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PROVIDING CLARITY AND A COMMON LANGUAGE TO THE "FUZZY FRONT END"

Eight companies collectively determined a theoretical construct for the Fuzzy Front End of innovation in order to provide a common framework and language; they found that highly innovative companies have a more proficient FFE.

Peter Koen, Greg Ajamian, Robert Burkart, Allen Clamen, Jeffrey Davidson, Robb D'Amore, Claudia Elkins, Kathy Herald, Michael Incorvia, Albert Johnson, Robin Karol, Rebecca Seibert, Aleksandar Slavejkov, and Klaus Wagner

OVERVIEW: *Eight companies that were Process Effectiveness Network members of the Industrial Research Institute attempted to collectively determine the best practices of the Fuzzy Front End (FFE) of innovation. Comparing one company's processes to those of another proved insurmountable because there was neither a common language nor clear and consistent definition of the key elements of the front end. As a result, the group developed a theoretical construct, defined as the New Concept Development (NCD) model, in order to provide a common language and insights on the front end activities. The model consists of three key parts: five front end elements, the engine that powers the elements, and external influencing factors. Proficiency of the FFE was evaluated at 19 companies by using the NCD model. Highly innovative companies were found to be more proficient in the FFE and in several elements of the NCD model.*

The front end of innovation, or what is often called the Fuzzy Front End (FFE), presents one of the greatest opportunities for improving the overall innovation process. This stage, which we define by those activities that take place prior to the formal, well-structured New Product and Process Development (*1*) or "Stage Gate™" process (*2*), is the target of increasing attention because of the widely-perceived lack of high-profit ideas entering the New Product and Process Development (NPPD) process. Moreover, considerable literature exists on best practices for the start of the NPPD process (*3*) as well as within it (*4–6*).

In contrast, there has been little research to date on best practices for the front end. Furthermore, many of the practices carried out during the NPPD don't apply to the front end because, as indicated in Table 1, the nature of the work, commercialization date, funding level, revenue expectations and other factors are fundamentally different (see "What is the Front End?," page 49).

It was for these reasons that an Industrial Research Institute (IRI) project team from eight companies (Air Products, Akzo Nobel, BOC, DuPont, Exxon, Henkel, Mobil and Uniroyal Chemical) began studying the front end, with the optimistic objective to develop a list of best practices for the FFE. The team members, all "owners" of the product development process within their firms, found it impossible to determine the best practices at each company. Comparing one company's front-end processes to those of another proved insurmountable because there was no common language or definition of the key elements of the front end. To address this shortcoming, a theoretical construct—defined as the New Concept Development (NCD) model—was developed to provide insight and a common language.

For the remainder of the article, we use the term "Front End of Innovation" (FEI) as opposed to Fuzzy Front End (FFE). We strongly believe that FFE implies that this portion of the innovation process is mysterious, and this attitude often results in a lack of accountability and difficulty in determining who is responsible to manage the activities in this area. The use of the term FFE incorrectly suggests that unknowable and uncontrollable factors dominate the front end, implying that this initial part of the innovation process can never be managed.

New Concept Development Model

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

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Table 1.—Differences Between the Front End of Innovation (FEI) and the New Product Process Development (NPPD) Process

	Front End of Innovation (FEI)	New Product Process Development (NPPD)
Nature of Work	Experimental, often chaotic. Difficult to plan Eureka moments.	Structured, disciplined and goal-oriented with a project plan.
Commercialization Date	Unpredictable.	Definable.
Funding	Variable. In the beginning phases, many projects may be "bootlegged," while others will need funding to proceed.	Budgeted.
Revenue Expectations	Often uncertain. Sometimes done with a great deal of speculation.	Believable and with increasing certainty, analysis and documentation as the product release date gets closer.
Activity	Both individual and team in areas to minimize risk and optimize potential.	Multi-functional product and/or process development team.

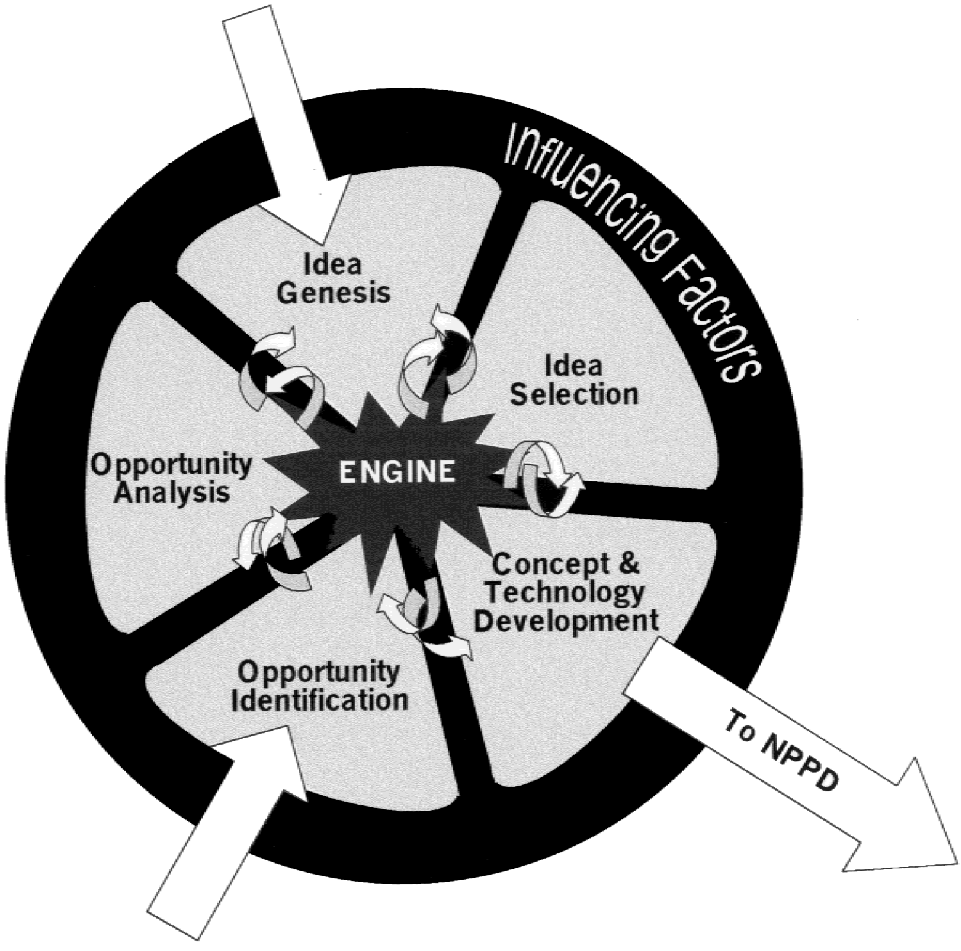

Figure 1.—The New Concept Development Model (NCD) provides a common language and definition of the key components of the Front End of Innovation. The engine, which represents senior and executive-level management support, powers the five elements of the NCD model. The outer area denotes the influencing factors that affect the decisions of the two inner parts.

1. The inner area defines the five key elements comprising the Front End of Innovation (FEI).
2. The Engine or "bull's eye" portion which drives the five front-end elements and is fueled by the leadership and culture of the organization.
3. The Influencing Factors, or environment on the periphery, consists of Organizational Capabilities, Business Strategy, the Outside World (i.e., distribution channels, customers and competitors), and the Enabling Science that will be utilized. These same influencing factors affect the entire innovation process, including the FEI, NPPD and commercialization, as schematized in Figure 2.

Several characteristics of the model are worth noting. The inner parts of the NCD were specifically designated as elements rather than processes. Processes imply a structure that may not be applicable and could force a set of poorly designed NPPD controls to be used to manage front-end activities. The circular shape is meant to suggest that ideas are expected to flow, circulate and iterate between and among all the five elements, in any

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What Is the Front End?

We define the front end by those activities that come before the *formal and well structured New Product and Process Development (NPPD) or Stage Gate*™ process. Even though there is a continuum between the Front End of Innovation (FEI) and the NPPD, the activities in the FEI are often chaotic, unpredictable and unstructured. In comparison, the NPPD is typically structured, which assumes formalism with a prescribed set of activities and questions to be answered. In contrast, Khurana and Rosenthal (*11,* p. 59) defined the FEI as being complete when a business unit commits to funding and launch of a new-product development project or decides to redirect or stop the project (i.e., the continue/no-go decision). We felt this definition was too restrictive because many projects receive substantive funding in the FEI.

Literature on the Front End

Cooper has discussed a Stage-Gate™ process that indicated that the front end consisted of a single "ideation" element that was responsible for the idea generation system (*2*). There was no discussion of how the ideation process works, or the key elements. Cooper's major contribution was in describing a Stage-Gate™ system for the whole NPPD.

Moenart, DeMeyer, Souder, and Deschoolmeester (*12*), in one of the first studies that specifically evaluated front-end activities, investigated the integration of marketing and R&D activities and how information exchange affects the success of the Front End of Innovation (FEI). This study focused on the critical information exchanges occurring in the front end.

In 1997, Eldred and McGrath described a process for managing technology uncertainty in the FEI (*7,8*). The process, termed Technology Realization and Commercialization, uses many elements similar to those of the more traditional SG system. However, the focus of this process is on technology development rather than product development. Cohen, Kamienski and Espino in 1998 (*9*) expanded Cooper's (*2*) ideation stage into three new stages to manage technical uncertainty. The additional gates provide a function similar to the process discussed previously for managing technology uncertainty (*7,8*). However, managing technology uncertainty is only part of front-end activities.

Perhaps the most comprehensive study to date on the FEI was published by Khurana and Rosenthal in 1998 (*11*). Their study presents important insights ". . . of the front end process at the point just preceding the continue/no-go decision . . ." (*11,* p. 59). Specifically, they indicate that successful organizations follow a holistic approach to the front end. This study provides important insights on the *necessary conditions for success when the FEI is complete.*

A recent article by Smith, Herbein and Morris began to examine the inner processes of the front end, and describes specific methodologies being implemented at AlliedSignal and Alcoa for improving and measuring parts of the FEI (*13*). New metrics are described that may be able to improve the screening of projects in the FEI.

Reinertsen, who coined the term Fuzzy Front End, also describes methodologies for screening ideas, and indicates that fast idea screening methodologies make more economic sense than improving screening efficiency (*14*). Both articles focus on effective screening methodologies to improve cycle time and create a "fast-failure" process so that only high-impact opportunities will be developed. However, effective screening represents only one element of the FEI.—**The Authors.**

order or combination, and may use one or more elements more than once. This approach is in contrast to the sequential NPPD process, in which "looping back" and "redirect or redo" activities are associated with significant delays, added costs and poorly managed projects.

While the front-end elements will be discussed in a clockwise progression, they are expected to actually proceed in a more random and non-sequential fashion, as denoted by the arrows that show "leakages" or movement between the areas. Finally, the separation between the influencing factors (i.e., environment) and the front end should be considered a continuum since interactions are expected between the influencing factors and the five front-end elements.

Influencing Factors (The Environment)

The FEI exists in an environment that consists of the corporation's business strategies, competitive factors, its organizational capabilities, and the maturity of the technologies to be utilized. The entire innovation process (both the FEI and NPPD) needs to be aligned with the business strategy to ensure an uninterrupted, flowing pipeline of new products and processes with value to the corporation. Sustained successful product development can only occur when the FEI activities can be accomplished with the organizational capabilities of the company. Understanding enabling sciences and technologies that will be part of the FEI is also critical, since technology typically advances by building on earlier achievements. These influencing factors, constantly acting upon people's minds, 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 FEI.

The Engine (Leadership and Culture)

Although leadership and culture have been identified as critical to new-product development, we have not found any study that systematically links the culture to the

Examples of the Five NCD Elements

Market Driven—Nonfat Potato Chips using a Fat Substitute Molecule

Development of non-fat potato chips using a Fat Substitute (FS) molecule (i.e., a molecule which provides the same flavor as fat but is not absorbed in the body nor produces any side effects) is used as an example to clarify the five inner elements of the NCD model for a market-driven product.

Opportunity Identification occurred when this hypothetical Food Company (FC) identified the need to develop low-fat products due to rising consumer trends or a competitive threat in this area.

Opportunity Analysis took place when the FC examined the trends in more detail. Did consumers really want low fat, or did they want low calorie and/or low cholesterol? How much would the consumer be willing to give up on taste? Was the market mainly a small niche? What are the regulatory issues? In this element the FC also examined the value of such an effort to their portfolio and the competitive threats if they did not develop such products.

In Idea Genesis, several methods of delivering non-fat potato chips were developed. Some ideas were in reducing the total fat content; others were in developing FS molecules.

In the next element, Idea Selection, several of the ideas were chosen for more detailed analysis.

In the final element, Concept and Technology Development, a scientific program was started and supported to develop the selected FS molecules.

Technology Driven—3M Notepads (15)

Development of 3M Notepads is used as a technology example to clarify the five inner elements of the NCD model. Opportunity Identification occurred when Spence Silver created an "unusual" glue that was more tacky than adhesive. Opportunity Analysis took place when Silver attempted to find an opportunity for this strange adhesive. He visited every division at 3M in his quest to find a business opportunity for this new technology. Idea Genesis occurred when several product ideas were selected, such as the sticky bulletin board and 3M notepads. Idea Selection occurred when the notepad opportunity was selected for continued development. In the Concept and Technology Development element, an entirely new manufacturing process was developed for attaching a "non-sticking" adhesive to paper.—**The Authors.**

success of the FEI. Further, the micro-culture of the FEI is different from the NPPD process, as indicated in Table 1.

Five Front-End Elements

1. *Opportunity Identification.*—This is where the organization, by design or default, identifies the opportunities that the company might want to pursue. Business and technological opportunities are explicitly considered so that resources will eventually be allocated to new areas of market growth and/or operating effectiveness and efficiency. This element is typically driven by the goals of the business. 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/speed-up/reduce the cost of operations. The opportunity could be an entirely new direction for the business or a minor 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.

The sources and methods that a company uses to identify opportunities it wishes to pursue are the essence of this element. There may be a formal opportunity identification process that is aligned with all the influencing factors. Creativity tools and techniques (e.g., brainstorming, mind mapping and lateral thinking) as well as problem solving techniques (e.g., causal analysis, fishbone diagrams, process mapping, theory of constraints) may be utilized. Alternatively, informal opportunity identification activities may occur which include *ad hoc* sessions, water cooler/cyberspace discussions, individual insights, or edicts from senior management. Opportunity Identification in many cases precedes Idea Genesis, but also may be an enabling step to link an unanticipated notion to a business or marketplace need that was not previously identified.

2. *Opportunity Analysis.*—Additional information is needed for translating Opportunity Identification into specific business and technology opportunities and 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 amount of effort expended is dependent upon the attractiveness of the opportunity, the size of the future development effort, the fit with the business strategy and culture, and the risk tolerance of the decision makers. This element may be part of a formal process or may be occurring iteratively in reaction to opportunities identified, such as "what-if" scenarios. Hard, quantifiable templates, which would be used in the NPPD, are typically not applied in this element. Both competitive intelligence and trend analyses are used extensively in this element.

3. *Idea Genesis.*—Genesis is the birth, development and maturation of the opportunity into a concrete idea. This represents an evolutionary process in which ideas are built upon, torn down, combined, reshaped, modified,

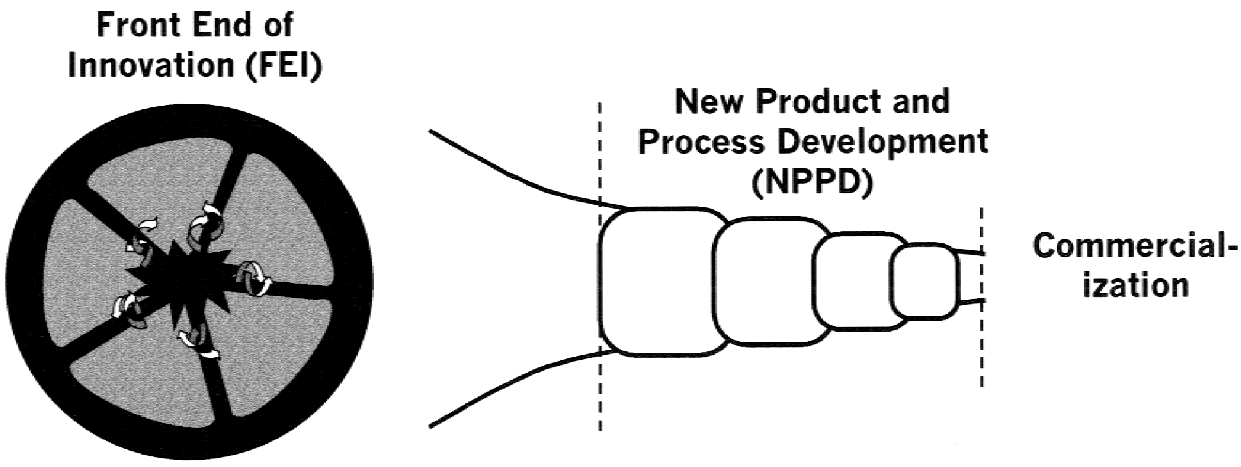

Figure 2.—Entire innovation process may be divided into three parts: Front End of Innovation (FEI), New Product and Process Development (NPPD) and the commercialization phases, which all are affected by the same influencing factors. The FEI is defined as those activities that come before the formal and well-structured NPPD process. The circular shape of the NCD is meant to suggest that ideas are expected to flow and iterate between all the five elements. In contrast, the NPPD portion is illustrated as a series of sequential, well-structured, chronologically-ordered steps.

and upgraded. The idea may go through many iterations and changes as it is examined, studied, discussed, and developed. Direct contact with customers/users and linkages with other cross-functional teams, as well as collaboration with other companies and institutions, often enhance this activity. Idea Genesis 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—an experiment that went awry, a supplier offering a new material, or a user making an unusual request. Idea Genesis may feed Opportunity Identification, demonstrating that the NCD elements may proceed in a non-linear fashion—advancing and nurturing ideas and opportunities wherever they occur. The output of this element is typically a more completely developed description of the "sensed" idea or product concept.

4. *Idea Selection.*—In most businesses there are so many product/process ideas that the critical activity is to choose which ideas to pursue in order to achieve the most business value. Selection may be as simple as an individual's choice among many self-generated options or as formalized as a prescribed portfolio method. More formalized project selection and resource allocation in the FEI is difficult due to the limited information and understanding at this point. Definition of the financial return in the FEI is at best often just a "wild" guess. Better selection models specifically designed for the FEI are needed so that market and technology risks, investment levels, competitive realities, organizational capabilities, and unique advantages, along with financial returns, may all be considered. Idea Selection, as in Opportunity Analysis, should be less rigorous than in the NPPD since many ideas must be allowed to grow and advance with less certainty.

5. *Concept and Technology Development.*—The final element of the model involves the development of a business case based on estimates of market potential, customer needs, investment requirements, competitor assessments, technology unknowns, and overall project risk. The level of formality of the business case varies according to the nature of the opportunity (e.g., new market, new technology and/or new platform), level of resources, organizational requirements to proceed to the NPPD and the business culture (formal, informal or hybrid). In some organizations, this is considered the initial stage (i.e., Stage 0) of the NPPD process.

Some companies manage technical uncertainty by using a Technology Development Process (*7–9*). The Technology Development Process may be completely or partially outside the NCD. Technology projects that explore fundamental scientific relationships, scout, or evaluate entirely new technology platforms are usually unstructured at the earlier phases and thus are part of the NCD. As the effort escalates, technology risk is often reduced, more resources are utilized, and the decisions become more structured, resulting in the later portion of the Technology Development Process moving out of the NCD and into the NPPD. In some cases, the Technology Development Process 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 Technology Development Process would remain inside the NCD if these factors were reversed.

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

Proficiency of the NPPD and the FEI

A survey was conducted of 23 companies in order to determine which elements of the NCD model were most important to highly innovative companies (Table 2). Proficiency of each of the elements of the model were measured from highly proficient (company has considerable expertise in this element and needs little improvement) to low proficiency (company needs significant improvement in this element). See "How the Proficiency Study Was Conducted," page 53.

The proficiency with respect to the NPPD and FEI stages of innovation is shown in Figure 3. All 23 companies demonstrated moderate to high proficiency in the NPPD, with a lack of significant correlation relating the proficiency of the NPPD process to the level of innovation. In contrast, the mean levels were lower for the FEI proficiency and there was a strong correlation ($r = 0.65$, $p = 0.001$) between the proficiency of the FEI and the level of innovativeness rating. In other words, *one contributing factor that may account for the high level of innovation is the proficiency of the FEI rather than proficiency of the NPPD process.* This reinforces the perception that the NPPD process, after extensive effort, has been "fixed" in many companies. The FEI serves as the next part of the innovation cycle for building proficiency.

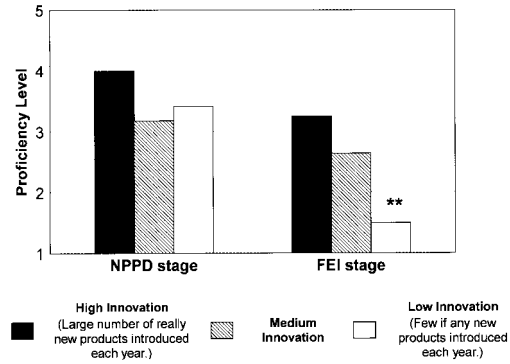

Figure 3.—The proficiency level of highly innovative companies is significantly greater ($p < 0.001$) than low-innovation companies in the Front End of Innovation (FEI). In contrast, there was no significant difference between high- and low-innovation companies in the New Product and Process (NPPD) part of the innovation process. Significance between mid- and low-innovation companies when compared to high-innovation companies ($p < 0.05$, **$p < 0.01$).*

Table 2.—Comparison of Companies Included in Survey

	Number of Companies	Size of Company ($ billions) (mean)	Size of Business Unit ($ millions) (mean)
High-Innovation Companies (Large number of really new products introduced each year.)	5	$22	$439
Mid-Innovation Companies	11	$8.3	$642
Low-Innovation Companies (Few if any new products introduced each year.)	7	$5.9	$780

Proficiency of the NCD Model

The proficiency of the Engine, the five elements of the NCD model and the Technology Development Process are shown in Figure 4. The proficiency of the Engine ($r = 0.58$, $p = 0.004$), Opportunity Identification ($r = 0.59$, $p = 0.005$) and the Technology Development Process ($r = 0.54$, $p = 0.01$) were highly correlated with the level of innovativeness. In other words, top management support and the culture of the organization lead to increased innovation levels. Opportunity Identification, which consists of identifying business and technological goals that are consistent with the environment, was practiced at the higher-innovation-level companies. The Technology Development Process was also strongly related to the innovation level. This result indicates that high-innovation companies have already begun to implement a Technology Development Process (*7–9*).

Idea Genesis, the area where the concepts for a new market or technology, product or process are conceived, was not significantly better in highly innovative companies. The literature is replete with numerous articles extolling the importance of being creative and methodologies for thinking "out-of-the-box." While many of these techniques ostensibly improve the quality of ideas and are the source of new products, there is no significant difference or correlation between highly and mid-to-low innovation companies. This confirms the

How the Proficiency Study Was Conducted

In order to determine which proficiencies are associated with highly innovative companies, 23 corporate managers attending a Process Effectiveness Network meeting of the IRI were asked to fill out a confidential questionnaire and evaluate the level of innovativeness and proficiency of the FEI along with key elements of the NCD model with respect to the division or business unit in which they worked. Each participant was intimately familiar with the product development processes in their company.

The level of innovativeness for a division or business unit was evaluated on a 5-point scale ranging from "Highly Innovative" (i.e., large percentage of really new products released to the market each year) to "Lacks Innovation" (i.e., few or no new products released to the market each year).

The participants were also asked to rate the proficiency of both the NPPD process and the FEI within the business unit of their company. Proficiency was rated on a 5-point scale from "Highly Proficient" to "Needs Significant Improvement." In a similar fashion, the participants rated proficiency of the Engine, each of the five elements of the NCD model, and the Technology Development Process utilized in their company.

The collected data were split into three groups as indicated in Table 2. Businesses rated 4 or 5 on "level of innovativeness" were grouped as "High-Innovation Companies." Businesses rated with a 1 or 2 were grouped as "Low-Innovation Companies," and "Mid-Innovation Companies" were those rated with a 3. Significance was evaluated between the High-Innovation companies versus Mid- and Low-Innovation Companies in each of the proficiencies discussed above. Correlations were determined between the innovation level and the proficiency rating. There was no significant difference or correlation between the size of the business unit or company among High-, Mid-, and Low-Innovation companies.—**The Authors.**

frequent truth of the observation that "ideas are a dime a dozen." It is how you manage and implement the ideas that are important. Alternatively, this is one area of the FEI that may need significant improvement by all companies. Perhaps many of the creativity and brainstorming techniques are not being adequately utilized in even the highly innovative companies.

Surprisingly, Concept and Technology Development, the area where the company develops a business plan and builds credibility for the idea, was not found to be significantly different or correlated with highly innovative companies. One would have assumed that highly innovative companies develop superb business plans in accordance with the prevailing wisdom that the level of pre-planning is directly correlated with success in the future NPPD stage (*10*). The highly innovative companies' proficiency levels were similar to those of low-innovation companies. This result is not easily explained. Perhaps the participants from highly innovative companies were more critical of the planning process than their colleagues from less innovative companies. Alternatively, this may represent an area of improvement for all companies. More information is needed to be able to explain this surprising conclusion.

The foregoing data and results should be viewed with caution. In order to obtain a more robust analysis, multiple components of each element of the NCD model need to be determined and evaluated, and key characteristics of each of the elements and reliable constructs need to be further developed. A much larger sample is also needed. However, despite these limitations, the NCD model provides entirely new insight into the FEI and its role in innovation.

Managerial Implications

The Front End of Innovation (FEI) appears to represent the greatest area of weakness in the innovation process. The high correlation between the proficiency of the FEI and the lack of correlation with the NPPD process when compared to a company's innovation level support this conclusion.

The Engine, which provides the drive and the leadership for the front end and the culture in which it must operate, has been shown to be a critical part of the FEI. Our study confirmed this as indicated by the high correlation between Leadership and Culture and the innovation level of the company. This study also verified the work of Khurana and Rosenthal (*11*) which indicated that successful companies effectively integrate their business and product strategy when identifying new opportunities in their front end. The importance of managing the Technology Development Process also was found to be a critical component and suggested that more firms should adopt the methodologies indicated in recent *Research · Technology Management* articles (*7–9*).

The pilot study discussed here provides a glimpse of the potential success factors for the front end. Progress in understanding the FEI may proceed through expansion of this study using more numerous and validated constructs with a much larger data base and developing a better understanding of the characteristics of each of the NCD elements. Despite the importance of the FEI, no similar studies have been done. We believe that the principal reasons are the lack of a common language and definition of the key components of the front end. It is impossible to improve a process if one does not have a way of discussing or sharing it. Although more research

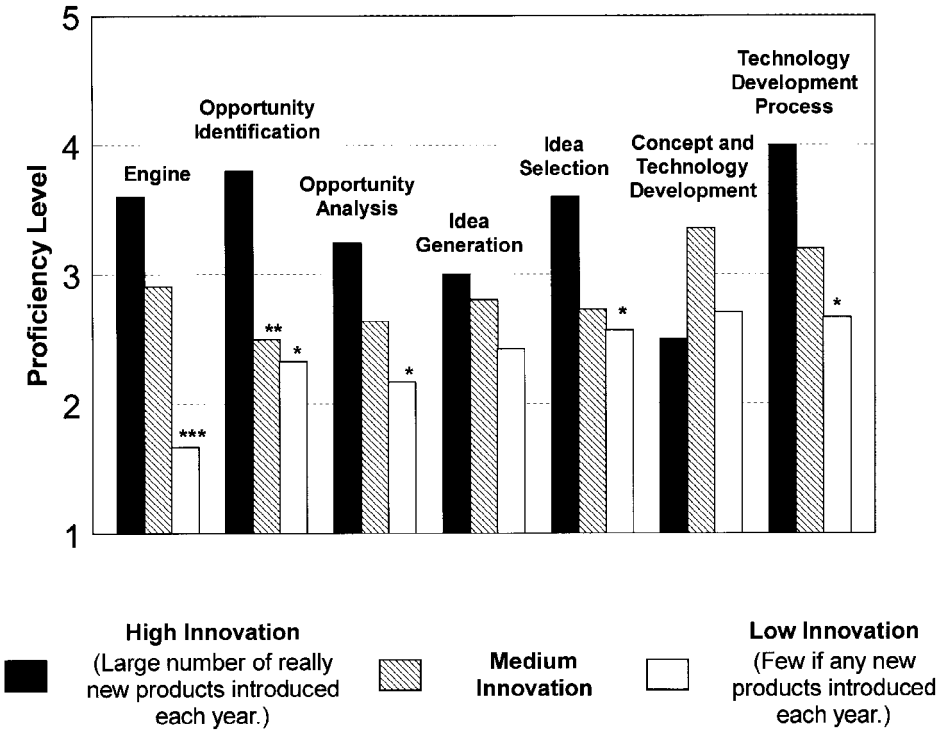

Figure 4.—For highly innovative companies, the proficiency level within the Front End of Innovation (FEI) is significantly greater in the engine ($p < 0.005$), opportunity identification ($p < 0.05$) and in the technology development process ($p < 0.05$) when compared to less innovative companies. Significance between mid- and low-innovation companies when compared to high-innovation companies ($p < 0.05$, **$p < 0.01$, ***$p < 0.005$).*

is needed to understand the FEI, the NCD model provides a common language, defines the front end of the innovation process and establishes terminology to describe its key elements. The NCD model brings clarity and rationality to the front end, thereby helping people to better articulate and manage the front end of the innovation process.

We propose that the terminology of the "Fuzzy Front End" be changed to Front End of Innovation. The former definition inappropriately suggests to people outside the product development domain that the front end is indefinable, uncontrollable, impossible to manage, and a continued drain on corporate resources. We believe that the use of the NCD model, similar to the NPPD process, and the adaptation of the name Front End of Innovation will help to increase both the understanding and positive image of the front end of the innovation process.

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References and Notes

1. The authors have utilized both product and process in their definitions since the innovation may be directed to the development of an entirely new process (e.g., a new and more efficient method for manufacturing chemicals). We prefer the definition of New Product and Process Development (NPPD) to Stage-Gate™ since the latter term refers to specific embodiments as discussed in (*2*). In many companies the NPPD would be equivalent to the Stage-Gate process discussed by Cooper (*2*).

2. Cooper, R. G. *Winning at New Products,* 2nd edition. Addison-Wesley Publishing Company, Reading, MA 1993.

3. Best practices for successful product development at the start of the NPPD are to have a project which is 1) well integrated with the company's product and business strategy, 2) clearly defined customer needs, 3) well defined product concept, 4) clear project plan, 5) senior management support, and 6) empowered project team (*4*).

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