FFE work is so early that revenue expectations are uncertain, and it is often not possible to predict commercialization dates. Third, funding for FFE work is usually variable. Fourth, FFE work results in strengthening a concept, not achieving a planned milestone.

Our quest started as an attempt to determine the most effective tools and techniques for the FFE. However, this initial effort proved fruitless, since there was no common terminology and vocabulary for the FFE. To this end, our

team developed a theoretical construct, the NCD model, which consists of three parts: the uncontrollable influencing factors, the controllable engine that drives the activities in the FFE, and the five activity elements of the NCD. The model highlights the iterative series of activities that may take anywhere from a few seconds in the minds of individuals to many months or years for defining a breakthrough concept.

NCD is not a linear process with specified steps and timing, as is the case of the Stage-Gate™ framework used by many companies for NPD efforts. It is a model that helps us better describe effective methodologies, tools, and techniques for each portion of the NCD. This model, with its common language and terminology, should allow business and technology leaders to better optimize activities in the FFE. That optimization should result in a significantly greater number of highly profitable concepts entering NPD. Further, the common terminology should allow investigators to better focus their research on parts of the FFE while still allowing them an understanding of the whole.

NOTES

1. The FFE is defined by those activities that come before the formal and well-structured NPD process. Even though there is a continuum between the FFE and NPD, the activities in the FFE are often chaotic, unpredictable, and unstructured. In comparison, the NPD process is typically structured, which assumes formalism with a prescribed set of activities and questions to be answered. New product development refers to both product and process development (e.g., a new manufacturing process that provides significant improvement in the product cost).
2. Although the authors prefer to call this portion of the innovation process the "front end of innovation," the conventional PDMA term "fuzzy front end" is used in this chapter. We believe that the latter term implies that the FFE is mysterious, lacks accountability, and cannot be critically evaluated. It is our belief that the term "front end of innovation" more appropriately describes this portion of the innovation process.
3. The authors use the term "effective practices" as opposed to "best practices." The latter term implies that there is a best practice that should be followed. However, certain practices may be "best" only in the particular setting of the company. Thus we use the term "effective"—to imply that these are the effective practices found at the companies studied. Only the company itself can determine what is best for it.
4. The Industrial Research Institute (*www.iriinc.org)* is a nonprofit organization of over 260 leading industrial companies. The member companies represent such industries as aerospace, automotive, chemical, computer, and electronics; carry out over 80 percent of the industrial research effort in the United States; employ some five hundred thousand scientists and engineers; and account for at least 30 percent of the country's gross national product.
5. Organizational capabilities were placed as an influencing factor since they typically change very slowly and thus are uncontrollable. Alternatively, organizational capabilities could move into the engine to the degree to which they could be modified and controlled by the corporation. In a similar fashion, internal culture was placed

in the engine since it is typically controlled by the corporation, though it could be considered an influencing factor to the extent that it is uncontrollable and changes very slowly.

6. Creative Problem Solving Group (*www.cpsb.com)*, 1325 N. Forest Road, Suite F-340, Williamsville, NY 14421.
7. Center for Creative Leadership (*www.ccl.org)*, One Leadership Place, Greensboro, NC 27438.
8. Society for Competitive Intelligence Professionals (*www.scip.org)*, 1700 Diagonal Road, Suite 600, Alexandria, VA 22314.
9. The reader is referred to *The PDMA Handbook of New Product Development* (Rosenau et al. 1996) and the Industrial Research Institute volume on creativity (*Creativity and Idea Management*, selected papers from *Research Technology Management*, 1987–1996) for a (somewhat dated) compendium of articles on creativity. The reader may also be interested in joining the American Creativity Association (*www.amcreativityassoc.org)*, whose vision is to be the primary association dealing with creativity.
10. Analog users are people who are innovating in areas significantly outside the industry but whose innovations may have direct applicability to providing new insights to the project team looking for breakthroughs. For example, a team looking at new skin creams and issues associated with fissures as the skin cream ages turned to earthquake specialists who were expert at measuring and predicting fissures.
11. Ethnography is a descriptive methodology for studying the customer in relation to his or her environment.
12. An archetype is an inherited idea or mode of thought that is derived from the experience of the race and is present in the unconscious of the individual. For more information about this technique the reader is referred to Archetype Discoveries Worldwide, 14401 South-Military Trail, Suite E203, Delray Beach, Florida 33484 (www.archetypediscoveriesworldwide.com).
13. The process owner is the person who is responsible for maintaining the idea selection process. He or she focuses on the process without becoming overly involved in the content of the meeting or the details of the ideas submitted. The process owner for the idea selection process is typically the same person who is responsible for the Stage-Gate™ process.
14. A disruptive technology is one that does not provide value to the companies' current customers but addresses the need of the company's future customers (Bower and Christensen 1995).
15. The product champion is the person who adopts the project as his or her own and shows a personal commitment to it. They vigorously advocate the project, often at their own political risk, and help the project through its critical times (Markham 1998).

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