

Creating Breakthroughs at 3M

by Eric von Hippel, Stefan Thomke, and Mary Sonnack



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Creating Breakthroughs at

3M

by Eric von Hippel, Stefan Thomke, and Mary Sonnack

Companies say they want breakthrough products, but most are far more adept at making incremental improvements to existing lines. A pioneering division at 3M successfully navigated a process that leads to breakthrough thinking.

WHEN SENIOR MANAGERS think of product development, they all dream of the same thing: a steady stream of breakthrough products—the kind that will enable their companies to grow rapidly and maintain high margins. And managers set ambitious goals to that end, demanding, for example, that a high percentage of sales come from products that did not exist a few years ago. Unfortunately, the development groups at many companies don't deliver the goods. Instead of breakthroughs, they produce mainly line extensions and incremental improvements to existing products and services. And as the pace of change accelerates in today's markets, that's a recipe for decline, not growth.

Given the imperative to grow, why can't product developers come up with breakthroughs more regu-

larly? They fail primarily for two reasons. First, companies face strong incentives to focus on the short term. Put simply, although new products and services may be essential for future growth and profit, companies must first survive today to be around tomorrow. That necessity tends to focus companies strongly on making incremental improvements to keep sales up and current customers—as well as Wall Street analysts—happy. Second, developers simply don't know *how* to achieve breakthroughs, because there is usually no effective system in place to guide them and support their efforts.

The latter is a problem even for a company like 3M, long known for its successful innovations. Traditionally, the company's management has fostered innovation by taking a get-out-of-the-way attitude toward prod-

uct developers who, in turn, have worked according to the aphorism "It's better to seek forgiveness than to ask for permission." This relationship between managers and developers has resulted in the creation of a long line of profitable products, from waterproof sandpaper and Scotch tape in the 1920s to Post-it Notes and Thinsulate in the 1970s.

But by the mid-1990s, 3M's top managers were concerned that too much of the company's growth was coming from changes to existing products. Breakthroughs were fewer and farther between. The demands for—and the rewards from—incremental improvements spurred the company to focus on current products. To counter this trend, management set a bold objective: 30% of sales would come from products that had not existed four years earlier.

For the company to meet that goal,

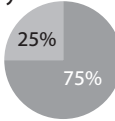
Users as Innovators

Research shows that many commercially important innovations are developed by product users rather than by the manufacturers that were first to bring them to market.

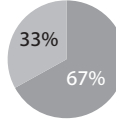


Computer Industry^a

systems reaching new performance high

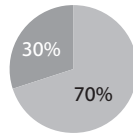


systems with radical structural innovations



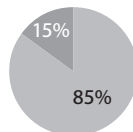
Chemical Industry^b

chemical processes and process equipment



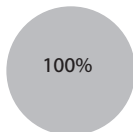
Pultrusion Machinery^c

major pultrusion-processing machinery innovations

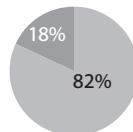


Scientific Instruments^d

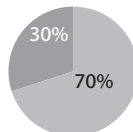
first of type



major functional improvements



minor functional improvements

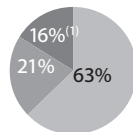


Semiconductor/Electronic Process Equipment^e

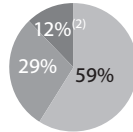
first of type used commercially



major functional improvements

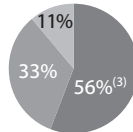


minor functional improvements



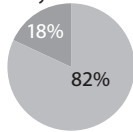
Electronic Assembly^b

Wirestripping and connector attachment equipment

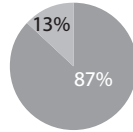


Surface Chemistry Instruments^g

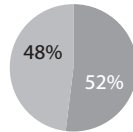
new functional capability



convenience or reliability improvement



sensitivity or accuracy improvement



^a Knight (1963)
^b Freeman (1968)
^c Lionetta (1977)
^d Von Hippel (1976)
^e Von Hippel (1977)
^f Vander Werf (1982)
^g Riggs and Von Hippel (1994)

(1) Developed by independent inventors and invention development companies.
 (2) Developed by joint user-manufacturer innovation projects.
 (3) Developed by connector suppliers.

many people at 3M – senior managers, marketers, product developers, scientists – would have to change their approach to their work. Accordingly, some employees started becoming acquainted with a new method for developing breakthrough products: the *lead user process*. The process – which makes the generation of breakthrough strategies, products, and services systematic – is based on two major findings by innovation researchers.

First, the researchers found that many commercially important products are initially thought of and even prototyped by users rather than manufacturers. (See the chart “Users as Innovators.”) Second, they discovered that such products tend to be developed by “lead users” – companies, organizations, or individuals that are well ahead of market trends and have needs that go far beyond those of the average user. Those discoveries transformed the difficult job of creating breakthroughs from scratch into a systematic task of identifying lead users – companies or people that have already developed elements of commercially attractive breakthroughs – and learning from them.

Consider how an automobile manufacturer would apply the lead user process. If the company wanted to design an innovative braking system, it might start by trying to find out if any innovations had been developed by groups with a strong need for better brakes, such as auto racing teams. The automaker wouldn’t stop there, however. Next it would look to a related but technologically advanced field where people had an even greater need to stop quickly, such as aerospace. And, in fact, aerospace is where innovations such as antilock braking systems were first developed: military aircraft commands have a very high incentive to design ways to stop their very expensive vehicles before they run out of runway.

In September 1996, a product development team in 3M’s Medical-Surgical Markets Division became one of the first groups in the company to test the merits of the lead user process. The team was charged with creating a breakthrough in the area of surgical drapes – the material that prevents infections from spreading during surgery. By November 1997, the team had come up with a proposal for three major new product lines as

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well as a new strategy that would take a revolutionary approach to treating infection. And the team may have done even more for 3M's long-term health: it persuaded senior managers that the lead user process could indeed systematize the company's development of breakthroughs.

But before we turn to that story, we must first explain how this process is different from other methods of product development.

Learning from Lead Users

All processes designed to generate ideas for products begin with information collected from users. What separates companies is the kind of information they collect and from whom they collect it.

Teams are usually taught to collect information from users at the center of their target market. They conduct focus groups and analyze sales data, reports from the field, customer complaints and requests, and so on. Then they rely on their own creative powers to brainstorm their way to new ideas. Teams that follow this method assume that the role of users is to provide information about what they need, and that the job of in-house developers is to use that information to create new product ideas.

The lead user process takes a fundamentally different approach. It was designed to collect information about both needs and solutions from the leading edges of a company's target market and from markets that face similar problems in a more extreme form. Development teams assume that savvy users outside the company have already generated innovations; their job is to track down especially promising lead users and adapt their ideas to the business's needs.

True lead users are rare. To track them down most efficiently, project teams use telephone interviews to network their way into contact with experts on the leading edge of the target market. Networking is effective because people with a serious interest in any topic tend to know of others who know even more about the topic than they do—people who

are further up on the "pyramid of expertise."

Team members begin by briefly explaining their problem to individuals who have apparent expertise on the subject—for example, research professionals in a field, or people who have written about the topic. They then ask for a referral to someone who has even more relevant knowledge. It's usually not long before a team reaches lead users at the front of the target market. The next step is to continue networking until lead users are found in markets and fields that face similar problems but in different and often more extreme forms. Those people can help teams discover truly novel solutions to important needs that are emerging in the target market.

Consider how a team focused on medical imaging carried out its work. Its members knew that a major trend in this field was the development of capabilities to detect smaller and smaller features—very early-stage tumors, for instance. The team networked to the leading edge of the target market and identified a few radiologists who were working on the most challenging medical-imaging problems. They discovered that some lead users among those researchers had developed imaging innovations that were ahead of commercially available products.

Team members then asked the radiologists for the names of people in any field who were even further ahead in *any* important aspect of imaging. The radiologists identified, among others, specialists in pattern recognition and people working on images that show the fine detail in semiconductor chips.

Lead users in the area of pattern recognition proved especially valuable to the team. Specialists in the military

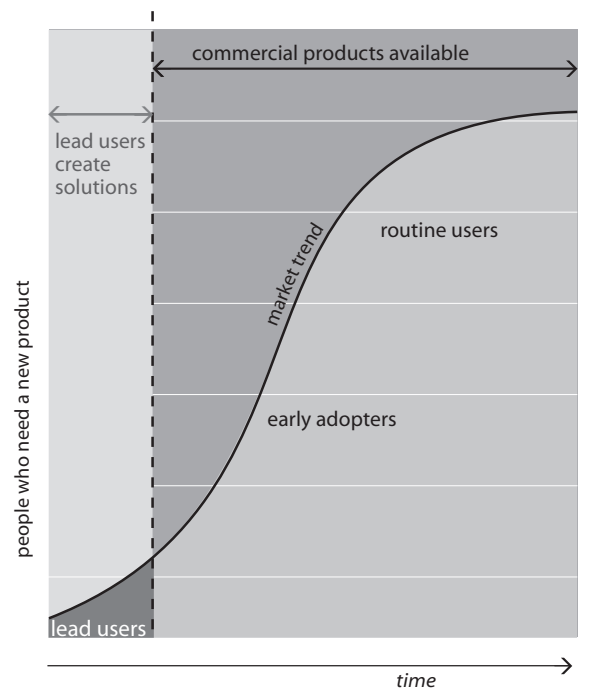
had long worked on computerized pattern recognition methods because military reconnaissance experts had a strong need to answer questions such as, "Is that a rock lying under that tree, or is it the tip of a ballistic missile?" These lead users had developed ways to enhance the resolution of the best images they could get by adapting pattern recognition software.

Lead users often help project teams improve their understanding of the nature of the breakthrough they are seeking. For example, the medical-imaging team's initial goal was to develop new ways to create better high-resolution images. But their discovery of the military specialists' use of pattern recognition led them to a new goal: to find enhanced methods for recognizing medically significant patterns in images, whether by better image resolution or by other means. (See the exhibit "Networking to Lead Users.")

It is rare for a manufacturer to simply adopt a lead user innovation

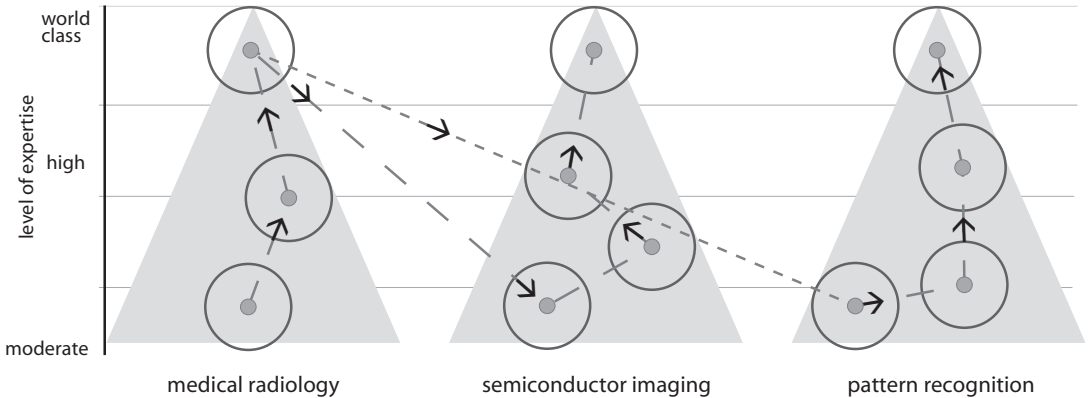
The Lead User Curve

The curve illustrates the shape of a market trend. Lead users have needs that are well ahead of the trend; over time, more and more people feel the same need.



Networking to Lead Users

Project teams network their way up "pyramids of expertise" to identify lead users and experts, first in the target market and then in other key fields. The medical imaging team began by finding expert medical radiologists, who referred them to specialists in semiconductor imaging and pattern recognition. As a result of discussions with these lead users, the team's goal changed dramatically.



“as is.” Instead, a new product concept that suits a manufacturer’s needs and market is most often based on information gained from a number of lead users and in-house developers. Some information is transferred in the course of telephone interviews or through on-site visits. More information is transferred when the team hosts a workshop that includes several lead users who have a range of expertise, as well as a number of people from within the company—product developers, marketing specialists, and manufacturing people.

A lead user workshop typically lasts two or three days. During that time, the assembled group combines its individual insights and experiences to design product concepts that precisely fit the sponsoring company’s needs. In the medical-imaging example, lead users with a variety of experiences were brought together: people on the leading edge of medical imaging, people who were ahead of the trend with ultra-high-resolution images, and experts on pattern recognition. Together they created a solution that best suited the needs of the medical-imaging market and represented a breakthrough for the company. Executives at 3M charted a similar course.

Diving in the Deep End

In 1996 Rita Shor, a senior product specialist in 3M’s Medical-Surgical Markets Division, heard an in-house

lecture on the lead user process. Shor had been charged with developing a breakthrough product for the division’s surgical drapes unit, and she needed help. Traditional market research was providing abundant data but could not point developers toward a breakthrough.

Shor called Mary Sonnack at 3M. Sonnack – sponsored by Chuck Harstad, 3M’s vice president of corporate marketing, and William Coyne, senior vice president of R&D – had spent the 1994–1995 academic year studying the lead user process with Eric von Hippel at MIT. Shor put the problem to Sonnack in stark terms: “Our business unit has been going nowhere. We’re number one in the surgical drapes market, but we’re stagnating. We need to identify new customer needs. If we don’t bring in radically new ways of looking for products, management may have little choice but to sell off the business.” After warning Shor about the high level of commitment that would be needed from team members and from senior management, Sonnack agreed to work with her.

Surgical drapes are thin adhesive-backed plastic films that are adhered to a patient’s skin at the site of surgical incision, prior to surgery. Surgeons cut directly through these films during an operation. Drapes isolate the area being operated on from most potential sources of infection – the rest of the patient’s body, the operating table, and the mem-

bers of the surgical team. But the diversity of the microbial world constantly challenged this protective fortress, which couldn’t cover, for example, catheters or tubes being inserted into the patient.

By the mid-1990s, surgical drapes were bringing 3M’s Medical-Surgical Markets Division more than \$100 million in annual sales. But the unit in charge of the draping business had not had a breakthrough product in almost a decade. Technological excellence was not the issue. In the early 1990s, the division had spent three years developing technologically advanced disposable surgical gowns. The gowns would safeguard surgeons and their patients from dangerous viruses such as HIV – and keep them more comfortable – by allowing water vapor but not viruses to pass through microscopic pinholes in the fabric. This technological and manufacturing feat, however, came to the market just as managed health care was taking hold in the United States. Surgeons loved the fabric, but insurers wouldn’t pay for it, and sales were disappointing.

In short, the division saw little room for growth in existing markets; declining margins on existing products; and, because of the drapes’ cost, few opportunities to penetrate less-developed countries. Under those circumstances, Shor convinced senior management to try the lead user process. A few weeks later, she and her project coleader, Susan Hiestand,

Step by Step Through the Process

The lead user process gets under way when a cross-disciplinary team is formed. Teams typically are composed of four to six people from marketing and technical departments; one member serves as project leader. Team members usually will spend 12 to 15 hours per week on the project for its duration. That high level of immersion fosters creative thought and sustains the project's momentum.

Lead user projects proceed through four phases. The length of each phase can vary quite a bit; the 3M team spent six months alone on phase 3, when it researched surgical conditions in developing countries through on-site visits. For planning purposes, a team should figure on four to six weeks for each phase and four to six months for the entire project.

Phase 1: Laying the foundation. During this initial period, the team identifies the markets it wants to target and the type and level of innovations desired by key stakeholders within the company. If the team's ultimate recommendations are to be credibly received, these stakeholders must be on board early.

Phase 2: Determining the trends. It's an axiom of the process that lead users are ahead of the trend. But what is the trend? To find out, the team must talk to experts in the field they are exploring—people who have a broad view of emerging technologies and leading-edge applications in the area being studied.

Phase 3: Identifying lead users. The team now begins a networking process to identify and learn from users at the leading edge of the target market and related markets. The group's members gather information that will help them identify especially promising innovations and ideas that might contribute to the development of breakthrough products. Based on what they learn, teams also begin to shape preliminary product ideas and to assess the business potential of these concepts and how they fit with company interests.

Phase 4: Developing the breakthroughs. The goal is to move the preliminary concepts toward completion. The team begins this phase by hosting a workshop with several lead users, a half-dozen in-house marketing and technical people, and the lead user team itself. Such workshops

may last two or three days. During that time, the participants first work in small groups and then as a whole to design final concepts that precisely fit the company's needs.

After the workshop, the project team further hones the concepts, determines whether they fit the needs of target-market users, and eventually presents its recommendations to senior managers. By that point, its proposals will be supported by solid evidence that explains why customers would be willing to pay for the new products. Although the project team may now disband, at least one member should stay involved with any concepts that are chosen for commercialization. In that way, the rich body of knowledge that was collected during the process remains useful as the product or service families are developed and marketed.

had assembled a team of six people from the R&D, marketing, and manufacturing departments. They all agreed to commit half their time to the project until it was completed.

Looking for Lead Users

The team's initial goal was, in essence, "Find a better type of disposable surgical draping." That was admittedly not a very creative first directive, but the way the problem is framed at the outset is not critical to the project's success. Experts and lead users are never shy about suggesting better ideas, and the evolutionary improvement of goals is an expected and desirable part of the lead user process.

The group spent the first month and a half of the project learning more about the cause and prevention of infections by researching the

literature and by interviewing experts in the field. The group then held a workshop with management in which they discussed all that they had learned and set parameters for acceptable types of breakthrough products. (This work constituted the first phase of the lead user process; see the sidebar "Step by Step Through the Process.")

For the next six weeks or so, team members focused on getting a better understanding of important trends in infection control. One cannot specify what the leading edge of a target market might be without first understanding the major trends in the heart of that market.

Much of the team's research at this early stage was directed at understanding what doctors in developed countries might need. But as the group's members asked more

and more questions and talked to more and more experts, they realized they didn't know enough about the needs of surgeons and hospitals in developing countries, where infectious diseases are still major killers. The team broke up into pairs and traveled to hospitals in Malaysia, Indonesia, Korea, and India. They learned how people in less than ideal environments attempt to keep infections from spreading in the operating room. They especially noted how some surgeons combat infection by using cheap antibiotics as a substitute for disposable drapes and other, more expensive measures.

As a result of their field observations, the team concluded that a crisis was germinating in the surgical wards of developing countries. Doctors' reliance on cheap antibiotics to prevent the spread of infection would

not work in the long run—bacteria would become resistant to the drugs. The team also realized that even if 3M could radically cut the cost of surgical drapes, most hospitals in developing countries simply would not be able to afford them. Those insights led the team to redefine its goal: find a much cheaper and much more effective way to prevent infections from starting or spreading that does not depend on antibiotics—or even on surgical drapes.

The team members then networked their way into contact with innovators at the leading edge of the trend toward much cheaper, more effective infection control. As is usually the case, some of the most valuable lead users turned up in surprising places. For example, the team learned that specialists at some leading veterinary hospitals were able to keep infection rates very low despite facing difficult conditions and cost constraints. As one of the country's foremost veterinary surgeons explained to them, "Our patients are covered with hair, they don't bathe, and they don't have medical insurance, so the infection controls that we use can't cost much." Another surprising source of ideas was Hollywood. One of the team members learned that makeup artists are experts in applying to the skin materials that don't irritate and that are easy to remove when no longer needed. Those attributes are very important to the design of infection control materials that will be applied to the skin.

As a final step in the project, the team invited several lead users to a two-and-a-half-day workshop. (As the sidebar "Why Lead Users Will Talk to Your Company" makes clear, the lead users' reward for participating was purely intellectual; they all signed over to 3M any property rights that might result from the workshop.) The bold central question, which had come out of the team's research, was now this: "Can we find a revolutionary, low-cost approach to infection control?" The participants met for several hours at a

Why Lead Users Will Talk to Your Company

Lead user innovations generate some kind of competitive advantage. When this advantage is significant, innovating users won't want to share what they know with competing companies or with manufacturers that would sell their ideas to competitors. Yet, most lead users are quite willing to give detailed information to manufacturers, and are usually willing to do so for free. There are two basic reasons:

First, lead users with compelling information often are in other fields and industries and would feel no competitive effects from revealing what they've done. Those lead users are generally happy to share their knowledge.

Second, lead users develop innovations because they need to—not as a source of competitive advantage. In those cases, they may want to transfer their ideas to a willing supplier.

For example, in a lead user study devoted to improving credit-reporting services, a team found that at least two major users of such services had developed advanced, on-line credit-reporting processes. One of the users regarded the service it had developed as a significant source of competitive advantage and refused to discuss any details with the team. The other, however, welcomed the team with open arms and fully revealed its system. As one manager said, "We only developed this in the first place because we desperately needed it—we would be happy if you developed a similar service we could buy."

It is always good practice for lead-user project teams to tell interviewees up front that their company may have a commercial interest in the ideas being discussed. When someone hesitates to talk about his or her ideas, the interview comes to an end. That frees up team members to move on to find other lead users who don't have such concerns.

time in small groups; the composition of the groups was then changed and the process continued. Some groups floundered for a while before pulling ideas together toward the end of their sessions. In others, extroverted people at first dominated the discussion; later, the introverts warmed up and began contributing. All the groups faced the challenge of navigating a sea of facts and trying to unite creative ideas with technical constraints.

In the end, the workshop generated concepts for six new product lines and a radical new general approach to infection control. The lead user team chose the three strongest product-line concepts to present to senior management. The first recommendation was for an economy line of surgical drapes. The drapes could be made with existing 3M technology and thus would not constitute a breakthrough product; nevertheless, they would be welcomed in the increasingly cost-conscious developed world.

The second recommendation was for a "skin doctor" line of handheld devices. These devices would eventually be able to do two things: layer antimicrobial substances onto a patient's skin during an operation and vacuum up blood and other liquids during surgery. The skin-doctor line could be developed from existing 3M technology and would offer surgeons an important new infection prevention tool.

The third new product proposal was for an "armor" line that would coat catheters and tubes with antimicrobial protection. These products could also be created with existing 3M technology, and they promised to open up major new market opportunities for 3M. The company had previously focused solely on products designed to prevent surface infections; the armor line would allow it to enter the \$2 billion market aimed at controlling blood-borne, urinary tract, and respiratory infections.

Changing Strategy

As a project team learns from lead users, the questions and answers it develops often point toward the need for strategic change. Indeed,

that's what happened at 3M. Besides unearthing concepts for new product lines, the team had identified a revolutionary approach to infection control—but developing the competences, products, and services that would bring that approach to market would require the division to change its strategy.

Until this point, the division had focused on products that were, in a sense, one size fits all. Every patient, regardless of the circumstances that brought him or her there, would get the same degree of infection prevention from the same basic drapes.

In the course of their research, the team members learned that some people entered the hospital with a greater risk of contracting infection—because they suffered from malnutrition, for example, or because they were diabetic. Doctors thus wanted a way of treating individual patients according to their needs through “upstream” containment of infections. In other words, they wanted to treat people before surgery in order to reduce their likelihood of contracting disease during an operation.

Should 3M move in that direction? The members of the project team debated the wisdom of proposing a strategic change to senior managers. According to one team member, “In thinking about challenging the entire business strategy, we were crossing boundaries. I think the lead user methodology had pushed us in that direction. It allowed us to gather and use information in a different way than we had before, and it also provided emotional support for change. Based on extensive research, we were suggesting a major change—but as a team. We didn't feel like lone rangers.”

But not everyone on the team wanted to make this last recommendation. One member feared that senior management might reject all the team's proposals if they made such a recommendation. In the end, the team decided to make the case for strategic change and successfully persuaded senior management to go along with it. As a result, implementation of the new strategy is

well under way. 3M has established a “discovery center” service to develop and diffuse the new approach to infection control. And the product lines needed to deploy it are being developed. Details about the most revolutionary product lines are proprietary, and we can't reveal them here. But senior management believes the new strategy will produce very positive and far-reaching bottom-line results for the Medical-Surgical Markets group.

Opening New Avenues

3M has now successfully tested the lead user method in eight of its 55 divisions. Support among divisional managers who have tested the method has been strong. For example, Roger Lacey, head of the company's Telecom Systems Division and an innovative experimenter with the lead user process, says “the method brings cross-functional teams into close working relationships with leading-edge customers and other sources of expertise.” Support among project teams also is strong. Developers at 3M regard lead user projects as creative, challenging work and will often adopt a project role on an informal basis before being officially assigned to a team.

William Coyne, 3M's senior vice president of R&D, believes the lead user process is the systematic approach to generating breakthroughs that had been missing at 3M. “Corporate management is very enthusiastic about the process, and the line of 3M people interested in learning the method from Mary Sonnack's group [3M's Lead User Process Center of Excellence] extends out her office door and around the block.”

Does the lead user process always guarantee success? Of course not; nothing can. Things like inadequate corporate support and inadequately skilled teams can derail even the most promising project. Nor will the lead user process crowd out projects and processes aimed at developing incremental improvements. Obviously, incremental approaches still have major value. But by giving companies a systematic way of finding the people and organizations on the

Thousands of Innovators

Innovative product users often far outnumber an individual company's product developers. For instance, many people believe that user-developed software products, such as Apache's Web server software, are better than commercially developed products. That's less surprising when you consider that more than a half million Web sites use Apache software and that thousands of users participate in developing and supporting it. That is many times the number of people a commercial software developer like Microsoft can afford to dedicate to server software development and support.

And consider video game development. Sony recently set up a Web site to support hackers who are interested in exploring and developing new types of games that could be played on the Sony PlayStation. It quickly attracted 10,000 participants, a number that vastly exceeds the number of in-house and contract developers creating games for the PlayStation. It's likely that, taken individually, in-house developers are technically more skilled than most user-developers. But the user-developer community mobilized by Sony is diverse in its skills and interests. In a recent *New York Times* interview, Phil Harrison, Sony's vice president of third-party R&D, said he thinks several of them will come up with “some radically new forms of creativity that will break the conventions holding back the business today.”

cutting edge—those who are so impatient and so much in need of the next big thing, they are willing to make it for themselves—the lead user method opens up new avenues. It takes teams and companies in directions they wouldn't have imagined during the day-to-day crush of business.



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