Nearly two-thirds of new products fail after launch. The extreme programming methods used in software engineering show how firms can adopt more effective, customer-led innovation processes.

Managing the development of product innovation is a severe challenge for industrial firms. Nearly two-thirds of new products fail after launch, largely because companies are under pressure to address rapidly evolving customer demand (Lempres, 2003). As a result, new product developers have recognised that they need to inject more customer know-how into their product innovation processes. In many “leading-edge” companies, R&D managers encourage the direct interaction of the development team with customers, in
contrast with traditional practices in which the marketing department undertakes customer research and "throws the results over the wall" to R&D (Holman et al, 2003).

However, the effective structuring and management of such a product innovation process imposes several implementation challenges. Commonly used and predefined new product development processes don't always offer the required flexibility to respond to evolving customer requirements or new technologies in high-velocity industries (MacCormack et al, 2001). Extensive up-front planning wastes time and may even slow the pace of the process when the available know-how is incomplete or obsolete. More effective product development approaches are required, based on probing and learning (Wheelwright and Clark, 1992).

Empirical research has shown that the integration of customer know-how into the development of new products leads to a higher degree of innovation, reduced risks and more precise resource spending. Further, the value of considering so-called lead users - users who recognise their product needs in advance of other customers and who significantly benefit from a new
product solution— in the early stages of the innovation process has been demonstrated by von Hippel (1976, 1988) and others.

However, there are downsides to customer integration. These may include the dangers of customer opportunism, the reduction of the developer's direct control over the new product development process, the additional financial and time costs associated with managing the customer relationships, the generation of inaccurate or unrepresentative know-how due to the limited domain of customer expertise, the internal denial of inputs from outside the company (known as the “not-invented-here syndrome”), the leakage of proprietary information, and the allocation of property rights (Katz and Allen, 1982; Dolan and Matthews, 1993; Littler et al, 1995). To overcome these problems, new methods for obtaining contributions from customers and building these contributions into commercially viable new products are needed.

In the search for analogies to flexible product innovation approaches that successfully manage the intersection of customers and R&D, we found an emerging solution from the extreme programming (XP) methods used in software engineering. Here, the product innovation process is organised to ensure a continual flow of high-quality contributions from customers to the development activities surrounding a new product (Gassmann et al, 2006). The application of XP’s customer integration and product innovation practices appears to be a potentially promising approach to solving the problems noted earlier. The application of XP in an industrial context is the aim of this study.

Research methodology
In the first phase, we explored product innovation processes and customer integration practices on a broad scale. This led to case studies on the factors and challenges in managerial practice among 16 product-developing companies that participated in export workshops and contracted research projects: Bayer Materials Science, Buechi Labortechnik, Endress+Hauser, Hitit, IVF Hartmann, Leica Geosystems, Mammut Sports Group, Model, MTU Aero Engines, Philips Lighting, Qiagen, Schindler, Seafar, Siemens Building Technologies, SIG Combibloc, and Zumbro. All the companies are based in Germany, Liechtenstein, Switzerland, or the Netherlands but are spread across different industries and range from small enterprises to large multinationals. The sample was constructed to maximise the heterogeneity of customer integration practices.

In the second phase, we carried out an in-depth analysis of companies with advanced customer integration practices to gain new insights. The companies are Buechi Labortechnik, Hitit, IDEO and Tribecraft: Hitit has long been known and studied as a company that successfully practices the lead user approach, and Buechi excels in its closeness to distributors and end-customers throughout its product innovation process. IDEO and Tribecraft both work in tight collaboration with their customers and, as a result, have developed product innovations that stand out due to their superior design. Overall, we recorded 88 interview hours. We collected data through face-to-face interviews with chief technology officers, R&D directors, R&D managers, developers, engineers and product managers. Participants were selected so that different levels of customer contact and new product development responsibilities were represented.

The insights from existing research, the XP method from software development and the successful practices of companies enabled us to derive a model of “extreme innovation.”

**IN BRIEF**

- “Extreme Innovation” allows for customer feedback and ideas to be integrated directly into new product development.
- Derived from the extreme programming method used in software development, extreme innovation has been tested and proven by companies.
- The innovation process takes a step approach to innovation, where each new phase of development is tested with customers.
- It requires a flexible approach to project management.
Extreme programming: An overview

Extreme programming (XP) is a process in software development which copes with fast-changing customer requirements and discovers potential new-product innovation through collaboration between customers and developers. It was developed in 1996 by Kent Beck in an attempt to simplify existing methods to software development (Acebal and Cueva, Lovelle 2002). Eventually, XP became one of the most popular disciplines of a group of new procedures known as “agile software development”. Similar to low-overhead methodologies, agile software development is built on the idea that, in environments characterised by rapidly changing requirements, software development is difficult to control. Most importantly, by ensuring that software engineers focus on smaller units of work, these methods minimise risk.

The defining characteristic of an XP methodology lies in its incremental, iterative development of sequenced small improvements, which minimise the length of the feedback cycles. Most design activities take place on the fly, starting with the simplest solution that could possibly work and only then adding complexity. At the beginning of a new product development project, the customer provides his or her basic needs for a new product. After successfully solving this basic need, the first release - which already represents a valuable product - is presented to the customer for feedback. From this basic product, the customer helps define another feature, using a so-called “user story”, to refine the product according to his or her needs. On the basis of the most relevant user story, the engineers improve the original solution through changes or add-ons and present the altered product to the customer as the second release. The same procedure takes place for the next release, and so on. As a result of these short, manageable iteration loops, planning accuracy is guaranteed because the customer can change his or her mind during the development, adding new knowledge and creativity.

Software development through XP finishes when the customer is satisfied, meaning that he or she does not value any more added features. The final product may not look like the product originally envisaged by the customer, but it perfectly fits his or her needs. “As soon as the customers see the first release, they learn what they want in the second release... or what they really wanted in the first,” states XP founder Kent Beck (Beck, 2000). However, the applicability of XP methodology for new product development is limited to certain types of customer needs. XP can be applied only to R&D projects that do not consist of complex technical constructs.

To enable continual customer integration into product innovation, we have developed a model of extreme innovation, the “extreme” derived from the extreme programming model shown above. Our model consists of (1) a proposed innovation process, and (2) a corresponding structural organisation to put the process in place.

Process organisation

To react to market information on a continuous basis during the product innovation process, rather than in intervals or batches, a flexible process is needed. The product innovation process must therefore be information and development-activity oriented, rather than geared to a rigid project plan. Insights from the XP method bring to light the value of small development steps, enabling regular feedback from the customer. Small development steps lead to early releases or prototypes in the form of “the simplest thing that works”, which are presented to the customer for feedback. New relevant functions and features can then be identified through the interplay between customers and developers.

In our suggested model for industrial new product development, the whole innovation process becomes an extended product definition phase (see Figure 1). Every development step leads to an intermediary project result (for example, a
prototype that can be presented to customers). The intermediate results also can be transferred to customers' sites. Such transferability is valuable because relevant information "sticks" to the customer site and can be released only at that location (von Hippel, 1994).

Each product development step helps to determine the priorities in the subsequent stages from both technical and customer perspectives. Project decisions are therefore based on each intermediary result rather than the long-term project plan. This enables the innovation team to continually solve problems as they check new findings with customers.

Project teams drive the development performance by focusing on the highest-value activities in every development stage, skipping unnecessary ones. Project managers shape the team and the workflow in response to new information from customers, offered in response to new technological possibilities. Development activities within each step - idea generation, concept definition, prototype development, and product design - can take place "on the fly" because their limited scope makes them manageable. The resulting intermediary prototypes or working models enable quick evaluations of feature costs and alternatives.

The product innovation project converges on a final prototype - a synthesis of the best solutions according to both technical and market perspectives. When the final prototype has been defined, it is transferred to the regular development process.

Organisational structure

In order to put the product innovation process in place, an organisational structure needs to be defined. To integrate customer contributions and respond to their evolving needs, product innovation teams need the following characteristics:
- The ability to hit moving targets.
- The capacity to optimise each development task.
- The ability to constantly improve the quality and timing of product and process information, providing the right information to the right people at the right time.
- The flexibility to react to new information continually rather than sequentially.
- Dynamic resource allocation.

Product development teams can be thought of as "innovation cells". A cell refers to an organic team that grows and disbands within the company. It is characterised by its flexible and changeable operations, with a structure and composition that can be adapted to temporal and goal-focused jobs. The product innovation cell organises development activities around projects and product teams, not around functional areas. Teams can use the creative leverage to achieve competitive advantage for the company.

A product innovation cell begins with an impulse from the market or a technological potential. Collaboration between the developer and the customer starts with defining the competitive position and areas of improvement that the new product will bring. The team can capture and answer real customer requirements and emotional needs. The necessary information and problem-solving capabilities come together to solve problems (von Hippel, 1994).

The team should ideally consist of a project manager and up to seven highly skilled developers and specialists to provide the technical competence. As the focus of the technical expertise evolves around the innovations identified during the course of the project, companies must train employees and even specialists to "wear more than one hat at a time". Developers may have to play a variety of design roles, for instance. Engineers should have training in several disciplines. The operations staff should know how to build prototypes and manage suppliers. Developers must also confer with manufacturers during the design phase rather than simply handing over detailed specifications, as they might normally do.

Product managers and marketing professionals should become part of the product innovation cell, too. They represent the interface of technological know-how and knowledge of customer needs. Instead of having the marketing department undertake the research and "throw the results over the wall" to R&D, the engineers in the product innovation cell should have direct and frequent contact with customers. The cell team should therefore be complemented by one or more selected product buyers - people within the customer organisation who have buying responsibility for goods and products. They can help prioritise product features. Finally, leading and typical users are consulted continually by the project manager, developers and engineers to gather new information about the product and validate intermediary development results. Databases of users and their status (leading or average) can be maintained to support the accessibility of the proper users at the right time.

Summary and implications

The implementation of extreme innovation in organisations
"Product development teams can be thought of as “innovation cells”. A cell is characterised by its flexible operations, with a structure that can be adapted to temporal and goal-focused jobs."

requires a great deal of flexibility and major investment. Many large multinational organisations have already established innovation departments. Within these departments, we see potential for applying an extreme innovation approach. However, the challenge these units face lies in the acceptance of their work by the rest of the firm. Employees in these departments must be selected carefully; they must be known and highly accepted throughout the whole company. Extreme innovation, which implies a dynamic team composition focused on a particular project, can prevent development departments from losing their “productive friction” by getting too used to each other. Departments must be challenged continuously by new team members and specialists.

The success of extreme innovation is ultimately determined by companies’ ability to allocate resources for their development teams in a fast and flexible way. Team leaders are responsible for bringing together employees with the right mix of skills and competencies to solve problems as soon as they arise. However, this team composition can only be created if the required development resources are in place and easily accessible. New product teams that constantly have to beg for resources from functional “silos” inevitably lack the required flexibility.

An effective innovation process integrating customer knowledge requires collaboration and entrepreneurial action from all team members involved. The extreme innovation approach enables a company to absorb its customers’ explicit and implicit knowledge, which provides extremely valuable guidance for steering new product development towards future customer needs.

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