Why Good Ideas and Good Science Do Not Always Make It Into the Marketplace

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Abstract

Good ideas and good science are not sufficient in and of themselves for successful commercialization of new technology. Understanding the barriers to commercialization so that ways around, under, over, or through them can be found is also crucial to success. Barriers can include market needs, technology push versus market pull, availability of a window of opportunity, economics, and risk aversion. A good starting point is to understand how the technology will fit in with a potential customer's operation. Pushing technology usually is not successful because of customer concerns about new products and processes; however, semitechnical education of the end user is an effective way to build market pull. Evaluating the economics of new technology is important not only to comprehend the potential of the new technology, but also to understand the most effective use of resources in the technology development. Risk aversion on the part of the customer often overrules the potential economic benefits of a new technology in the decisionmaking process. To address these issues, many corporations have established stage-gate and portfolio-management processes. These concepts can be used effectively even without the establishment of a formal process. Both successful and unsuccessful new products and new processes are provided to illustrate these issues and the ways to solve them.

Keywords: Barriers, economics, risk aversion, technology push, market pull, stage-gate.

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Introduction

As technologists, our main goal is to develop a specific technology and then to work on turning it into a commercial success. The problem with this strategy is that it often leads to technical success but no real implementation, causing great frustration for the scientist. It is unnecessary to list examples of failed technologies here, as many of us are familiar with these from our own experience. Rather, it is more important to consider the potential hurdles from invention to commercial success, evaluate which ones are likely to limit or be fatal to technology implementation, and then address them as early in the development process as possible.

Although many articles have been published on the subject of technology development and implementation (Google® identified 73,300,000 citations, including 94,000 books), the information seldom seems to fit a person's particular program. For example, a roadmap developed for crossing the Great Plains is unlikely to be useful for the Rocky Mountains. Each technology has its own unique hurdles, whether it be rivers, lakes, swamps, or mountains; thus, each technology needs it own roadmap. By thinking through the entire process beforehand, a good roadmap can be developed and used to avoid ending up frustrated in a dead-end canyon or standing precariously at the edge of a mesa.

Large organizations are able to use strategies, such as stage-gate processes and portfolio management, to make research more profitable by concentrating on the technologies that offer greater payouts, higher chances of success, and lower risk to the organization. For most organizations, such formal processes are too cumbersome. However, the technologist can apply some of the

thought processes that have gone into developing these formalized methodologies in a less formal manner.

This paper does not intend to design an exact pathway but rather to list factors that should be considered and addressed throughout technology development and implementation. Although this author's area of expertise is organic chemistry, the rules are based on more general principles and will transfer across most market segments. Note that these comments apply more to typical manufacturing industries than to those that depend on new products for survival.

Understanding Needs

It seems obvious that in developing a product it is important to meet the needs of the marketplace. However, information on exactly what is needed can often be difficult to obtain for several reasons. First, technical people are usually not directly in touch with potential end users of the technology. Second, customers may not realize what new technology they need. Third, although the new technology may seem to have a market fit, it may not actually be the best available.

The separation of technical people from end users leads to an unclear idea of what is needed for a technology to succeed. Some routes for information transfer are illustrated in figure 1. Every step in the transfer of information—from the end user of the technology to the person developing the new technology—serves as a place where information may get filtered and distorted. Although technical service, sales, and marketing people are very good at what they do, they tend to think of products from the viewpoint of current technology. In concentrating on their job, they simply fail to record information that is important for the development of a successful new technology. In many cases, they may not understand the information provided as it relates to more sophisticated or longer term applications, and they seldom have the background to brainstorm with customers on developing new technology. Finally, they are rewarded for current sales and have no incentive for time spent on sales that would not take place for 5 to 10 years.

Even if technical people can have direct contact with users of the technology, customers may not always know what they actually need. As packaging for pet food and fertilizer changed from plain to printed bags, the packaging companies encountered problems with the adhesives for sealing the bags. They requested better adhesives to bond the printed surfaces. In many cases, however, the adhesives stuck very well to the ink film, but the ink film did not adhere well to the bag. Thus, what was needed was a better ink, not a better adhesive.

Even if we can develop seemingly suitable technology, it may still not be the right technology. Many companies developed waterborne adhesives and inks to replace solventborne products, figuring that companies would switch for environmental reasons. In some cases, the waterborne systems were accepted in the marketplace, but in other cases the waterborne technology was not a commercial success for a number of reasons. First, few and less stringent regulations have been put into place than once feared; thus, many operations still use solventborne systems. Second, there has been a general realization of the paucity of a market for environmentally friendly products that cost more or have lower performance. Customers will not buy an inferior product for the same price. Paper companies learned this lesson in the recycled paper market by having to spend considerable amounts of money on additional technology and equipment so that the recycled fiber would meet standard paper specifications for brightness. Third, companies found other ways to solve environmental issues. Many printing operations continue to use solventborne inks with collection and recycling of the volatilized solvent, rather than trying to solve the print quality and slow drying problems associated with waterborne inks.

Regulations have a major impact on technology implementation. An important benefit of dealing with potential customers early in the development of a product or process is to learn all the regulations that must be

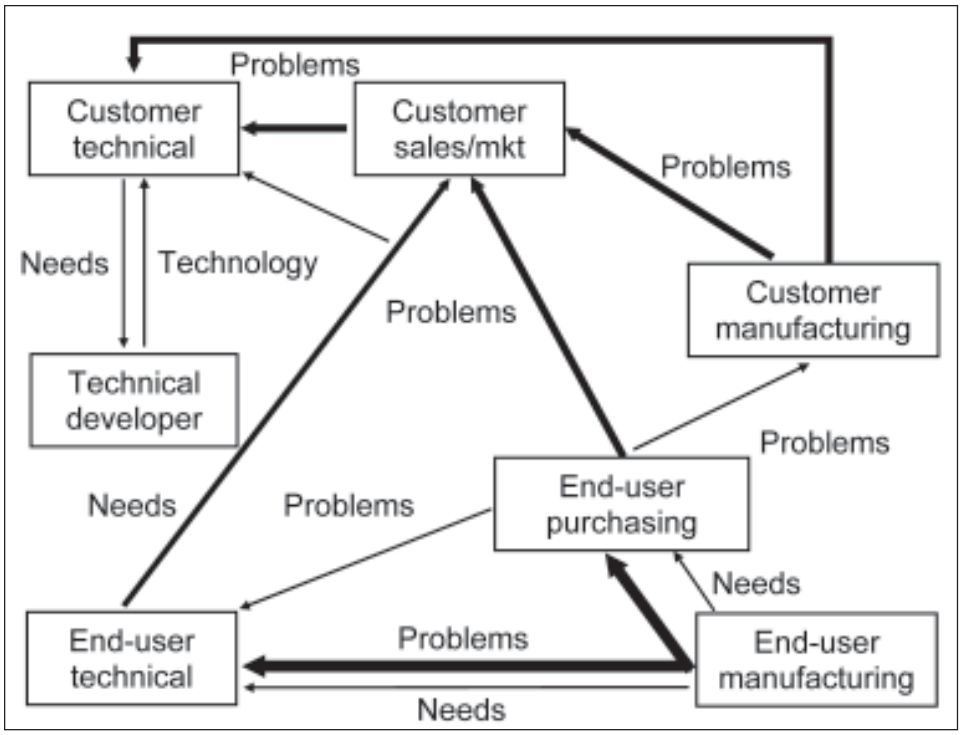

Figure 1—Information transfer between technical developer, customer, and end user is complicated. Problems flow back through the system quickly and with great emphasis. Needs are less likely to flow back through the system because of filters.

balanced to run the business. Does the new technology positively or negatively affect the company's ability to meet these regulations? This includes not only product performance, but also air and water emissions and disposal of byproducts.

How do we address these issues? Nothing replaces direct contact between the person developing the technology and the potential users of the technology. If at all possible, visit the customer's technical staff, the plant's production and technical personnel, and key marketing and business personnel. If the immediate customer's product is sold to another manufacturing operation, it is equally important to visit these people in that operation as well.

In addition, many users of new technology may be outside the company's current customer base. How can relationships be built with these potential customers? Attending meetings and conferences is crucial for cultivating relationships with technical people in other companies. However, it is also important to attend meetings that are attended by users of the technology. If you are trying to promote a wood adhesive, note that more adhesive users are likely to be present at a wood products meeting than at an adhesives meeting; in addition, these meetings are important for finding out the limitations of current products and discovering new products.

Leveraging can take place by looking outside your immediate field. Union Camp developed a gel candle business because technical personnel in the Bush Boake Allen Division that made fragrances worked together with technical personnel in the Chemical Products Division that made gellants from fatty acids. Together they made a unique product that was presented as a concept to the specialty products industry and was commercially implemented.

Aspects to Implementing New Technology

Market Pull Versus Technology Push

An important aspect of marketing new products is understanding the difference between technology push and market pull. Assume that we have developed a wonderful new adhesive technology for stronger engineered lumber. The standard model is to promote the technology to an adhesive company. If this company decides the technology is interesting, then it will need to convince an engineered wood producer to develop a product using the new adhesive. If the engineered wood producer decides to market the new bonded lumber, then its sales team will have to convince a builder to use it. Each step of the technology push involves convincing technical, sales/marketing, and business people in each company, and the developer of the adhesive technology generally has control over only the first step of the chain.

On the other hand, if you work with a major builder to show the economic advantage of a new engineered lumber, you are using market pull. When the builder asks the supplier for the improved engineered lumber, you can bet that this project will get priority with the engineered lumber producer, as well as with the adhesive supplier.

Because we are technical people, our emphasis is almost always on technology push, rather than market pull. The problem is that this route is often like pushing a rock up a steep hill; we are likely to be run over if we are not always pushing hard. With enough hard work we may convince the technical personnel at another company of the advantage of this technology, but generally these people have the least influence on product direction. The sales and marketing personnel are the most influential, and production personnel are second. Technical push can work if you are providing a product or process that falls within a company's current business strategy for new products. If the company has decided to make a composite that has no formaldehyde emissions, then the technology for a formaldehyde-free adhesive is more likely to be readily accepted.

On the other hand, market pull uses other people, in particular the customers of your target company, to help get the rock up the hill. Thus, you first convince the users of composite panels that the new adhesive will provide them an advantage. They will then pressure the composite manufacturer to use the adhesive technology, and the composite manufacturer will in turn put pressure on the adhesive manufacturer to implement the technology. As mentioned before, it is important not only to understand your customer's operations but to also understand your customer's customer's operations. Plus, the contacts that you develop in assessing market needs can be used later in developing market pull.

Technology push can work, but it is better if it can be combined with market pull. The benefit of working both routes can be illustrated in Ikea's interest in environmentally friendly wood products. Knowing Ikea's interest, a panel producer could approach their adhesive supplier and ask for a low- or non-formaldehyde-emitting panel product. The adhesive supplier may indicate that it can supply a low-formaldehyde product that meets the German E1 emission class or the more recent Japanese standard, but it may also indicate that there are no suitable adhesives for panel products that have no formaldehyde emissions. Thus, if an adhesive can be developed with no formaldehyde, then promoting this technology with both the adhesive manufacturer and the panel producer would greatly increase the likelihood that the technology would be accepted.

Window of Opportunity

Window of opportunity is the time in which the market is open for new technology. The window opens as a result of changes in regulations, economic forces, or consumer interests. The window generally closes when technology is implemented to meet the new market demand, the altered economic forces are no longer present, or consumer interest changes to something else. Concerns about formaldehyde emissions led to regulations that limited emissions. Changes in adhesive

formulation then led to fulfillment of the regulations and closed the opportunity for other adhesives. Surging gas prices led to increased sales of more efficient automobiles and trucks, but the demand for these vehicles decreased as gas prices declined. The success of environmentally friendly products often depends on consumer interest at the time.

The appropriate technology generally needs to be created prior to the need because technology development takes too long to fit into a window of opportunity. Therefore, it is important that new technology development is accompanied by foresight. After agreeing to limit the use of wood treated with chromated copper arsenate (CCA), companies needed fully developed technology that wood treaters could use immediately. Prior to this agreement, however, it was difficult to convince managers, marketers, and sales staff of the need to develop alternative treatments. As soon as the window opens, the technical person must have the alternative ready to go. Market anticipation is a valuable skill for any organization.

On the other hand, technology developed before a window of opportunity opens often has to sit until the window opens. No matter how hard you push, alternatives that are costly or do not improve performance are not likely to be used as long as the current product is acceptable in the marketplace. Thus, in the case of treated wood, companies had known about alternative products such as copper azole or alkaline copper quat (ACQ) for a long time, but these products could not compete against CCA-treated wood on the basis of price or performance. The reduced use of CCA-treated wood opened the window for other treatments to enter the marketplace.

Of all the factors affecting new product success, the window of opportunity is the hardest to plan for because it involves some event or series of events over which the developer of the technology generally has little control. The technical person has to realize beforehand that a window may open and have the product ready for implementation in a short time. Again, market anticipation is important for success. On the other hand, educating the customer about the benefits of a new technology can sometimes open a new window of opportunity or accelerate the opening of a window.

Not every technology is highly controlled by a window of opportunity. After all, we continue to await a better mousetrap because mice and rats continue to invade our living quarters. The current traps work, but if a better trap comes along it will no doubt succeed, as long as it offers some distinct advantage to the customer.

Economics

It seems obvious that economics is an important issue for implementing new technology. However, economics often gets deferred until late in the development process because technical people are often not trained in economic calculations and generally have insufficient information to calculate the detailed economics of a new process. Nonetheless, it is important to do the best possible economic evaluation from the beginning of technology development and to refine the evaluation as process development continues and more information is gathered. The primary reason for this evaluation is that it makes little sense to develop a process or product for which the economics are highly unfavorable. Secondary reasons are that economics can indicate which areas of research are most important and can be useful in promoting the technology. Without a good idea of the economics, it is difficult to promote any technology and impossible to prioritize research and development projects.

How do you conduct an economic assessment? The four main factors to consider are the net worth of the material, production labor costs, indirect costs, and capital costs.

Net worth of material—
The net worth of a material is the easiest of these factors to estimate and can initially be used to select programs

with a chance of success compared to those that are clearly uneconomical. The simplest calculation involves the price per one unit of the product minus the cost of the raw materials required to produce that unit of product. This figure is then adjusted by the value of the byproducts (either credit or debit). For uncertain values, use your best estimate and see what happens to profitability when this estimate is varied by a 10 percent, 20 percent, and 30 percent increase or decrease. If the cost of the product is more than the expected sales price or profitable only by taking the most optimistic case, your efforts are probably better spent elsewhere. These calculations can also help focus the development process on the issues that will provide the greatest reward. How critical is it to improve product yield, or to find value for the byproducts, or to find a lower cost raw material? Many processes suffer from the low or negative (pay for disposal) value of the byproducts. The fermentation of corn to produce ethanol can leave a byproduct of lesser value than that of the raw material, which drags down the overall economics of the process. The net worth value of the material needs to be very positive because the production, indirect, and capital costs need to be subtracted, as illustrated in figure 2.

Production labor costs—
Production labor costs can be the most significant part of total production costs because for most companies, labor costs are the largest expense and represent the greatest cost difference between production in developed and underdeveloped countries. Most companies are willing to spend capital money to reduce labor costs, as evidenced by the purchase of equipment ranging from mechanical tree harvesters to automated production lines. Other production costs such as utilities are often less critical, but they can be a significant factor if, for example, a large amount of water is evaporated as in the drying of wood or manufacture of paper.

Indirect costs—
Indirect costs are usually dominated by management, sales and marketing costs, and, in some cases, by research. If the new technology fits within the customer's current operation and markets, it has little or no effect on these costs. On the other hand, new product lines in new markets require additional staff and result in higher indirect costs to the organization.

Capitol costs—
Capital costs can be a significant factor. The way to keep these costs at a minimum is to develop technology that fits within the organization's current processes, both for the equipment used and for maintenance of the current production rate. Any new equipment will need to pay for itself in a short timeframe and will have to compete against other capital expenditures within the company. Any decrease in production rate is doubly detrimental because less total product is created and consequently less total output per worker. On the other hand, an increase in production rate is of interest to both management and production. A brand new process for pulping wood can have many advantages but it often requires new equipment, which means scrapping much of the invested capital currently in use.

Gathering of economic information—
How is economic information gathered? Information can be obtained from many sources, depending on the specific new product or process. The best source is to work closely with a potential customer and its customer(s), who often provide general price information once you have developed rapport. Many government agencies, including extension services, and local business development groups have information on economics or can provide contacts. In some cases, multiclient studies are available.

Companies are in the business to make money. Why would they want to waste their time and money on processes or products that will not improve their profits? The less you understand about the economics of the

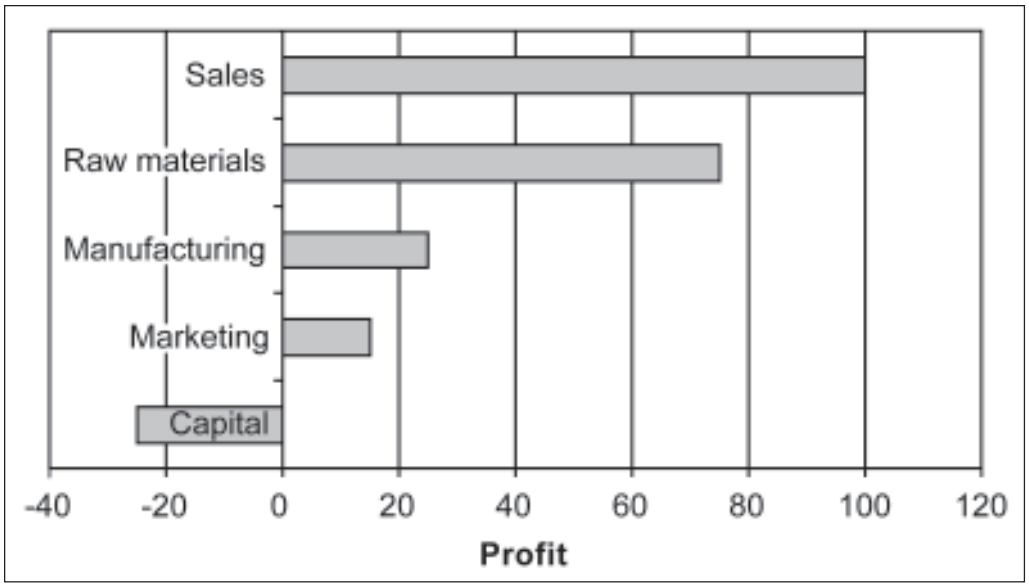

Figure 2—The economics of introducing new products: profit diminishes with each additional factor. To be viable, it is best to minimize the cost of each step. If capital expenses are significant, it could be worth spending efforts on reducing capital costs at a higher production cost for a new product until the technology is proven.

technology that you are promoting, the lower your creditability with the potential user of the technology. The additional benefit of starting an economic evaluation as early in the process as possible is that it can help direct the research to improve the economics of the technology.

Risk aversion

Risk aversion is the least appreciated aspect in implementing new technology and is often the overriding reason that new technologies are not implemented. After investing a lot of time and money, what happens if the technology does not meet the target expectations? Will major customers be lost because the new product does not meet expectations or because the customer does not foresee higher value from the new product? Has plant output been slowed because of scale-up issues or equipment problems related to the new product? Will the variability of the feed or production equipment lead to low-quality products or low product yields? And so forth.

Companies are always concerned about losing a major customer if the new technology does not live up to expectations. Consequently, sales and marketing staff tend to stick to the status quo. They often do not understand the technical benefits for the company and for their customers. Education is crucial—even to the point of dragging company reps into the lab or plant so that they can appreciate the new technology. A fair amount of time and effort is sometimes required to develop a way of communicating the technology to nontechnical people, but it is better to have these people working with you rather than against you. We had developed a way to reduce the perception of odor in one of our products, but the technology was stalled within our company owing to management objections. This was solved by getting the marketing manager involved with the project from the scientific perspective. A blind odor evaluation by the marketing manager convinced him of the value of the technology and led to its presentation to our customers, ultimately leading to commercial implementation.

Like sales and marketing personnel, production people generally like the status quo. They know how to deal with the current process, even if it has problems. They are concerned about new technology because they will need to learn how to make adjustments when things go wrong, as they often do. By understanding how things are done in a plant, you can try to direct new technology so that it requires the least change from existing operations. It is also important to develop processes that are the most robust, that is, the least influenced by changes in materials and conditions.

Risk aversion is an extremely important issue in the implementation of new technology. The best way to deal with it is to understand why people are afraid of change and then to make sure that you minimize the effect by educating all the right people and making your process as robust as possible.

Ways to Implement New Technology

Stage-Gate Methodology

The discussion thus far has been on specific areas of concern that need to be considered in developing and implementing new technology. Many large corporations have put into place formal systems to evaluate where to spend research dollars. These systems have been called by various names, but stage-gate seems most appropriate. This system places evaluation gates at set places between the initial idea and final implementation, as shown in figure 3.[2] At each gate, the technology receives greater scrutiny to correspond to the greater commitment of corporate dollars and staff power to the technology. These processes are highly formalized and require too much time to be useful for many organizations. On the other hand, not using this methodology leads to research and development time spent on projects that have little chance of success. Even if a formalized process is not used, the more knowledge that people have about technology assessment, the better they are at planning and developing new technology.

The benefits of looking ahead at future stages are to determine the hurdles before they become a major problem and to learn, before investing a lot of resources, if a hurdle is likely to kill a project. An example of a project killer is trying to use a natural material that is available only in low volumes for a large-volume market. A similar problem is using a natural material that has high variability in its composition, which could lead to major difficulties in converting the material into a consistent end product.

Another advantage of looking at all steps of new technology implementation is that it becomes evident what resources and additional expertise are needed. Using the expertise of others is important to efficient technology development. If at some point technology development requires a process engineer or a marketing person, then why not involve such staff early on so that they can provide insight into critical parameters? It is generally better to address these issues in the beginning stages rather than modify the process because a critical hurdle cannot be solved by the current technology.

Portfolio Management

Large companies go beyond stage-gate methodology to portfolio development to allocate resources between short- and long-term programs and to decide upon individual projects within these programs. It is beneficial for some of the same concepts to be used within smaller organizations. One of the greatest challenges in research is to determine when an individual program should be terminated as a result of some hurdle—technical or business—that cannot be overcome or would require too many resources to overcome. Evaluating a variety of research programs allows you to determine if there are better places for developmental efforts.

[2] Cooper, R.G. 1993. Winning at new products. Accelerating the process from idea to launch. Reading, MA: Addison–Wesley Publishing Company.

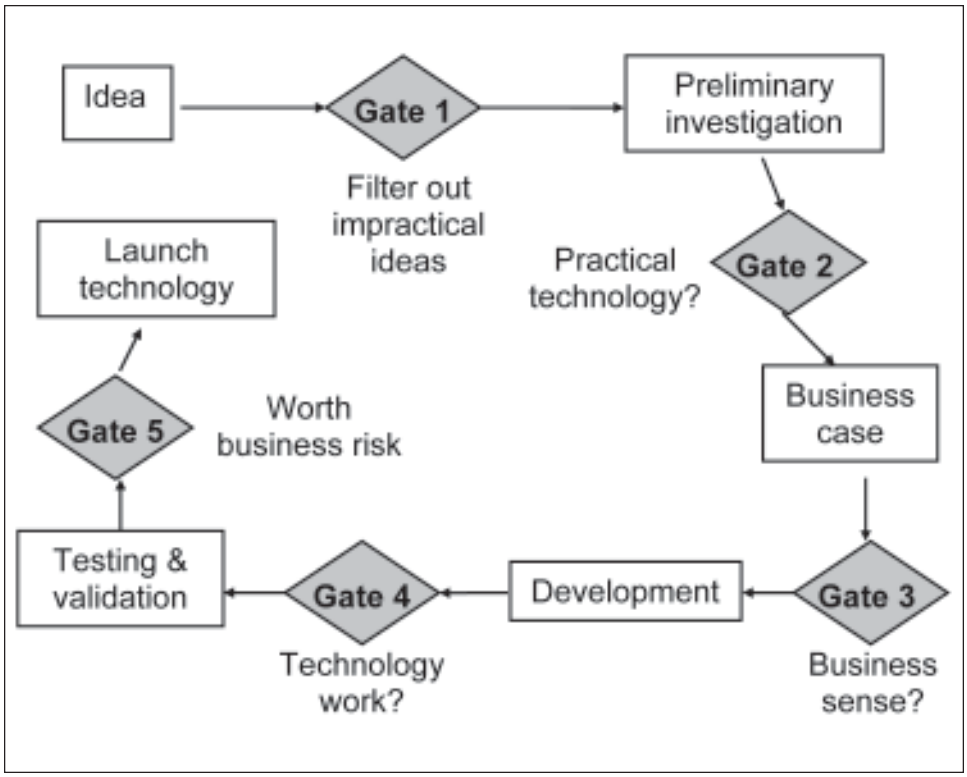

Figure 3—Stage-gate evaluation: each gate serves as place to filter out projects with less chance of success.

Concluding Remarks

The successful implementation of technology depends on many factors other than the quality of the technology itself. It is important to understand these other factors early in the development process to give the new technology the best chance of success. First, it is necessary to obtain a clear understanding of the customer's real needs, not just perceived needs, by close interaction with both the direct customer and that customer's customer. Second, by working with the end user as well as the direct customer, you can exert an influence on both technology push and market pull.

Even if you maintain close interaction with customers, many hurdles can stall technical implementation. For many technologies, there is a window of opportunity when new technology is most likely to be implemented as a result of changes in regulations, outside economic forces, or market demand. Evaluating the economics of the technology is too important to postpone until the technology is developed. Early economic evaluation with refinement as more information is developed can be a strong asset in determining the most critical issues in technology development and in presenting the technology to potential customers. However, even technologies with good market needs and economic potential can have their implementation stalled by risk aversion.

Stage-gate evaluation and portfolio management are formal processes for evaluating where to put research resources. Although these methods may be too formal for most uses, the thought processes used in developing them can help to ensure that key hurdles are considered early in the process and that ways to overcome the hurdles are incorporated into development.

Technology transfer is not something that should be considered after a technology has been developed. It should be integrated in the development process itself. You are unlikely to be successful at chess if you think of the opening moves and the checkmate as disparate entities rather than integral parts of a complete plan. Why should technology development and transfer be any different?

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