The PDMA ToolBook for New Product Development

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Introduction

Welcome to *The PDMA ToolBook for New Product Development*. This *ToolBook* is written by new product development (NPD) experts. It provides in-depth information on a collection of 16 leading-edge product development tools and techniques. What really distinguishes this book is that its tools can be used immediately by applying the information provided here. Each chapter explains a tool, lists the steps to implement it, provides examples of its use, and provides both keys to success as well as pitfalls to avoid. Most chapters include diagnostic guides and sample templates. Each tool has been used successfully by a number of organizations to improve new product development.

Since different sets of tools are apt to be more useful to you depending on your organization level and NPD experience, this book is organized into four parts for your convenience. While all four parts will be of at least general interest to anyone involved in NPD, we suggest that you look first to the part that most closely fits your current responsibility in the organization.

**Project Leaders**—If you are leading a product development team, you will find the first half of the *ToolBook*, Parts 1 and 2, most useful. These tools help those leading projects manage their project more effectively or efficiently.

Part 1 presents four tools a project leader can use in the Fuzzy Front End of the project—tools to help you do a good job on the up-front homework of a project. These tools help with tasks that can be done before true development starts. Each of these tools provides a different method for improving the project’s odds for success by increasing understanding and knowledge. Fuzzy Front End project leaders will benefit from applying one or more of these tools before they start each new project.

The tools in Part 2 are useful across the entire life of a project. Although projects likely would benefit most from using these tools earlier rather than later, project leaders can apply any of these at any time. You will probably benefit from applying each of these tools a number of times during the project.

Parts 3 and 4 contain cross-project tools—specifically, tools to be utilized by process owners (Part 3) and program managers (Part 4). Process owners are those executive managers responsible for developing and maintaining the firm’s NPD process. They also may be responsible for deploying and facilitating process use across the organization. A program manager is the person assigned responsibility for overseeing development progress for all of the projects associated with all the various product lines within a business unit or organization.

**Process Owners**—those who are responsible for developing, maintaining,
and deploying the product development process in the business unit or firm—will benefit the most from the tools in Part 3. Each tool in this part represents a method to improve a particular aspect of the product development process. These are tools that your firm may consider incorporating into its standard NPD procedures.

**Program Managers**—anyone who is responsible for managing a program of multiple NPD projects within a business unit or organization—will find the tools in Part 4 most useful. These tools provide four different ways for measuring and improving the overall portfolio of projects that the firm undertakes over time.

**HOW TO USE THIS BOOK**

This is a book that you will use chapter by chapter, not all at once. We recommend that you start by reading the introductions to each part. The introductions provide more information about situations that may be aided by each of the tool chapters. You also may want to skim several of the chapters just to become familiar with some of the specific tools. Then, as you consider a weakness in your NPD process or a problem situation that you’d like to fix, you can go to the particular chapters that apply to that situation and try putting one or more of these tools to immediate use.

Alternatively, you may just be looking to improve some aspect of your NPD on a proactive basis. In this case, we recommend that you look at the chapter(s) that most closely fit the NPD area you are looking to improve. The chapters are full of best-practice tools that can improve the effectiveness of any NPD organization.

The CD-ROM that accompanies this book contains several important items. Most chapters have templates, diagnostics tools, photos, examples, and additional information on the CD.

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The tools of Part 1 will be most useful to project leaders prior to the actual start of an NPD project. At this point in the NPD process, the product or service has not been specified, the business plan has not yet been approved, and only a few of the team members may have been identified and are working actively. These tools help NPD teams do a good job completing the up-front homework of a project, which has been shown to strongly correlate with project success.

Each tool of Part 1 provides a different method for improving the probability of project success by increasing understanding and knowledge about competitors, technologies, markets, and customers. The tools are organized from more general, broader types of tools in Chapter 1 to those that are more focused and narrowly targeted at solving one particular problem in the later chapters of this part.

Chapter 1, “Fuzzy Front End: Effective Methods, Tools, and Techniques,” defines five tasks of New Concept Development that must be completed before a formal NPD process can be started: opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition. Completing these tasks is enabled by the leadership, culture, and business strategy “engine” of the corporation. Without this engine, concept develop-
ment is not supported effectively in the organization. In the FFE, teams iterate back and forth between these five tasks until they define a concept that is acceptable, strategically as well as in terms of feasibility and potential, for entering the development and commercialization process. This chapter overviews a number of methods, tools, and techniques that help teams successfully complete each of these tasks, and that help create an effective leadership, culture, and strategy engine for supporting ongoing concept development.

“Hunting for Hunting Grounds: Forecasting the Fuzzy Front End,” Chapter 2, is a tool for helping an organization move from current markets and products to new markets and products. It is especially useful for firms in mature product markets, where future new product opportunities are usually limited to incremental improvements to the current products and where there is little future additional growth opportunity for the organization. The chapter steps through the four stages in this method: preparing (building a charter and project plan), hunting (discovering a large number of potential opportunity areas), model building (winnowing the full set of opportunities down to three to five problems that make sense for your organization to solve), and path building (creating a series of high probability, new-revenue-stream business opportunities to move the firm into the new product-market area in a planned manner).

An in-depth, qualitative telephone interviewing tool that helps organizations discover how a new product concept’s critical attributes are seen by prospective customers is presented in Chapter 3, “Telephoning Your Way to Compelling Value Propositions.” While this technique can be used for increasing understanding for any concept, it will be most useful for firms who market to other businesses and have difficulty doing focus groups or other types of market research because their customers are geographically dispersed or not readily accessible in person. It is also useful for those trying to develop understanding in formulating a complex or technology-dependent concept. The chapter defines the characteristics of a compelling value proposition, presents the steps associated with the in-depth interviewing method, shows how to successfully use a telephone to do these types of interviews, and closes with information on how to recast the collected information and insights into a compelling value proposition.
Chapter 4, “Focusing NPD Research on Customer Perceived Value,” describes market research methods and tools that help a firm understand how customers evaluate all of the benefits and costs of an offering and compares them to the benefits and costs of other products or services that they perceive as being alternatives. Although this customer perceived value is the basis upon which customers decide which products and services to purchase, it is difficult to quantify because it is market perceived (not firm imposed), complicated, important only as it is relative to other alternatives, and dynamic because marketplaces are always changing. The chapter overviews techniques for understanding customer wants and needs, identifying value attributes, and understanding market factors, perceived importance, and perceived relative performance. The understanding gained from developing this information can then be applied to specific new product development issues. Firms entering new markets or participating in dynamic markets or business environments will find this tool especially useful in maintaining product success.
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
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.

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

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

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 cir-
cular shape, to suggest that ideas are expected to flow, circulate, and iterate
between and among all the five elements. The flow may encompass the ele-
ments 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 sig-
ificant 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 develop-
ment 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 influ-
encing 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-
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. 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. 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.
1. Fuzzy Front End: Effective Methods, Tools, and Techniques

**Most Effective Methods, Tools, and Techniques**

- 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 effect-
iveness, 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 identi-
fication 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-

**EXAMPLES**

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 busi-
ness 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.

**Effective Methods, Tools, and Techniques**

Effective enablers for this element involve methods of envisioning the future so
that opportunities may be chosen for further analysis. Principal methods util-
ized for assessing the uncertain future are roadmapping, technology trend anal-
ysis 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 road-
mapping process. Since then, practitioners have mapped key technologies (Koen
1997) and products for a wide variety of applications, including catalysts (Jack-
son 1997), optical memory (Capron 1997), and health care (Varnado et al.
1996).

Use of competitive intelligence methods and activities for transforming dis-
aggregated 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, ana-
lyzing, and communicating the best available information on competitive trends
occurring outside one’s own company. This is not just about information gath-
ering; 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 pre-
paring 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 pur-
sue.

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 reeval-
uated how appliances are shipped, and developed an alliance with Home Depot
Most Effective Methods, Tools, and Techniques

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

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.

**EXAMPLES**

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.
Effective Methods, Tools, and Techniques

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 
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.
EXAMPLES

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. 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,