

Strategic Technology Management

Building Bridges between Sciences,
Engineering and Business Management
(2nd edition)

edited by

George Tesar, Steven W Anderson,
Sibdas Ghosh, & Tom Bramorski

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Imperial College Press

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STRATEGIC TECHNOLOGY MANAGEMENT

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This book is dedicated to:

my Sluníčko,

the loving memory of my parents, Virginia and William Anderson,

my wife Jayati, daughter Taumoha and son Moyukh Ghosh, and

my wife, Loretta, and sons Charles and Michael.

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Introduction to the Second Edition

In a rapidly changing technological environment where introductions of new product ideas, concepts, and products in our society are ever more increasing phenomenon, it is even more important for scientists, engineers, and business managers to clearly and effectively communicate their ideas and expectations. In order to maintain and improve this communication process, we need to educate the next generation of managers to be able to not only communicate clearly and effectively, to understand each other's problems, challenges, and obstacles, but also to work together side by side.

This was the overall aim of our first edition. We discovered quickly that besides educating students in sciences, engineering, and business management to begin to understand each other, we were faced with comments and suggestions from practicing scientists, engineers, and business managers that they needed to develop their practices within this framework. Several large corporations found our approach useful in their in-house training programs. We received several comments from the management training programs offered by business schools in North America and in Europe regarding the value of the approach we are using and the importance of some of the cases included in the first edition. We also learned that several major technical universities used the first edition as a text in their senior policy programs; courses were attended by both science and engineering students and business management students. We were pleased with these comments.

We also recognized, through book reviews and personal suggestions from colleagues who used the first edition, that some cases needed to be updated or changed. This is mainly due to recent changes in scientific and technological developments and in business practices. For the second edition, we have selected cases that reflect these developments. In the process of discussing the changes with our international colleagues, we were told that the first edition has also

been used in training entrepreneurs interested in introducing their ideas to the market. Many of these entrepreneurs are medical doctors and instrumentation engineers who have more efficient ways of measuring certain events related to computerized medicine. The entrepreneurs found the first edition useful in developing their understanding of moving an idea into the market.

Since we introduced the first edition, the emphasis on green or renewable technology has increased dramatically. Areas of biology, chemistry, and ecology started to focus on green and renewable technology with unprecedented rigor. In our own presentations and training sessions, it became obvious that these two aspects of technology will play an important part in almost every field of scientific, engineering and business management in the future. We decided to include cases that partially or fully focus on these developments. It is unfortunate that more cases have not been as readily available as we expected.

The emphasis on integrating sciences, engineering, and business management is becoming rather international in scope. A number of technical and engineering programs in North America, Europe, Japan, and even Africa are gradually integrating business management concepts into scientific and engineering programs. Even medical programs are introducing more quantitative decision-making in order to introduce more objectivity and the latest scientific knowledge into their practice. Computer modeling as a basis for decision-making is becoming routine in medicine today. These trends in medicine have stimulated a greater need for new computer-based products and service. An increasing number of specialists will have to be educated and trained to develop the necessary products and services for the medical profession, and also to determine their marketability. We see the second edition of this publication as contributing to this need.

We wish to thank all our colleagues for their constructive comments, the reviewers who reviewed the first edition and provided us with their constructive comments and occasional criticism of the first edition, and also the anonymous reviewers for their constructive suggestions. In addition, we wish to thank our publisher, Imperial College Press and, especially, the editors in charge of our publication for their cooperation, comments, and patience.

Topic Area 1

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Managing the Creative Process in a Cross-Functional Global Environment

In order to be competitive and maintain its market position, firms need to manage more closely their existing products and strategically introduce new products. Since firms today operate in a highly competitive market place where they compete with firms that maintain global production capabilities and are faced with increasingly more informed consumers, they need to take a broader perspective concerning their innovation efforts, introduction of new technology, increased productivity, and improve the efficiency of their new product development programs. It is the new product development effort that is becoming an important segment of both technical and marketing management. To succeed in rapidly growing and globally competitive markets, firms must develop capabilities that will strengthen their product development and management activities.

Many firms realize that they need to examine their product development and management efforts from a perspective of the entire firm. They need to understand the technological side of the business just as well as the marketing side. Top management needs to realize that product development and management is a continuous and on-going process that begins with research in the laboratories just as much as it begins in the market. In laboratories scientists, researchers, and application engineers conduct studies that eventually may lead to new products, while in the market marketing researchers are identifying and examining new product opportunities among consumers.

Whatever the source of new products might be, new products need to be systematically developed within the firm. New product development is a complex collective effort that combines input from many functional areas within the firm. Even if the new product development

process is highly structured and formalized, there is a need for additional information, expertise, or recommendations that must be solicited from functional specialists outside of the new product development process. In some firms, there is a tendency to manage a relatively open and unstructured new product development process that encourages unsolicited cooperation from individuals that may have only a marginal interest in new product development. How the new product development process is organized may not necessarily be an important issue, especially for the high technology firms. What is important is its productivity.

Some firms prefer to organize their product development and management activities into a highly structured and sequential process that is reviewed and controlled by the technical and the marketing staff separately. The process is managed by the respective functional managers such as R&D, engineering, or marketing and is eventually the responsibility of the top management. In this environment the scientists, engineers, or the other product development specialists are typically not participating in the strategic management process of the firm, but are only a part of the operational process of product development or management.

Since the product development and management function is becoming strategically more important, firms are responding by forming cross-functional product development teams. The responsibility of these cross-functional teams is to systematically evaluate all aspects that lead to the development of a new product and, in some cases, even to its eventual long-term market performance. Many cross-functional teams are formed not only to develop new products but also to introduce new technology or commercialize technology by building the necessary organizational structures and developing leadership for these structures, which may lead to formation of entire new ventures or subsidiaries.

With the rapid adoption of information technology and more globally diversified market opportunities, firms need to consider a variety of options impacting their product development and management efforts. With emphasis on financial efficiency and marketing effectiveness, firms are examining many options driven by the rapidly

changing technological environment. Firms are exploring their own technological expertise and are comparing it to their marketing competence. Top managements of these firms realize that their technological expertise must be in balance with their marketing know-how.

In some firms, the scientists, engineers, or technical product development specialists are far more skilled in applying their technological expertise than their marketing counterparts. They quickly discover that they are attempting to develop products that their marketing specialists do not understand, and consequently, are ineffective in supporting these products in the market. The opposite situation sometimes also emerges. The marketing personnel is highly skilled and is capable of conducting marketing research studies that indicate what strategic position the firms needs to take, which products to introduce, and what at what level of technology. However, for whatever reason, the technical staff are not able to develop these products. It becomes the responsibility of top management to resolve the differences between the marketing specialists and the technical staff.

Firms operating in hyper-competitive global markets need to carefully balance their technological and marketing competencies. One way for top management to assure that there is a balance between the technical and marketing functions in their firms is to develop an effectively functioning communication process and support it with a well functioning information system. An effective communications need to be opened between the technical and marketing sides of the firms. Scientists, engineers and laboratory technicians must be able to communicate with marketing managers, individual sales persons, and even marketing research specialists especially at the beginning of the product development process. In addition, the two sides need to be able to operate together utilizing the latest available internal and external information.

Close cooperation on product development activities between the technical and marketing sides of the firm tends to lead to more creativity and productivity. Their ability to utilize information from a common information source tends to open the communication process between the two sides even more. Such cooperation also leads to more new product ideas. Scientists and engineers working in their

laboratories need to generate new product ideas that can be effectively communicated to the commercial side of the firm. They have to be able to explain the innovative propensities of their new product ideas to the financial, marketing, and manufacturing managers who will ultimately assist in marketing of the products that they are proposing. The business specialist must be able to objectively and professionally examine these ideas from the perspective of the market and the prevailing competitive climate.

The new product development efforts today typically begin either with a technological innovation that originated on technical side or the product development efforts that originated in the market. Scientists, engineers or laboratory technicians may have identified a suitable technological innovation, or through marketing research studies a market opportunity was identified. Regardless of the source of the innovation or opportunity, both sides of the firm are needed to convert that opportunity into a viable product.

If the product starts from a technological innovation and eventually is introduced in the market, this type of marketing is generally called market push marketing. A product opportunity that initially started in the market and eventually was introduced in the market is referred to as market pull marketing. Either type starts with a new product idea. The difference is in how the idea eventually reaches the market.

Both the technical and marketing product development specialists work with new product ideas. A new product idea is a construct, used by both the technical and business side of the firm, which describes a potential market innovation. New product ideas are generally formulated as descriptive statements. They represent a starting point in the product development and management process. Firms with a well-structured and managed technological function require accurate documentation of all new product ideas. For most high technology firms, new product ideas represent potential business values and, in some special cases, can be commercialized without being further developed.

New product ideas need to be screened systematically to make certain that the firm has the necessary technological and marketing abilities to develop the new product idea further. On the technical side of

the firm, the screening process consists of a series of clearly defined steps needed to verify that the firm has the scientific, technological, and engineering abilities to develop the ideas into a workable prototype and eventually into a marketable product. The marketing side has the responsibility in the screening process to determine the commercial potential of the idea. Initial discussions are held with the marketing specialist, sales personnel, and financial analysts. These discussions are generally held internally and may be supplemented by input from outside consultants.

New product idea screening processes are frequently a part of policies and procedures, are well documented, and become a part of the entire new product development and management effort. High technology firms tend to even develop their own software for the purpose of screening new product ideas. Other firms may purchase software off-the-shelf from an outside supplier, such as a consulting firm, and modify the software for their particular needs. Since new product ideas as such might be a source of potential income, systematically screened ideas are frequently sorted out into categories: those ideas that may be suitable for internal development, ideas that may be offered for sale, and ideas that may have no present commercial internal or external value.

The two issues that may emerge while new product ideas are being screened deal with technology tradeoff cost analysis and business plan development. The first issue addresses the basic question of whether or not the financial investments in the new proposed idea be justified given the level of technology and the estimated forecasted market demand for the eventual product. Cost analysis and the technology tradeoff analysis are important matters in themselves, especially among the large high technology firms faced with a large portfolio of new product ideas. The second issue focuses on the development of a preliminary business plan. The plan is prepared on the basis of the available preliminary information. The expectations are that this version of the business plan may have to be significantly modified and formalized later when more complete information will be made available about the potential product.

Although top managers of the larger high technology firms clearly suggest that the new product development process needs to be

managed from the top and that it should be formalized, many other firms do not follow that model. Firms tend to develop new products only when the existing products are reaching the end of their lives. They become less and less profitable for the firms, the sales force is facing increasing resistance in offering the product, and consumers lose interest in the product because better options are available in the market. Therefore, it is important to have a reasonable projection for a product life cycle.

When new products need to be developed because the existing products are no longer attractive to the consumers, it might be too late for the firm, and it may have to pull out of the market. Even with the use of latest technology, including computer based design programs, and scanner data, it takes a great deal of time to develop a new product and introduce it in the market. Every step of the process needs to be carefully planned and executed. The external business environment in which new products are being developed is changing quickly. Top management must constantly assess the changes that are taking place and relate the changes to market conditions to effectively manage its products so that they do not lose their value in the market.

Sometimes, the entire new product development process is impacted by major environmental changes that come unexpectedly. New technology is dramatically introduced; there is significant change in the market demand or a financial climate more conducive to research and development activities created by the government. In these situations, firms must act quickly to develop a more competitive position because all the other competitors or potential competitors will also act. Some of the recent political, social, and economic changes in a number of countries around the world clearly demonstrate how the market or competition can fundamentally change.

A result of the recent environmental, market, and competitive changes suggests that firms need to have long-term new product development strategies. Some of these strategies, in a form of standard policies and procedures, are mandated by top management. In other firms, special new product development units are organized whose sole responsibility is new product planning and development. Yet, there are still many firms that attempt to develop new products

in a chaotic state that creates financial and managerial hardship for the entire firm. Firms that started out as one-product firms, with all their market activities, centered around the single product, ultimately find it very difficult to develop and market another product.

In order to effectively develop and market new products in rapidly changing hyper-competitive global market, firms must approach the entire new product development process differently. They must begin with a systematic generation and collection of new product ideas. The ideas must be carefully screened to determine their potential. If their potential appears to be competitive and profitable in the market, the new product ideas need to be systematically developed into new products. Firms must approach the new product development process from a broad top management-level perspective. An effective communication process between the technical side and the marketing side of the business needs to be established and sufficient information needs to be shared between the two sides. Although there is no clear consensus on how typically the new product development process should be organized, individual firms usually find a way to organize the process in such a way that it produces the best result for that firm.

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The WINDEX 1200: Aircraft Development¹

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The product development process in small firms is a complex process highly charged with emotions, personal expectations, and anticipations from the market. Frequently, the decision-makers have strong convictions about their product's design, performance, and market position. These convictions may differ dramatically from what the market perceives in terms of design, performance, and market position. When these differences become difficult to resolve by the managers responsible for the product development process, the process may proceed endlessly without any tangible results. This case involves many issues regarding the product development process in a small firm that competes on an international market. RADAB is a privately owned firm focusing on the development of the Windex 1200 motorized glider.

¹ This case was developed by Jan Bodin of INC Graduate Business School, Nancy, France for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

Company's Dawn

Three owners, Harald Undén, Sven-Olof Ridder, and Lars Bergström founded RADAB in 1964. RADAB is an acronym that stands for Research and Development, AB. The owners have known each other for a long time. Harald Undén and Sven-Olof Ridder met while they were still in an elementary school. Sven-Olof Ridder and Lars Bergström also knew each other for a long time, perhaps before they were 20 years old. All three had a strong interest in building and flying model airplanes. All three were also avid sailors. During the 1960s, they used their free time to restore boats and try to improve their sailing skills. While restoring boats they recognized a need to improve some of the tools and equipment used on a sailing boat. Because of lack of resources, they made some of the tools and equipment themselves at the Royal Institute of Technology in Stockholm where Ridder and Bergström were engineering students.

Their products were very successful — other sailors begun to ask if they could make similar products for them. They agreed since it gave them an opportunity to finance their own hobby. After some time they decided to start a company and do business in a more formal way. They did not start the firm with specifically planned objectives or projects. In recent years, RADAB employed between two and seven employees.

Today, Harald Undén is an acting CEO, and the only owner, who has continuously been receiving a salary from the company. Sven-Olof Ridder is the dominating force when it comes to generating ideas. He is the innovator and a competent engineer. His ideas are seldom questioned and everyone within the company is aware of his competence, especially in the field of aerodynamics.

Lars Bergström is the least active owner within the firm. In the beginning of the 1970s, due to a health problem, Lars moved to Sarasota in Florida where he and Sven-Olof Ridder also have their own company, B&R Design, which specializes in products for the sailing industry. Lars stays in contact with his two partners by telephone, fax, and by visiting Stockholm and RADAB's home office couple of times each year. He is an undemanding person, an engineer, interested in selling and marketing the products developed within RADAB.

Earlier Products

In the mid-sixties, Ridder came up with an idea of a new accessory for their sailing boat, a wind-direction indicator. In 1964, he gave a prototype as a Christmas present to Bergström. They saw a potential market for the product and started to produce it under the Windex trademark.

Initially, the wind-direction indicator was made of aluminum. It was primarily Bergström who promoted the product by making presentations at sailing-clubs. In 1972, they invested in necessary tools to make the wind-indicator using plastic material. The mould was actually taken as payment against one of their invoices. Since the manufacturing process had become more effective and cheaper, the company was making steady profit. As a result of improved manufacturing they were able to keep the same price for 15 years during the 70s and the first half of the 80s. Competitors have tried to copy their product. At one time they could count over 30 copies of Windex being sold worldwide. Windex was a cash cow.

In the beginning of the 1970s, a new project was started. This focused on a sailing boat available as both a kit or ready to use. Many new gadgets were featured in the design, including a folding wing-keel, safety-ladder, and bathing-platform among other innovations. When the boat, named Windex 92, was finally ready, the market had shifted its preferences from sailing boats to motorboats. There was a surplus production of sailing boats and the second-hand market was large resulting in low prices.

Windex 92 faced many obstacles — high price tag, production difficulties, and additional problems in distribution. Windex 92 never became a success. During the development stages potential customers and journalists were very much interested in the prospective product, but when RADAB finally had a commercially viable product to offer, the market did not respond. They saw the market launch of Windex 92 as a failure at RADAB but still, regard the product as a good internal success. Windex 92 represented the first attempt at RADAB to design and market the “home-builder-kit” and introduce it in the “do-it-yourself market”. The outcome was a financial failure.

In the mid-1970s, Ridder developed a variant of the wind-indicator suitable for wind-surfers. The product failed. Subsequent investigations determined that wind-surfers did not want any help in determining wind directions, or any technical gadgets predicting natural conditions.

The Development of the Motorized Glider

At the end of the 1970s, the owners were ready for a new commitment. Ridder, now a professor in aeronautical engineering at the Royal Institute of Technology in Stockholm, had the idea to design and build a revolutionary motorized glider. It is hard to pinpoint the exact date when the idea emerged. Ridder started to sketch on an aircraft 30 years ago and he held lectures at the local Experimental Aircraft Association² (EAA) Chapter 222 about his idea during the second half of the 1970s. This idea resulted in the first blueprints of an ultra-light glider with an eight h.p. engine and a total weight of only 64 kilos.

The glider started to take the form in the beginning of the 1980s. Ridder and Undén worked on the concept during their spare time. The aircraft, engine included, was planned to have the equivalent performance of a regular glider without an engine. From the beginning, their plan was to present an aircraft kit to presumptive buyers. The rationale was to keep a low price by simplifying the manufacturing process as much as possible. The owner's main interest has always been to develop new designs since they find the administrative and manufacturing parts dull and uninteresting. Bergström even suggested

² The *Experimental Aircraft Association* was founded in 1953, in the United States. It is an organization spread all over the world. EAA is divided into different chapters or groups. In the United States chapters can be found in different regions. Outside the United States, the common way is to have only one chapter in each country. In Sweden, the local chapter number is 222 and was founded on 20 January 1965. It is an idealistic organization that works for the members' rights to build and fly an amateur-built aircraft with the minimum of restrictions. They work with information and education, and act as the amateur builder's spokesperson toward the Swedish Civil Aviation Administration and other government agencies. They have a close relationship with the Flight Safety Department since EAA is responsible for preparing the application, including giving a suitability judgment, for each person who applies to build an aircraft.

that they would sell off the project when everything was worked out and they had a stock of orders.

The first sketch of the aircraft had a wingspan of ten meters. Ridder developed a new wing-profile that was tested at the Royal Institute of Technology. The wing-profile did not match the glider's performance profile. A second profile was developed, tested, and was found suitable for the glider. Ridder is explicit and up front with the fact that the project had been almost impossible to carry out without his connection to the Royal Institute of Technology. External organizations and individuals have supported the idea in various ways. The Aeronautical Research Institute of Sweden and the Royal Institute of Technology have made certain constructional tests possible. Another important group that has had some input to the process is Ridder's colleagues at the Royal Institute of Technology. In addition to the wing-profile, the stabilizer has been wind tunnel tested. An aerodynamic engineering student at The Royal Institute of Technology, as a degree project, carried it out. Ridder, based on his skill and experience in the area, designed the fuselage.

The formal start of the project was on 31 December 1982, when Ridder and Undén sent an application to EAA for permission to build an ultra-light glider with self-launching capability. Their application was approved and resulted in building permit number 354. About the same time a decision was made to incorporate the project into the firm. As they realized that the development would demand a larger workshop area, they also rented some additional space next to their present office. In 1984, they renewed their EAA application, this time changing category from *ultra-light* to an *experimental* glider with self-launching capability.

They worked on the technical aspects and developed a prototype, Windex 1100 that had its premiere flight on 15 March 1985. In most aircraft projects, the dominating episode during the development is the premiere flight of the prototype. Although most of the construction's specification can be calculated in advance, the flight test will give the final judgment on a design. Everyone involved noted with satisfaction that one "phase" that went smoother than expected was the flight-testing and evaluation.

The Windex 1100 prototype was built and cut out of foam with a laminated shell. It is a method used for short series of test-planes and prototypes, but is not suitable for the production of longer series. Ridder's urge for refining the construction, to make it optimal, resulted in additional adjustments after input from the test flights and development of a second prototype called Windex 1200. Modifications included a longer fuselage, extended wingspan, and T-formed stabilizer. In Windex 1200, the materials were no longer regular fiberglass and plastics but a structure of honeycomb and epoxy molded in an autoclave.³ After they developed a flying prototype, they applied for additional funding from the Swedish National Board for Industrial and Technical Development⁴ (NUTEK) to develop a commercially viable product. Requested by NUTEK, RADAB produced a marketing plan.

RADAB searched for, and found, a manufacturer in Sailcenter of Sweden AB, located in Ätvidaberg south of Stockholm. After completing each part, they sent the moulds (set number one) to the manufacturer. On 21 March 1988, when most of the moulds were completed and at the manufacturer, Sailcenter's factory burned to the ground. All parts were destroyed and a weakness in the development process emerged. When they started to reconstruct each part, they had difficulties finding the proper blueprints. They found different versions but had a hard time sorting them out. Questions emerged: Which version was the latest? Why had they done the adjustment? They had to backtrack and start over again. Naturally, they took the opportunity to make some additional adjustments to the concept, when they had the chance, and sent the moulds (set number two) once again to Sailcenter of Sweden AB.

Windex 1200 finally had its premiere flight on 27 April 1989. It is an interesting fact that although the constructions from Windex 1100 were supposed to just be refined in the final construction, no parts are interchangeable between the 1100 and 1200. A second pre-series kit

³ An autoclave is a sealed and airtight confinement, with the composite material covering a mould and "baked" under both high temperature and high pressure. The method imparts a very high and solid quality to the manufactured parts.

⁴ Known today as the Swedish Business Development Agency.

was built parallel to the W1200 prototype in the RADAB's workshop. The three external builders, among them the technical chief at EAA in Sweden, implemented additional modifications to the construction based on the prototype's flight evaluation. Their modifications included air brakes of new design, a larger main wheel, retractable supporting wheels in the wings, and additional fuel tanks in the wings, among other things.

Parts of the Windex 1200 prototype's flight evaluation were carried out in Florida. While there, they got in contact with Steve Coan, a professional aerobatics glider pilot. He tested the Windex 1200 and wrote a flight evaluation. Coan was so impressed that he ordered three ready-to-fly planes certified for aerobatics. RADAB did the additional calculations and when they found that the difference between the normal and aerobatics version was minimal, they decided to certify all planes according to JAR 22 A⁵ (Aerobatics Category). The second set of the Windex 1200 moulds that was sent to Sailcenter of Sweden AB included most of the modifications presented above. In addition, the wing spar was modified from all-glass to carbon fiber. The design capable of +9G/-7G even exceeded the demands for the aerobatics category.

At first, Sailcenter AB did not receive a general manufacturing permit from the Civil Aviation Agency (CAA). As a result, people from CAA needed to inspect each part on-site before signing an acceptance certificate. Since it was not practically possible to let the CAA representatives inspect all parts at the same time, the process was considered too costly for RADAB. In 1991, NUTEK raised questions regarding the potential sales volume and money invested in the project. Over time, new people entered the decision group at NUTEK. Some of them entering in the later stages, raised questions why NUTEK invested money from the start. At that time RADAB was financially overextended. They let go of their employees in order to shrink the organization, thereby minimizing their costs due to a drop

⁵ 1 G is the normal earth drag-coefficient. Gliders that are built for normal use according to JAR 22 (Utility) have limits of +5.3 and -2.65 G. The aerobatic version is limited to +7 and -5 G. As a reference, a normal person can handle +3 to +5 G before they lose their vision and start to become unconscious.

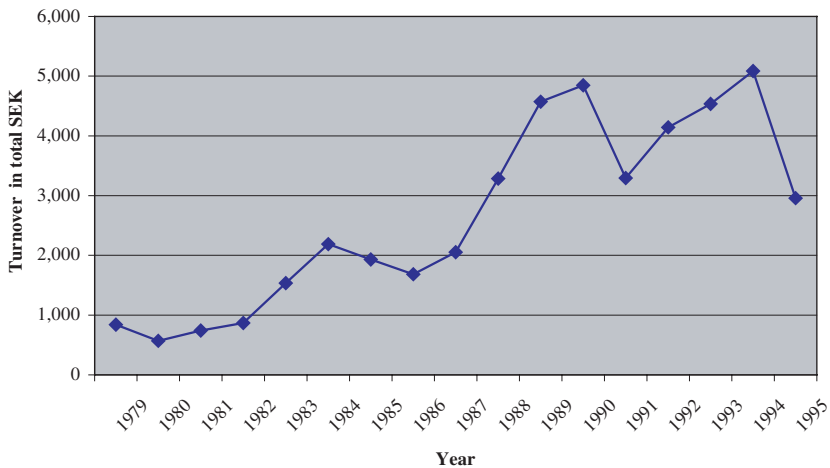


Fig. 1. RADAB's turnover in total SEK between 1979 and 1995.

in turnover, as can be seen in Fig. 1. (The yearly profit margin is of little interest since the owners have decided to reinvest most of the money in new ideas and projects.)

After downsizing, the CEO, Undén, was the only one still formally working at RADAB. The same year RADAB delivered 4–5 Windex 1200 kits, thereby raising new capital. They also applied for an additional 500,000 SEK loan at NUTEK for the development of the wing coupling and additional adjustments to the construction. Over time they have also worked at making the kit easier to build for the prospective buyer by applying new technical solutions like abrasive water cutting and drilling.⁶ The adjustments have mainly involved refining the cockpit module thereby simplifying and shortening the building time for the buyer. It is notable that even if the motorized glider was an idea that Ridder had nurtured for a long time, he kept his regular job as a professor at the Royal Institute of Technology throughout the project.

⁶ Abrasive water cutting uses a beam of water under such an enormous pressure that it can cut through metal. Since the method is using plain water there are no residues. Another advantage is that the method is "cold". The part will not be heated in any way that might cause additional labor in later stages of processing.

International Movements

Bergström's relocation to the United States in the early 1970s due to medical reasons has probably helped all parties at RADAB to see things in a more global context. They have, throughout the process, been looking for solutions to their problems — both domestic and international.

Their reason for involving companies in other countries in the development process can be derived from numerous factors. First, the way the Swedish CAA wanted to examine and test all parts would cost too much, they had to work around the problem. Second, due to economic constraints, NUTEK forced them to manufacture ready-to-fly aircraft. The reason behind this was that it would get the aircraft out on the market faster (no building-guide necessary) and they could aim at a higher profit margin. Third, it was not possible to find a company in Sweden with either skill or equipment suitable for this kind of production. Since the certifying-process, JAR-22, is accepted in most countries, including Sweden, they could bypass the certification problem by going abroad. They contacted *Szybowcowy Zakład Doswiadczalny* (SZD) in Poland, mainly for three reasons. First, SZD is a large glider manufacturer with a vast experience in certifying gliders. Second, when the gliders are certified in Poland the planes together with all parts are also certified in most Western countries through a rather simple transfer process. As a result the kit, as well as the ready-made plane, would be approved in Sweden by CAA/EAA. Third, Poland holds, relative to Sweden, a low salary level thereby making the total production costs lower.

After negotiating a contract with the Polish manufacturer they started to experience vast communications problems. No one answered the faxes they sent. When they phoned and asked about the progress in testing and manufacturing, the answer was “good” and “looking fine”. When they later visited the factory, they started to realize that it was not true. When they demanded all the facts about the process from the SZD personnel, they were asked for more money. Returning to the written contract to find support for their claim of negligence and not fulfilling the original intentions, they

found that no stipulated deadlines were included. After additional efforts to bring the cooperation back on track without success, RADAB decided to terminate their business with SZD. No legal actions were taken and RADAB solved the dispute by buying back their parts for, as the CEO put it, “a rather small fee”.

In 1990, RADAB started to focus on setting up a suitable sales organization for the Windex 1200. They established ARACO — a sales company in United States managed by Bergström. This was done for two reasons. First, the US market is the largest in the world for this kind of products. Second, due to liability reasons, they decided to separate the marketing and selling of the Windex 1200 from RADAB. Their problem with the certification process still remained. Due to their international recognition in the 1991 Aerobatics World Championship where the glider took bronze-medals in two categories, they had some prospective partners, this time in Austria. A former engineer at one of the Austrian glider manufacturers wanted to start his own firm, and saw the production and certification of Windex 1200 as an interesting part to his business concept. The venture was never carried out. Others were interested in becoming an agent for the Windex 1200. In 1992, they started to negotiate with a representative in Great Britain. During 1994, the Briton started building his own kit to have as a demonstration plane.

The Engine

Parallel to the development process of the glider, RADAB was searching for a suitable engine. It turned out to be a long and difficult endeavor. The market for small efficient engines in the area of 25–35 h.p. seemed to be almost nonexistent. In addition, the concept of applying an engine in the back of the plane added many constraints to the engine-construction. It had to be a very light and effective engine. It also had to have a sleek design, to uphold a good aerodynamic performance. Their search led them to the König engine from Germany, a three-cylinder star engine with an output of approximately 20 h.p. The star configuration was not a suitable design in this case, and the performance was not enough to get the plane off the ground

made inquiries in Czechoslovakia about future production facilities for the engine.

Ridder's theoretical background and Jonsson's background in racing and tuning motorcycle engines resulted from different opinions regarding the engine design. Ridder wanted a sleek design with no excess weight. Jonsson argued for a more traditional and robust construction. Their different viewpoints resulted in not only Ridder, but also Bergström, objecting to RADAB paying S&T Verkstads AB.

The CEOs Problem

At the next board meeting at RADAB, the question was raised whether or not to continue to financially support Jonsson's engine development. What should Undén do?

Appendix A

Technical Note

The development of an aircraft can follow different certification procedures. For those aiming at producing a complete and ready-made aircraft, you have to certify the aircraft according to some of the Joint Airworthiness Regulations (JAR) or equivalent; JAR-22 for gliders, JAR-23 for motorized aircraft, etc. These regulations state how things should be done and how it should be documented in order for the Civil Aviation Agency (CAA) to give their formal approval.

Another way is to build the aircraft as an ultra-light or experimental aircraft according to the regulations of the Experimental Aircraft Association (EAA). By doing that you agree upon the fact that the future customer will build more than 51 percent of the aircraft him or herself and that you as a producer only can deliver a kit that the builder has to complete. By doing so the builder is also accepting the responsibility of liability of the product. Due to the increased liability problems in the US, manufacturers like Cessna and Piper have experienced huge problems. This situation has made it possible for a number of new manufacturers with new ideas and new technology to

enter the market. It is reasonable to say that it is the kit manufacturers that have been the driving force within the industry during the last 20 years.

Materials

An aircraft can be made out of traditional materials like wood and metal, but over the years the dominating material have been some sort of composite material. This have made it possible for more advanced and complex designs since the shape of the part is formed in a mould and gets the final form straight away instead of carved or hammered into the right shape. Performance has as a consequence been increased in a radical way.

Among the different techniques of building an aircraft out of composite material, the use of an autoclave is among the more extreme, since not many companies have the equipment needed for large aircraft parts. In this case, the production process is based on Prepreg, a pre-impregnated glass fiber with epoxy resin and Nomex honeycomb (a polymer similar to Kevlar). The Prepreg and Nomex honeycomb is applied in the mould and on top of the carbon fiber material a plastic film material is located. This film has vacuum air canals, which facilitates vacuum being established between the film and the laminate. The mould, including the laminate and plastic film vacuum bag, is entered into the autoclave and is cured in 90 min at a temperature of 120°C with a pressure of 2–6 bar to the outer side of the plastic film.⁸

Aircraft Engines

The aircraft engine can, as well, be divided into two categories. The first would entail reliance on engines equipped in small commercial planes such as the Cessnas, Pipers, or others. These types of engine have different back-up systems like parallel ignition systems, the use of low rpm and horsepower compared to engine volume, etc. This type of engine has to be serviced by a certified aircraft-engine engineer at

⁸ <http://www.sailcenter.se/info.htm>. October 2001.

certain intervals in order to keep the aircraft airworthy, but one is allowed to use the aircraft commercially and take passengers.

The other category of engines entails those that can be serviced by the owners. This category of engine is not allowed to be used in commercial flights, and when it comes to motorized gliders, the engine should always be looked upon as a support function. The pilot should still behave as if he was flying a pure glider. Even if that is what is stated in the regulations, today's engines have proven to be highly reliable. Many of them are, in fact, converted car engines.

Technical data of the Windex 1200⁹

A complete 3D view of the Windex 1200C can be found on the next page, Appendix B. A complete Windex 1200C kit with costs of 39,300 Euro divided into following subparts:

Fuselage kit	14,600 Euro
Fast built wing kit	16,300 Euro
Engine ¹⁰ and propeller unit	8,400 Euro

⁹ <http://www.windex.se>, October 2002.

¹⁰ The König SC-430, 3-cylinder engine has a displacement of 430cc and delivers 20 h.p. at 4200 rpm. The weight is 13.8 kg (30.4 lbs).

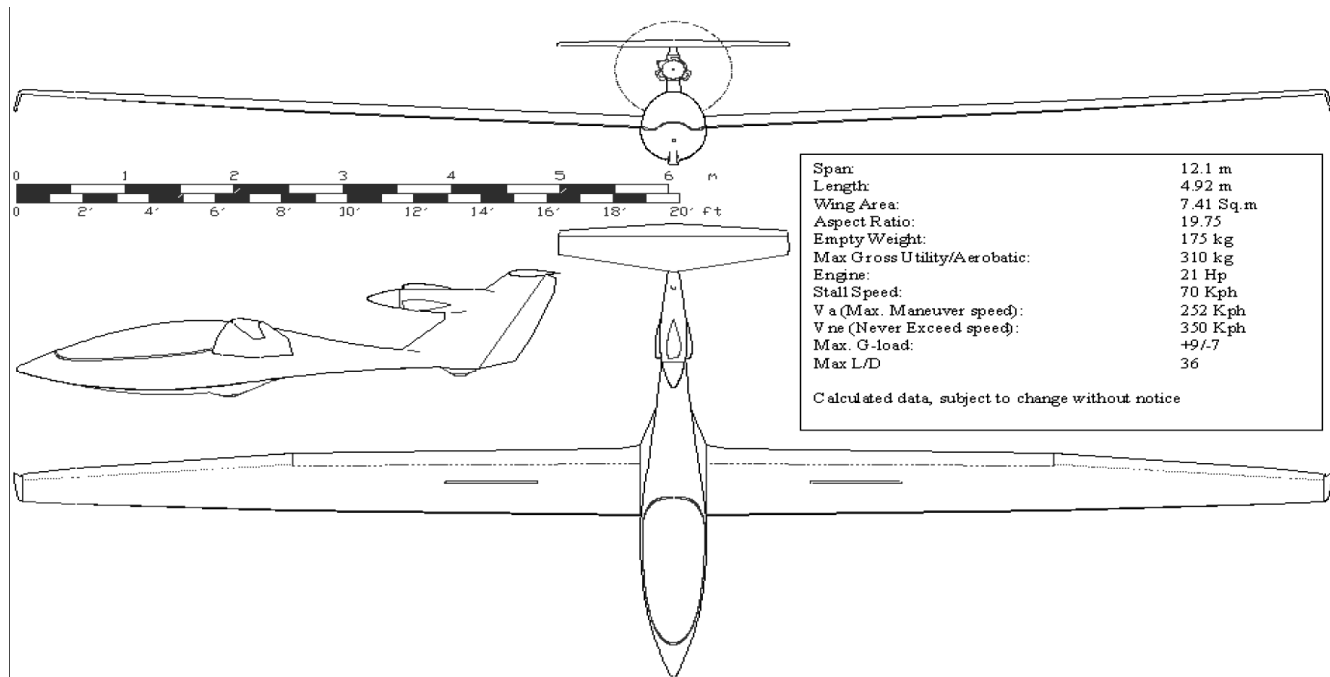
on high altitude and in warm climate. They took the strategic decision to develop their own engine, a major undertaking by itself. Undén even acknowledged that it would probably demand at least 50 million SEK⁷ to “do it right”. Ridder found it interesting to experiment with a new engine design, but in the end the new concept did not work satisfactorily. The representatives at NUTEK had doubts, and tried to talk them out of the idea. They even gave them support and advice through consultants on engine construction.

Through common interests in aircraft and composite materials, RADAB got in contact with Bertil Jonsson at S&T Verkstads AB outside Stockholm. Bertil Jonsson has a history in tuning engines for racing and renovating motorcycles. He has worked with a variety of things like ultrasound as a tool for cleaning parts, different types of painting techniques like thermo, electrostatic, plasma painting, and diamond coating. Since 1955, Jonsson also holds a glider pilot license. His first contact with the Windex aircraft was when he and his wife, in the beginning of the 1980s, attended a fair named Älvsjömässan, where the Windex 1100 prototype was exposed. The comment to his wife was “I’m going to have one of these!”

Jonsson had a mutual understanding with Ridder and when he heard that RADAB worked with carbon fiber, he contacted them. He met with Undén and Ridder and they started to talk about the specifications for an engine suitable for the aircraft. Jonsson found that they needed a special kind of engine and realized that it would involve certain problems. After the first meetings, the contact was mainly upheld via Undén. Jonsson started working on the project on pure interest, and helped RADAB develop a more conventional three-cylinder engine. After a while RADAB started to partially cover him for his costs, but their mutual understanding was that the major part of the development costs would be paid as a commission fee on each engine sold. The three-cylinder 300 cm³ engine produced approximately 26 h.p. With larger cylinders that later were introduced on the market they planned to improve the performance to at least 30 h.p. During the same period they also

⁷ Fall 2002: 1 Euro equals approximately 9,20 SEK.

Appendix B. A Complete 3D view of the Windex/200.



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Anderson Research Institute: Marketing of a New Technology¹

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In January 2000, Bill Anderson, founder and CEO of the Anderson Research Institute (ARI) was reviewing all the market and product studies that highlighted the advances made to date in using chemical procedures for medicinal chemistry. While reassured by the findings, Mr Anderson realized that coming out with a commercial product was an important “first” for this pure-research company, and he was anxious that each detail should withstand careful analysis and scrutiny. Mr Anderson had also been plagued with numerous calls in recent

¹ This case was developed by Anusree Ganguly, PhD, Associate Professor of Chemistry at Ohlone College, Fremont, California and Shekhar Somanath of Qualcomm, Inc., Campbell, California for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

days from biotech companies asking for additional details on the scientific research being conducted at his institute. He had undertaken research to bring himself up-to-date on the Institute's possible first entry into the commercial biotech market. It was late in the evening as Bill Anderson, founder and CEO of Anderson Research Institute, hung up on the phone with the CEO of Envirogen, their long-time partner, asking him about a modified literature process on the synthesis of neutral amines of boronic acids. This was a chemical procedure developed at the Anderson labs that was modified drastically from a procedure described in the early 1950s in the chemical literature. "There's money to be made in this!" was what Bill muttered to himself as he walked out of his office into his car, preparing for his hour and a half commute back to his home in Northern California.

Background

Anderson Research Institute was a small institute focusing on fundamental and applied research in the areas of medicinal chemistry. In the late 1990s after a very successful career in academics, which ended in a full professorship at a very well-known university in Northern California, Dr Anderson decided to cash out some of his investments in the stock market which had given him incredible gains over the last 30 years. This investment was used in collaboration with his university to start the Anderson Research Institute in 1997. Cofounder Dr Richard Newman, who worked with Bill Anderson, developed the initial patents that composed the institute's technology base. ARI from the beginning had been successful in tapping the private investors and federal government for funds to continue its operations and research activities.

The institute employed a modest crew of about eight post-doctoral workers and research scientists from all over the world and a team of three lab technicians. Bill had toyed with the idea for a while now of marketing a few of the chemical reactions developed in his lab, which seemed very popular, judging by the inquiries from other labs that kept coming to him regarding the methodologies he used. Not a businessman by a far stretch of the imagination, Bill's initial interest

in documenting and marketing this technology was to escape this everyday nuisance of pestering phone calls/letters/e-mails from other scientists trying to process these products in better and purer yields. Much later did he realize what a huge lucrative potential this idea held for his institute.

Industry History

A hot area of chemical research then and now, a common area of investigation in bio-organic chemistry, deals with the lab synthesis of chemical compounds which mimic, or are “analogs” of naturally occurring compounds in the body, but with a slight modification. These chemical mimics can be of various types such as analogs of DNA bases, certain enzymes, carbohydrates, nucleotides, nucleosides, or porphyrins. All these chemicals are classes of compounds that are used in the day-to-day biochemical cycles in the body. By creating a slight modification in the structure of the synthetically created analog, the aim is to confuse the body between the natural substrate and the synthetically delivered compound and thus inhibit the further processing of this compound in the body for an end goal which is often therapeutic in nature. A good example of this type of work is the development of a class of boronic-acid-based inhibitors of protease enzymes which were developed in the early 1970s, and since then have remained the subject of many chemical investigations. In the last 50 years, there has been a significant amount of interest to incorporate the element boron in biologically active molecules.

The most recent generation of such boron compounds exploit biochemical pathways to accumulate boronated biomolecular analogs inside cells as exemplified by the tyrosine analog, L-4-borono-phenylalanine (BPA). BPA is one of the lead boron containing clinical compounds to treat glioblastoma multiforme (a form of brain cancer). BPA mimics L-tyrosine (the body’s natural compound) in the early stages of melanin synthesis and in this way although is accepted by the body in confusion, is not further metabolized and it accumulates in melanoma cells, thus providing concentrations of boron high enough for effective treatment. Another interesting application for

biomolecular boron derivatives comes from the application of these boron-based compounds as “transition state” analogs for enzymes. Transition state analog inhibitors are compounds whose structure (or the resultant structure upon binding to an enzyme site) resembles that of the postulated transition state of the reaction that the target enzyme catalyzes in the body. Since the designed inhibitor does not undergo the conversion that the natural substrate would, the enzyme and the inhibitor are locked at the transition state and thus the action of the enzyme is inhibited. In cases where the inhibitor contains boron, if able to travel and localize selectively in tumor cells, this provides for great use for BNCT (Boron Neutron Capture Therapy) treatment and can be effectively used in the chemotherapy regime.

The Technology

Amines are basic functional groups in organic chemistry. Any compound containing this basic amino ($-\text{NH}_2$) group is called an amine and is named using the prefix “amino”. Thus, an amine of a boronic acid is called an amino boronic acid. The technology that was in question was the synthesis of neutral amines of benzene boronic acids. Based on the figures shown below (Fig. 1), depending on the position to which these amino groups are attached to a benzene boronic acid, we can generate three popular amines which are the *ortho*-amino benzeneboronic acid (Fig. 1(a)), *meta*-amino benzeneboronic acid (Fig. 1(b)), and the *para*-amino benzeneboronic acid (Fig. 1(c)).

Amines of boron-based compounds are vital components of medicinal chemistry research wherein the element boron is retained in a molecule so that its unique properties can be realized. These amines have been used as precursors for the synthesis of a class of compounds known as benzoxazaborines and benzodiazaborines which are compounds which have been used as model systems in the design of new, potentially bioactive analogs of naturally occurring substances where the element carbon is replaced by boron. There is ample precedence that analogs prepared by this strategy can possess

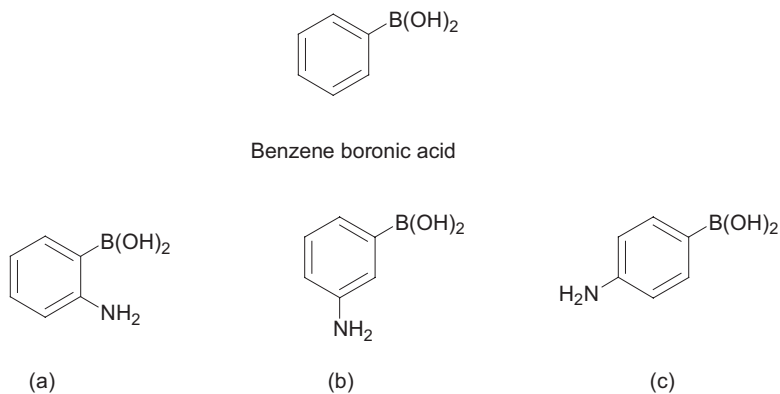


Fig. 1. Three popular amines.

unique physicochemical and useful biochemical properties. Research in this area capitalizes on the fact that a boronate molecular fragment is an exceptionally close mimic of natural enzyme function and is very useful for protease (enzyme) inhibition. “We also find these boron compounds as potential antituberculosis agents and also in strategies that greatly improve the anion binding ability of neutral urea-based receptors in the body”, said Dr Newman in an earlier interview. Quite a few boron compounds have shown considerable promise in that area. These days one also sees applications of boron-based compounds as nucleoside analogs (i.e., compounds that mimic parts of DNA). These applications bring with them tremendous therapeutic applications.

Other applications of boron-based compounds are found in fluorescent probes in biochemical, biological, or even medical diagnostic applications. In all or most of the syntheses of the boron compounds described above, there is a need to manufacture an appropriate amino boronic acid either as a precursor chemical or as a key intermediate to lead to these exciting end products. Thus, neutral amines of these boron compounds are always in high demand because a good synthetic route to these chemicals involving lower costs and higher purity can attribute to a significant increase in quality and ease in the overall synthetic route to these boron end products.

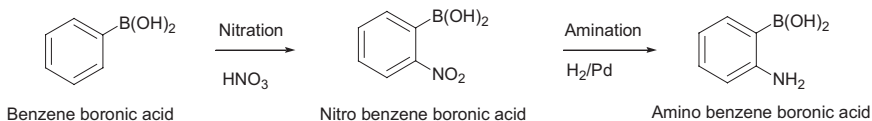


Fig. 2. Synthetic strategy.

The synthetic strategy in general involves the basic reaction scheme, as shown in Fig. 2. The technology that needed to be marketed was the synthetic route to these amino boronic acids produced in a high yield and a high purity. Although it is only the general reaction scheme that has been shown in Fig. 2, slight modifications to this general reaction are sufficient to afford the three amines, *ortho*, *meta*, and *para* amino boronic acids, in high yields and at a very reasonable cost. Note that the starting material, benzene boronic acid is bought commercially and at a very low cost, adding to the economic feasibility of the process.

In the Anderson Research Institute, the procedure for these amination reactions had been well established for quite sometime now. This procedure adapted in the Anderson labs involved a modification (introduced by Anderson scientists) of a very old general literature procedure. Although Anderson scientists have been able to work out this modification to a point that the process is duplicable and can be reproduced quite reliably, obviously other scientists were having difficulty following this same protocol to generate the pure amines in a pure form especially in large amounts. After many coaching sessions (via telephone and private consultations) other labs were able to work out this technology but not with the same ease and proficiency as the Anderson chemists. Follow-up discussions by Anderson scientists with other labs led to the conclusion that the problem lied in generating neutral forms of the amines. Other researchers would often come up with the salt form of the amine, shown below (Fig. 3) whereas what was actually required were the neutral amino boronic acids.

The fact that the Anderson researchers actually had the neutral form and not the salt form was further verified using a variety of characterization techniques such as NMR (Nuclear Magnetic Resonance),

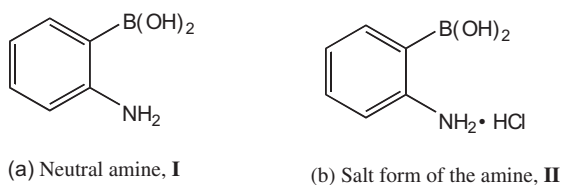


Fig. 3. Neutral and salt amines.

MS (Mass Spectroscopy), and Elemental Analysis. NMR is a technique which shows two completely different signals and analysis patterns for an NH_2 group as in **I** and an $\text{NH}_2 \cdot \text{HCl}$ (amino salt) group as in **II**. Mass Spectroscopy is a technique by which one can measure the molecular weight of a compound. The mass of a neutral amino compound such as **I** is clearly lower than that of **II**, due to the fact that **II** has an extra HCl group associated with it. Elemental analysis is a technique that confirms the percentage of atoms in a compound. Clearly, **I** would have a lower percentage of H and an extra Cl atom as compared to **II**. By all of the above mentioned tests, the structures of the amino boronic acids made in the Anderson laboratories were confirmed to be having the neutral form and not the salt form which other labs consistently kept coming up with. This led to the realization that the technology to make these amines in the neutral form was not clearly available either to the scientific community or in the commercial market. This technology was something that could clearly be very attractive to the biotech industry also sold to the scientific community.

Borotron

Many drug-delivery companies had looked at creating an amino boronic acid substrate (Borotron), which had the attractive features of being non-reactive in the body and also be able to store relatively large quantities of drug for slow release. This was particularly found to be useful due to their potential medical and biochemical applications, such as use of boron compounds for BNCT of certain cancers and as enzyme inhibitors. BNCT is a binary therapeutic strategy based

upon the neutron capture reaction observed with a ^{10}B nucleus and a neutron flow of low kinetic energy (thermal neutrons). Boron naturally exists as two isotopes ^{11}B and ^{10}B occurring in an 81.17 to 18.83 ratio. The latter having a cross-section of 3850 barns (1 barn = 10^{-28} sq.m), efficiently captures low energy neutrons, and this nuclear fission reaction produces both ^4He and $^7\text{Li}^+$ nuclei along with about 2.4 MeV of kinetic energy and weak gamma radiation. Since the energetic and cytotoxic product ions travel only about one cell diameter in tissue, one may specify the cell type to be destroyed by placing innocent ^{10}B nuclei on or within only the doomed cells. Thus, BNCT is a therapeutic method that selectively destroys malignant cells in the presence of normal cells, a highly valued goal of oncologists.

ARI's research involved the synthesis of a class of such boron compounds which were intended for testing as "transition state" analogs for a critical enzyme in the body. Each of the members of this class (called chemical "targets") were synthesized by a complex multi-step synthetic procedure, however the key synthetic intermediate for this entire class was a common compound. This compound was an amino boronic acid, which is an amino group attached to a boronic acid commonly referred to as Borotron in the medical community. The target markets for ARI's technology were patients with different kinds of carcinoma requiring advanced medical treatment. However, the Borotron could also be effectively used to develop medicines for the treatment of tuberculosis and inflammatory conditions of the intestine.

The Strategy

Given the current climate in Federal and State funding for research, Bill Anderson was well aware of the fact that their rather generous federal research fund that supported most of their research projects could be the next target of a federal cut in that area. Besides, the stock market crash did not make it easy for Bill to keep a steady supply of dollars coming in as before. It was never Bill's intention to convert his institute into a business center. However, under increasingly difficult economic times, he saw no harm in making some extra money by

selling their intermediate substrate directly to pharmaceutical and biotech companies or to sell their technology to chemical and biotech companies either as a lump-sum source of income or as a steady source through royalties.

Anderson figured that with the overwhelming interest shown by the biotech companies in the work performed at his research labs, an attractive overall strategy could become a “virtual” company that took its products far enough into development to create value without building huge operating infrastructures. As stated by Bill Anderson, the lab’s CEO, the company strategy would be simple. Instead of creating a big corporate infrastructure, the company would minimize costs by hiring a handful of experts to oversee work in key areas and then outsourcing most of the actual work. By curtailing its expenses, ARI could generally minimize its need for capital.

While ARI had performed only primary research in the past at their labs, given the significant market potential for their substrate, Bill Anderson was contemplating what the best approach to commercialize the product would be. While the idea of going to market with the product directly seemed very attractive, he was aware that ARI would have to build the necessary infrastructure and organization to build the Borotron product on a mass scale. Bill realized that he would have to farm out a lot of work, in addition to maintaining its own staff of researchers and some support personnel, and also build core management competencies by hiring additional business and functional area managers. In addition, he would have to generate significant capital and raise funds to invest in facilities, equipment, production, personnel, marketing, and sales force. ARI had neither the capital nor the marketing organization to launch Borotron. Therefore, Bill Anderson felt that the best approach for the company would be to look for a partner that would contribute cash and marketing expertise in exchange for a share of profits in a joint venture.

The Opportunity

In early 2000, ARI was approached by Envirogen’s management team to form an alliance for using Borotron in their enzymes and cancer

treatment drugs. Envirogen and ARI had had a long-term relationship. Besides the fact that Dr Newman served as the technical advisor on the boards of directors at Envirogen, Robert Duffy, the founder of Envirogen, had performed joint research on leading edge technologies involving substrates with Bill Anderson during his academic affiliation. In addition, Envirogen was testing the use of the Borotron compound in a cancer drug that was under development. This in fact was what prompted Robert Duffy to understand the full potential of using the boronic substrate in Envirogen's products and the technological lead it would gain by acquiring access to this technology.

Envirogen Corporation

Envirogen Corporation, based in Santa Clara, California, was the fifth largest biotech company in the United States. The company's sales reached \$300 million in 2000 through researching, developing, manufacturing, and marketing products for human health care. Envirogen also had its roots in the academic environment, having been founded as an enzyme-manufacturing company in 1992 by Robert Duffy, a Stanford University scientist whose vision was to develop enzymes with natural substrates for use in diagnosis and therapeutic treatments.

Envirogen had a number of products in their pipeline and this diversity allowed them to play a leadership role in a broad range of cutting-edge technologies and therapies, according to Don Philips, their CEO. The wide array of technologies provided Envirogen with an excellent platform for achieving breakthroughs in major unmet medical needs. Rather than to concentrate efforts on the next big hit, however, the company had decided to manage its R&D like a portfolio by outsourcing innovations through partnerships. Envirogen's strategy was to supplement its internal R&D with strategic alliances with external companies in order to access high-quality products in late-stage development.

Envirogen had grown rapidly through the innovative use of joint ventures and alliances. The joint venture with ARI was attractive to Envirogen for several reasons. In addition to the benefit of increasing

earnings through the rapid introduction of new and effective drugs using Borotorn, the joint venture would represent an excellent fit for Envirogen's specialty substrate therapeutics and allow the firm to tap new markets. Also, building a strong partnership with ARI might enable Envirogen to strike the same kind of deal for other derivative products. ARI was also rumored to be working on another substrate using their patented technical process that was targeting a much larger segment, the multibillion-dollar market of anticholesterol drugs.

The Market

In 2000, there were nearly two million patients in the United States with different forms of carcinoma. Of these, an estimated 500,000 required some form of therapeutic treatment to survive. All of these patients were candidates for the BNCT treatment, which was easily facilitated through the use of the Borotron substrate. The US cancer-patient population had grown at a compounded annual rate of 8 percent over the last 10 years, driven by multiple factors. Europe had roughly 500,000 patients who could be candidates for the BNCT treatment, with the population growing at approximately 6 percent annually; the Japanese market had roughly a population of 200,000 cancer patients, growing at the same rate as the European population.

In discussions with Dr Newman the previous evening, Bill figured that besides the cancer treatment market, since the compound could find application in the development of drugs for tuberculosis and other therapeutic applications, the total potential market for use of Borotron was much more than what was covered by Envirogen. Bill figured that he would have to assign one of his staff to perform a quick market research study to understand the potential for Borotron in other key markets. At the back of his mind, Bill was wondering if it was possible to negotiate a non-competition clause with Envirogen just for the cancer drug market while having the ability to pursue other drug manufacturers for use of Borotron for different kinds of drug development.

Competition

There was only one drug approved by the FDA for cancer treatment using BNCT. This drug was developed by Crystal Pharmaceuticals and did not employ the boron amino acid in its purest form. There were several drugs under development for the treatment of cancer using boron isotopes. However, most of these products were in an early stage of clinical development. Thus, we are looking at a monopoly in this particular market, at least at the present time.

There were at least 50 research labs in the United States working on advances in pure science, with most of them being affiliated with universities. Although a third of them were focusing on developing chemical substrates and their derivatives that could be used in medicinal applications, Bill was not sure how many of the research labs were focused on boron amino acid research or alternatives to that. However, he was aware that a few of the top biotech and pharmaceutical companies were spending a lot of time and money on developing a similar compound since it had potential applications in a number of drugs. At best guess, Bill thought at least the top six biotech companies might be interested in using a compound like Borotron in drug development. However, he was not sure if any of them had affiliation with other research labs and were testing the use of similar compounds in their drugs.

Opportunities and Risks

Patents are key to protecting technologies, processes, and products. ARI had received a few US patents for the technology and manufacturing process of Borotron, as well as for a broader class of boron amino acid binding agents. After having successfully completed phase I and phase II trials of a cancer drug under development using the Borotron technology in collaboration with a biotech company, ARI had announced, in late December 1999, positive preliminary results from a phase III study that encompassed 125 patients at 10 different medical centers. Thus, ARI had actual clinical studies to support the sale of its Borotron-based compound.

Products in the biotech industry were characterized by many unique features, which made them difficult to value. Once a product was marketed, the revenues, costs, and product potential could be estimated with comparative ease. However, given the long time frame between idea inception, regulatory approval, and product marketing as well as the small number of ideas that ultimately resulted in a marketable product, biotech drugs were subject to numerous uncertainties. There were three major risk factors in each pharmaceutical/biotech development project: the probability of clinical success or failure at progressive stages of development, delays in the development and approval process, and uncertainty of the future revenue stream (if any) of the resultant product.

Since the cancer drug undergoing tests using the Borotron isotope was almost close to completing Phase III tests, there was a higher probability of that to move on through FDA filing to FDA approval to final launch. This presented an immediate opportunity for ARI to start negotiating with Envirogen for marketing its technology. A brief outline of the drug approval process is described in Fig. 4.

One feature of the biotechnology industry that made it hard to realize the potential value of organic research and the use of compounds in drug development was the complexity of the product life cycle. Only after the FDA approved the drug would the actual value of compounds that went into manufacturing the drug be effectively evaluated. To evaluate the clinical risk of a biotech drug, one could consider its stage of clinical development and its probability to make it to the market.

As a drug progressed through the different clinical stages, the revenue stream generated through market launch drew closer. Although it took several years for a drug in Phase III to reach the market, the probability of success increased with each step. The uncertainty surrounding FDA approval was compounded by the impact of changing regulations and governmental policies as well as by the arrival of

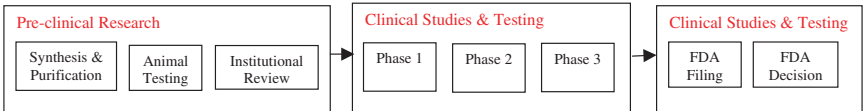


Fig. 4. The FDA drug approval process.

competing compounds. With regard to the drug using the Borotron compound, an expeditious response from the FDA would occur one year after filing, that is, in 2001. Because of the encouraging results of Phase III studies, ARI believed that cancer drug using Borotron could be launched in the United States at the beginning of 2001. The team assumed a 20 percent probability of a one-year launch delay in the United States (and therefore in Europe) beyond those dates and a 10 percent probability of a two-year delay.

Market Success

Once a drug received FDA approval, uncertainties remained concerning its market success. Depending on market conditions (e.g., competition, health-care policies, and market need), the average life cycle of a biotech drug was estimated to be around 12 years, with the peak penetration rate reached within the first five years. Drug sales generally peaked between Years 4 and 6 after market launch and started to decline by Year 7 because of the entrance of new or improved products. Currently, there was no serious competition for Borotron in the cancer therapeutic market, but many research labs were working on alternate substitutes for the boronic amino acid substrate. For Borotron, the team projected (conservatively) that the life cycle of the drug would be as low as 10 years and as high as 20 years.

Because many factors varied predictably with the volume of sales, the primary variable forecasted was the cancer drug revenues. Once approved for the US market, the drug was expected to enter the European market the following year. It was estimated that 80 percent of the US market would be eligible for the drug, while this ratio might be lower (60 percent) for the European market. Many factors were expected to influence revenues.

- *Peak penetration rate in the market:* Based on different marketing analyses reports, it was expected that the peak penetration would be 50 percent at Year 5.

- *Price per patient:* The annual price of the drug per patient would depend on many things, including how many pills the patient used and competitive pressures on the price that could be charged for the pill. The Envirogen team figured that they would be able to derive \$1,000 as the average annual price per patient. The team members decided to use the average industry gross profit margin of 70 per cent for their analysis and it could be argued that the Borotron compound played a critical part in the efficiency of the drug.

The Decision

Bill Anderson was pondering about what other benefits ARI could derive from being able to market their substrate technology to Envirogen, in addition to having a recurring source of cash payments for using their process. He was clearly eager to conclude a deal and launch the venture with Envirogen. However there were certain questions that still needed to be answered before he met with Robert Duffy and his executive team the next morning.

1. Was technology licensing the best commercialization approach for a small research lab like ARI?
2. Should ARI be considering commercializing the technology process and Borotron, by developing a business on their own?
3. What factors should Bill Anderson be considering when he meets with Robert Duffy?
4. What was the likely enterprise value of the joint venture for ARI? This estimate would need to reflect the risks inherent in investing in a drug not yet approved by the US Food and Drug Administration (FDA). Also, the joint-venture team would need to determine the best way to value a business with no operating history and an uncertain future.

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Flatplains Robotics International¹

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Mike Woods, the president and CEO of Flatplains Robotics International (FRI) and his vice president of engineering and sales, Jim Smith, were driving back to their offices in rural Wisconsin from a major industry trade show that was held for the past seven days in Chicago at McCormick Place. This was a very important trade show for these two executives. It brought together the latest technology in their field of electronic medical equipment. Such equipment is used in major research hospitals all over the world. The trade show was an important part of FRI's sales and promotional effort; it also helped

¹ This case was developed by George Tesar, Umeå School of Business at Umeå University and Sibdas Ghosh, Department of Natural Sciences and Mathematics at the Dominican University of California for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

FRI's top management understand who their competitors are. Both Mike and Jim left the trade show in a state of shock.

In addition to their standard seminar presentations on the latest various topics of design and development of components in the electronic medical equipment field, they had discussed their engineering expertise with the visitors to the trade show. To reinforce their engineering skills and capabilities, they featured a prototype of a universal robot in their relatively modest booth.² Mike and Jim alternated in guiding the robot in their booth, performing various simple maneuvers, and frequently approaching visitors by talking with them through the robot's remote audio system. This year, many of the visitors paid more attention to the talking robot than to Mike's or Jim's computer-based presentations outlining their engineering know-how. Many visitors found the robot to be interesting and potentially useful. A number of them even proposed various potentially ingenious applications for the robot in actual work-related situations.³ The universal robot was an unexpected success for FRI. What especially bothered Mike on the way back to the office was the offer they received from a subsidiary of a large German electronics firm.

A team of representatives from the German subsidiary attending the trade show stopped at FRI's booth to discuss the possibility that its subsidiary would be interested in purchasing many of these universal robots from FRI and would market them under its own brand name. Before Mike was approached with the actual offer, he noticed that a number of visitors were watching their robot for extended periods of time over the past two or three days. Now Mike realized who they were. Both Mike and Jim agreed that this was indeed an interesting offer for FRI. Although Jim was not necessarily disturbed by the offer, he was uncomfortable with the conditions that the representatives of the German subsidiary placed on the offer.

² A robot is defined as "... a machine that looks like a human being and performs various complex acts (as walking or talking) of a human being". (*Merriam-Webster's Collegiate Dictionary*, 10th Ed. Springfield, MA: Merriam-Webster, Incorporated, 1999).

³ Engleberger, JF (1980). *Robotics in Practice: Management and Applications of Industrial Robots*, with foreword by Issac Assimov. New York: Amacom. A classic publication on robotics and robots (note by the author).

The representatives of the German subsidiary suggested that before any marketing agreement could be signed, they wanted to review all available design and testing documentation concerning the prototype, including the summaries of all trials where the prototype was tested independently by a potential client in the client's facility, or when the prototype was tested by an independent testing laboratory such as UL.

Jim felt that these conditions were unreasonable and unrealistic. Mike maintained that with some imagination, these conditions could be met. Since Tom Cort, their vice president of marketing, was not in the car with them, they were concerned about his reaction to the offer. Tom is a careful, very analytical manager, well trained in marketing and product development. He believes that reliable and extensive information is needed before any sound strategic corporate decisions can be made. Although Tom was at the booth when the offer was made to Mike, he did not react to it. Instead, he continued to discuss business with one of their important clients. Shortly after the offer was made, he left the trade show and returned to his office in Wisconsin.

Both Mike and Jim realized that the documentation requested by the representatives of the German subsidiary did not exist, and that is why they were partly concerned about Tom's apparent reaction to the offer. Tom obviously knew that the documentation did not exist. Several times in the past, he had discussed similar problems with the staff engineers and, on some occasions, privately with Mike and Jim. He was distressed by the apparent lack of a documentation system tracking product development and testing at FRI.

Before Mike and Jim returned to their offices, Tom had already made up his mind and called a meeting of all the key marketing and engineering personnel to discuss the offer and possibly, retroactively, produce the documentation. When Mike returned to the office, he met Tom in the hallway. Tom told him about the decision to call the meeting; Mike agreed.

Company's Background

Flatplains Robotics International is a small electronic engineering firm that specializes in designing and fabricating specialty equipment for

research hospitals and scientific laboratories in a number of countries, but mostly in North America, Western Europe, Japan, and, recently, in several Middle Eastern countries. Their equipment is generally designed to the technical specifications or current requirements of individual researchers working in medical research. The researchers are primarily medical doctors or scientists, living abroad, who studied in the United States and prefer to use equipment familiar to them from their previous research projects or their doctoral studies. Many of these researchers participated in research funded by agencies of the US government that specified the use of domestically fabricated laboratory equipment. FRI is listed as one of the approved suppliers of custom-fabricated laboratory equipment on many US government lists.

FRI's management works closely with several large hospitals and research laboratories in the Midwest. When research personnel need a new piece of equipment for their projects, they call in Jim Smith or Tom Cort and simply ask them to design the equipment and build it. Frequently, the price and other terms of sale are negotiated later. Some researchers prefer to come to FRI's facilities, spend several days working with their engineers, and directly help design what they need. FRI's design engineers have a reputation of being friendly, cooperative, and extremely knowledgeable in their field. This close cooperation between clients and their engineers is one of the factors that Jim stresses in his sales presentations.

FRI is a privately held company that employs about 50 individuals, mostly engineers. The head of "in-house" engineering has a doctorate in physics from a well-known university on the east coast. Most of the engineers work independently as designers, and sometimes, also as fabricators of the equipment that they designed. Most of the engineers are very self-reliant and resourceful. Although they work together on large projects, they do so only at the request of Mike Woods, the president. One of the staff engineers recently remarked about the lack of teamwork at FRI: "Working in this place is like being back in graduate school."

Mike Woods started FRI in the early 1970s as a fabrication shop specializing in custom fabrication of electronic equipment. Mike, a graduate

of the leading university in the state, started out as a pre-med student but after three years transferred to electrical engineering. Some of his friends stayed in medicine and eventually became medical doctors or researchers in their fields. Mike's interest in medicine continued while he was studying engineering and, at one point, he decided to apply his engineering education to the design, development, and fabrication of medical instrumentation and equipment used in medical research.

Mike's first important order came from a friend who was doing research at the university where they both studied. Instead of just building an instrument from blueprints, Mike was asked to design the entire instrument. The instrument was used in a major internationally recognized research study and the results of the study were eventually published in a well-known medical journal. The testing instrument that Mike built was featured in the journal article. Orders started coming in.

Shortly after that experience, Jim Smith, who at that time was working for the company as the chief engineer, had an opportunity to join one of the state export development missions organized by the export development group in the governor's office. Based on the concepts developed for their previous clients, Jim came back from the mission with several orders for new equipment. Because of the increase in orders, Mike and Jim decided to name Tom Cort as the vice president of marketing, reorganized the company, and changed the name of the company to Flatplains Robotics International. They both anticipated that their engineering knowledge would someday be valuable in the robotics industry.

Today, FRI employs several multilingual engineers from several foreign countries who are also responsible for domestic and international sales. All members of the management team travel extensively and are comfortable in multicultural situations. If they have one weakness, according to Tom Cort, it is that they are all short-term project-oriented and do not see the "big picture" ahead for FRI.

The Universal Robot

The universal robot that the subsidiary of the large German electronic firm wants to market under its own brand name came about capriciously.

Several staff engineers along with Mike were working in the shop one Saturday morning on an idea for a new circuit board they needed for a client's project. During the brainstorming sessions, a younger, recently hired engineer suggested that someday they could design an actual robot to illustrate the concepts that could be built into the circuit board they were designing. Even though, up to that time, the word "robot" was a part of the company's name, the engineers in the firm had never actually built a robot. Mike thought it was a great idea.

The following Saturday, some of the engineers met again and designed a simple prototype of a robot that could perform a number of basic routine operations. After several Saturdays, the prototype of this universal robot was ready. The robot was designed to be programmed manually by taking it through its routines and tasks, or it could be programmed by a computer. A computer programmer working in the laboratory wrote the software for the robot at home during his spare time. Since the robot had no specified purpose, except that of demonstrating the ingenuity of FRI's engineers, most of the software programs were written for applications selected by the computer programmer.

According to Tom Cort, the vice president of marketing, the robot could be used for both consumer and industrial applications. For example, in domestic situations, the robot could be programmed to wash floors, pick up a variety of objects in open spaces, and even serve drinks at parties. This was clearly demonstrated during some of the parties given by Mike in his home. It was speculated by Jim, and also Mike, that in manufacturing applications the robot could be programmed to spray paint on nonuniform objects, pass assembly parts from one station to another to keep the production line moving, or even bring needed parts from the parts inventory area.

This prototype of the universal robot designed by FRI could potentially perform these functions extremely well, especially under controlled laboratory conditions, in demonstrations where the robot could be closely controlled by an engineer, and in situations where the robot was controlled by a computer program written specifically for that operation. All of these situations were verified in FRI's laboratories

by their own technicians. No additional outside testing was conducted before the trade show in Chicago.

The Agenda

Tom sat in his office and thought about what he wanted to discuss in the meeting. He liked to have his agendas clear and concise. He thought about all kinds of issues that could come up during the discussion as well as the conditions of the potential marketing agreement with the German subsidiary. Liability issues, misrepresentation, and even future competitive concerns were on his mind. After considerable introspection he concluded that, in reality, there were two issues that needed to be placed on the table: (1) should they go back and retroactively reconstruct the design steps for the prototype and summarize the in-house testing procedures and submit those or (2) should they forget about the current offer and develop a new system of documentation and testing for all of their future inventions and products?

The meeting was called for Friday afternoon at 3 p.m. As the meeting date came closer, Tom became more nervous about the entire dilemma. The two items on his agenda also produced uncertainty in both Mike and Jim. Whenever any of them met in the hallways or at the coffee machine, they talked about the offer with different levels of expectations and concerns. Some of the staff engineers who were invited to the meeting had their own ideas about retroactively reproducing the documentation. The agenda became more and more controversial as the time for the meeting came closer.

The Meeting

Tom called the meeting to order exactly at 3 p.m. In a serious and cautious tone, Tom introduced the points on the agenda and indicated that he wanted to have an open discussion on both of the topics and invited Mike to speak first. Mike reviewed the events at the trade show and outlined the discussion with the representatives of the subsidiary that resulted in the potential offer. He indicated that although the offer had some interesting implications for FRI, he personally had

some major reservations about FRI's ability to enter such a marketing agreement.

Jim spoke next. His perception of the offer was more positive. He suggested that instead of debating how they could retroactively reconstruct the documentation, they should be concerned about why the subsidiary of a large German electronics firm wanted to sign an agreement with a Wisconsin developer of an untested universal robot. Jim suggested that the subsidiary knew well that FRI could not manufacture the robots on its own. The capital investment to develop production capabilities is prohibitive for FRI. Any business would take time to check out a potential partner. If they had done that, they would have found that FRI is not a large company with unlimited financial resources. So, why were they even asking? He felt that there was a bigger picture behind this. Did FRI have technology that they wanted? Was the initial offer just an opening statement in a long negotiation process so that FRI would disclose information? As Jim spoke, the atmosphere in the meeting changed.

At this point Tom suggested that, at its face value, the offer might be realistic. Since FRI had the technology to build these robots, it could negotiate a joint venture with the German subsidiary. The joint venture could be externally capitalized. The joint venture would be responsible for the production of these robots; the German subsidiary would take care of the marketing.

The potential offer from the German subsidiary suddenly started to impact the future of FRI. Some participants in the meeting felt very uncomfortable with the issues being introduced. A simple request by the German subsidiary to review the documentation had turned into a major discussion about the future of FRI. Mike felt that he had to intervene. Although he relied heavily on the input and management practices of Jim, Tom, and the other employees, it was still his company.

Tom argued that FRI had an obligation to respond to the offer positively or negatively. In any case, a clearly outlined strategy had to be developed for this response, and now was the time to do it. At this point a discussion developed between Tom and Jim. Tom wanted to follow the original agenda and implied that the two points on the

agenda actually represented a response strategy. Jim, however, insisted that based on the previous discussion, they should be more careful and creative in their response, since it was possible that the offer, in reality, might be a way of getting proprietary information from FRI.

After another out-of-control discussion among the attendees at the meeting, Mike outlined three points around which their strategy for dealing with the German subsidiary should be structured. FRI's options were: (1) go back and reconstruct the entire design, development, and testing process to produce the documentation, (2) "package" the universal robot and offer to sell it to the German subsidiary, and (3) inform the representatives of the German subsidiary that the documentation does not exist and FRI is not interested in their offer. Mike concluded by stating that he strongly supported the third option.

The other participants, particularly the younger engineers, did not agree. They felt that this offer presented a unique opportunity for FRI, and that its management had the responsibility to follow up on the offer in the most professional manner possible. They were concerned that FRI might not have another chance like this in the future. It became obvious that the current situation would not be resolved in this meeting. At this point in the meeting, Jim suggested, "Why don't we ask Marvin?"

Marvin First is a long-time friend and mentor to Mike Woods. They played golf and traveled together socially. Marvin was a retired senior vice president of operations for a very large US-based international corporation. He frequently stopped at FRI to check on Tom and had recently taken an interest in Jim's area of international sales. Marvin frequently served as a "sounding board" or a resource person for both Mike and Jim. Tom, however, saw Marvin as a retired executive from the "old school of manufacturing and sales", but he was willing to support this suggestion. So, Marvin was called in.

Call in Marvin

When Mike came home that evening, he thought about the meeting over a glass of wine, picked up his cellular telephone, and called Marvin.

Marvin was glad to hear from Mike and promised that he would come to Mike's office first thing Monday morning. Marvin told Mike that he considered this opportunity to be important for the future of FRI.

When Marvin came to Mike's office Monday morning, Mike invited Jim and Tom to join them. Mike reviewed the entire situation, what had happened in Chicago, and how the Friday meeting had ended. Marvin looked puzzled. "So, what is the problem?" he asked. "Just do it!"

Marvin saw an enormous opportunity for FRI. He explained that products such as universal robots and offers from large German subsidiaries do not frequently come along, and that FRI should do everything in its power to take advantage of such a deal.

Both Jim and Tom tried to explain to Marvin that this offer did present enormous implications for FRI, but that there were other considerations. The offer was unsolicited. Neither Jim nor Tom understood the motivation behind this offer from the German subsidiary. FRI was not financially strong enough to get involved with manufacturing. In Marvin's mind, none of these arguments were relevant.

Marvin argued that the documentation was just a minor obstacle. FRI had the documentation. It was in the minds of the engineers. It was in the minds of Mike and Jim; they were both involved in the process of designing and fabricating the prototype. All they had to do was to sit down and write down everything that they knew about the development process, call in a professional technical writer, and complete the documentation. The testing part of the documentation was just as simple according to Marvin. All the parties in Mike's home, some of which he attended, represented testing outside of FRI's laboratory.

Mike, Jim, and Tom listened to Marvin very carefully. They respected his judgment. He had many years of management experience and a sound understanding of FRI's operations. Still, all three felt somewhat hesitant about Marvin's recommendation. As they were further discussing Marvin's suggestions, Mike received a telephone call from Hans Hammer, the chief negotiator for the German subsidiary. Hans wanted to know if he could come to Wisconsin for a visit, sign a nondisclosure agreement with FRI, and begin to finalize the marketing agreement.

Hans pointed out further that his subsidiary was willing to have all the robots produced by FRI. His subsidiary would even put a nameplate on each robot indicating that it was their product, but the product was produced by FRI. This additional information had a different impact on all four individuals present in Mike's office. They all agreed, however, that the time to make a decision was near. Mike promised Hans that he would call him back in the next two days. Hans felt that he could wait that long.

Decision Time

Mike realized that it was up to him and his two vice presidents to make a decision. He was somewhat disappointed with Marvin's recommendation, but at the same time, he felt comfortable with the notion that they could put the documentation together, if necessary. Mike told Jim and Tom that he would think about the decision overnight and that he would let them know the next morning what answer he would give to Hans Hammer.

Mike could not sleep that night. He thought about all the issues, he considered the inputs from Jim and Tom, but could not decide. At one point he felt that perhaps Jim was correct when he questioned the motivation of the German subsidiary; perhaps they just wanted to understand the technology embodied in the robot. When he came to the office in the morning, Jim was waiting for him. Jim wanted to know what decision Mike had made. Mike looked at Jim very seriously and said, "Is Tom in yet? Call him! We need to talk".

Appendix⁴

The term robot is a Czech word and means "forced labor". Early robots were simple mechanical devices that performed pick-and-place operations. Robots do not look like human beings and do not have human feelings, but they do the work of humans more effectively.

⁴ The following material was developed to provide a fundamental understanding of robots from both the scientific and management points of view.

With the advent of computer technology, modern robots can perform more precise operations suited for jobs that are regarded as hazardous and risky for humans.

A typical robotic structure includes: (1) a mechanical device or a manipulator, (2) an end-effectors tooling — a gripper with which the robot performs intended tasks, (3) a power drive, (4) a sensor system which also functions as control feedback, and (5) a controller. The mechanical handling device known as the manipulator emulates the hands of a human being and has joints, also known as shoulder, elbow, and wrist. The wrist contains a pitch, yaw, and roll orientation. Electric, pneumatic, or hydraulic actuators drive the joints. The controller is comprised of a computer with two programs, a control and a task program. The control program, provided by the manufacturer, specifies the movement of each joint of the robotic manipulator. The task program, provided by the user, dictates the manipulator motions needed to complete a specific job.

The quality of the manipulator depends on five parameters: (1) accuracy, (2) repeatability, (3) stability, (4) spatial resolution, and (5) compliance. An analogy could be drawn between the effectiveness of the manipulator and the human skeleton. For example, the shoulder, elbow, and wrist joint will be under stress when a physical load is applied to the body. Under an overload environment, the human control system will be damaged approaching a rest point. Loads are handled best and with the least strain when the arms are bent close to the body. On the other hand, loads are most difficult to lift and control at arm's length.

The operation of the arm in the flight of the space shuttle Columbia in 1981–1982 is an example of the advancement of robotics technology. The arm is a 50 ft mechanical manipulator controlled by the astronaut from a position located at the rear of Columbia's cockpit. The astronaut follows the target point using television cameras attached to the manipulator and tries to bring the end of the arm to this target. On the third flight of Columbia, the arm equipped with remote control, was tested with 353 pounds of payload. The task of this controlled manipulator is to place satellites into orbit and retrieve them when they become dysfunctional.

The development of modern robots occurred in two directions: (1) industrial and (2) domestic applications. Industrial robots have been developed to perform tasks such as loading and unloading machines, spot and arc welding, spray painting, parts assembly, drilling and burring metals, inspection, die-casting, and forging operations. However, most industrial robots have limited sensing ability. For example, a robot will not be able to complete a task successfully if assembly parts are not presented to the robot in a precise, repetitive manner. Also, when an object enters the work area of a robot, the robot and the object will collide resulting in damage to both. Thus, an industrial robot must be capable of sensing its surroundings and have enough intelligence to respond to a changing environment in a fashion similar to human beings. An ideal industrial robot should possess elements of sight, touch, and corrective action (intelligence).

Alternatively, domestic robots have been evolving primarily for the home hobbyist market. Most of these devices are capable of voice synthesis (speaking), detecting light levels (vision), and motion. That is, moving while using programmed instructions and sonar-type navigation systems. However, both industrial and domestic robots have limited intelligence with necessarily restricted applications.

Advanced robots, both industrial and domestic, must have the capacity to sense their surroundings and be intelligent enough to adjust to changes in their environment. An intelligent robot should be able to incorporate elements of vision, touch, and speech recognition. Sensory perception and intelligence are the common denominators for any advanced robot equipment with end-effectors (hand-gripper). The mechanical design of the end-effectors should be flexible to accommodate multi-fingered grippers similar to that of a human hand that is composed of 22 individual joints or axes of motion. In addition, the end-effectors must incorporate various sensing devices. The sensing devices are used to detect and feedback variable process data so that control decisions can be made. In turn, the controller software coordinates movements of the end-effectors with sensory feedback data.

Sensory perception, also known as feedback, must be installed in a robot in order for it to function as more than just a mechanical

manipulator. There are six categories of sensors: (1) proximity sensors, (2) range sensors, (3) tactile sensors, (4) voice sensors, (5) acoustic sensors and (6) machine vision sensors integrating the visual detecting capabilities of a television camera with a modern pattern recognition algorithm. The sensor is a transducer that converts one form of incoming energy such as light or sound to an output of electrical energy. The conversion is linear so that the more intense the light impinging on the sensor, the greater the output of electrical energy. All sensors belong to one of the two groups: vacuum-tube sensors or solid-state devices.

A capability for electronic speech is being developed among modern robots. Two techniques are commonly used in electronic speech: (1) ROM, read-only memory and (2) PSS, phoneme speech synthesis. In ROM, the computer reads the given word or phrase from the memory, converts it from a digital to an analog signal, and amplifies it to produce the required sound. The storing of words and phrases in memory makes the entire vocabulary of the robot fixed and limited. In PSS, the computer puts together sounds, called phonemes, to produce a given word. In turn, words are strung together to produce phrases. There are approximately 64 sounds, or phonemes in the English language. By storing these fundamental phonemes in the memory, the computer is capable of an almost infinite vocabulary.

Speech recognition uses two types of systems: (1) an isolated word recognition system where the computer recognizes a specific input such as yes or no and (2) a connected-speech understanding system, which is speaker-independent and can interpret the spoken phrases. The connected-speech understanding system uses a feature analysis technique, which further utilizes phonetic data of spoken words.

An intelligent robot, in addition to controlling various manipulators and end-effectors, must incorporate sensory perception and make decisions based on sensory feedback signals. It requires a direct application of artificial intelligence in a computer network involving knowledge engineering. The knowledge engineering has two main components, hardware and software design. In robots, they both involve networking of a multiprocessor system, which in turn, requires hierarchical planning.

In a multiprocessor system, several minicomputers are interconnected forming a central computer network with each processor dedicated to a specific task. Thus, a hierarchical system is analogous to the human central nervous system that generates behaviors in human beings. It has been demonstrated that basic muscle reflexes remain if the brain stem is severed at point A and the coordination of these reflexes required to stand is still possible if the brain is cut at point B. Walking requires the region below point C to be operable, and primitive tasks can be performed if the region below point D is available. However, the complex tasks, including thought processes and decision-making processes, require an intact cerebral cortex.

Digital computers perform operations and make decisions using on and off states exhibiting two-state operations. Similarly, the basic elements of the brain, neurons (nerve cells), also illustrate two-state operations. The human brain is composed of approximately 20 billion neurons. Each neuron consists of a body with several fiber branches called axons and dendrites. Neurons come together to form junctions called synapses. The function of neurons is to generate and conduct nerve impulses of approximately 50 mv with duration of about 1 ms. These nerve impulses create both chemical and physical changes in the neuron body and associated fibers. The presence or absence of nerve impulses can be interpreted as on and off or two-state operations. The neurons are analog in nature, operating like tiny operational amplifiers in their range of functions. A comparison can be made between the brain and a digital computer. For example, the eye acts as an input device and the vocal cords act as an output device. The central nervous system then provides the computational, logic, control, and memory portion of the system. The overall structure of the brain and its sensory organs is, therefore, very similar to that of a typical digital computer.

Consequently, in the future, advanced robots could evolve into complex mechanical devices operated by highly advanced computers capable of performing a variety of functions in a fuzzy environment.

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Topic Area 2

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Product Concept Development in a Competitive Market Place

Product ideas selected for further development are converted into product concepts. The definition of a product concept depends a great deal on how an individual firm uses the concept in the context of its overall product development process. To some firms a product concept represents a relatively broad description of a potential product, more specific than a statement describing a new product idea, but still without precise scientific, engineering, or even marketing design specifications. Other firms, especially smaller high-technology and manufacturing firms, consider the notion of a product concept as something that is, from a technological perspective, clearly defined to the point where it could be sold because it might have potential commercial value. In this context a product concept consists of a set of clearly defined product attributes that can be easily understood by scientists or marketing managers.

Marketing managers try to introduce a set of guidelines for product development specialists. These guidelines are used when the product development specialists convert new product ideas into new product concepts. These guidelines summarize what the product concept description needs to include as documentation for the product development specialists further on in the new product development process. For example, marketing researchers need to verify the feasibility of the product concept in the market and top managers need to develop tentative plans and budgets for potentially new products.

These guidelines also need to delineate three distinct areas concerning the development of a potential product and its documentation. The product concept as a document should first include a short description of the concept in general along with a statement explaining exactly how the proposed product will be used. This step is

followed by a relatively detailed technical explanation or description. In order to explain the technical or scientific properties of the potential product, mathematical equations or models, engineering diagrams, or even chemical formulas, sometimes accompany this description. And, finally, the individual who is proposing the product typically includes a sketch, a computer-generated drawing, or a photograph, that describes the envisioned configuration of the proposed product.

The guidelines developed for a product concepts document provide a foundation for the actual development of product attributes during the development process. From a marketing management point of view, each product can be described as having three sets of attributes: functional, physical, and psychological. The functional attributes describe the actual use, application, or general purpose of the product. The functional attributes describe how the product will be used. The physical attributes describe the actual material make-up of the product. They describe the material that will be used for the construction, fabrication, or configuration of the tangible form of the product. In some cases different materials can be substituted or exchanged to enhance the market value of the product, therefore these issues must be taken into consideration early on in the conceptualization of the proposed product. The psychological attributes describe the intangible aspects of the product that potential consumers or users should find advantageous over competing products available on the market. Psychological attributes are viewed as the motivating factors for consumers to purchase the product and need also to be considered early in the product conceptualization process.

From a marketing management perspective, product concept documentation is considered as a sort of a contract between the product planning specialists, top management, product development specialists, and product managers. The product concepts statement represents the platform from which these various groups involved with product development make decisions. However, as the product development process becomes more competitive and important for corporate level decision-making, it is also taking on an additional role.

Not only are product concepts used for internal assessment of the potential success of the proposed product, but product concepts are also used extensively as the basis for marketing research studies. Product concept documents can also serve as communication platforms for marketing researchers as they develop various studies concerning consumers' intentions, perceptions, and preferences. They can also serve as common reference points in communicating with industrial designers, engineers, and other product development specialists. One principal advantage of the use of product concepts is that different specialists can describe the potential product in relatively the same way and still leave some potential for individual interpretation, imagination, and creativity before the actual prototype is developed.

With the expanding use of computer-aided design (CAD) and computer-aided manufacturing (CAM) programs, a product concept statement is considered to be an integral part of the preliminary information required to activate a computer-based product development program. The basic design decisions tentatively describing the potential product attributes are made as a part of the input into these computer-based product development programs. Once the program is running, the CAD operators consult with the technical product development specialists and the product managers who will be responsible for the product in the future. The CAD design operators need as much clarification of what the product ought to look like in its functional and physical forms. The new product concept statement should typically include all this information.

Similarly, as is the case with new product ideas, product concepts are considered to be important assets of a firm and are kept securely in the new product development computer-based programs and require managers, or any other product development specialists, to use an authorized code to access them. In high-technology firms especially, product concepts tend to have commercial value and can be marketed. Special high-technology fairs are organized for the purpose of selling technology and product concepts that could not be developed internally because they would be too costly to develop. In the computer and medical equipment instrumentation industries, or in the field of specialty chemicals, R&D-intensive

firms augment their sales revenue occasionally by selling product concepts that are considered to have a low potential value. Occasionally a firm is financially or technologically not capable of developing the product from the concept specifications and, as a result, sells the concept to a firm that is able to develop the product and introduce it to the market. From an international perspective, after the transition in the early 1990s many firms in Central and Eastern Europe successfully sold product concepts as they were not able to develop or market on their own.

Once a product concept is successfully formulated it needs to be systematically evaluated or screened. This is done both internally and externally. Internally, the product concept is examined within the context of the strategic plan. Currently available resources and the technical expertise of the firm are considered. The fundamental question that needs to be answered is whether or not the firm currently has the means and abilities to successfully develop the product and subsequently introduce it to the market. For some firms this is a complex question. Rapidly changing market conditions and the firm's competitive profile make it difficult for the top management to objectively decide whether or not the firm has the necessary resources and technical know-how, and most of all, decide which proposed product represents better potential in the future. The external evaluation of a product concept focuses on existing or potential competition for the proposed product, potential market forecasts, and projected pricing levels, potential consumer acceptance of the proposed product, and its established technological climate. Marketing-related issues are examined by marketing researchers, while scientists, engineers, or even outside consultants retained by the firm for that purpose, may be asked to assess the technological climate for the proposed product in the market.

Both the internal and external assessments of a proposed product concept are important for many firms, especially smaller firms, because they help the firm to recognize its strengths and weaknesses. Sometimes a firm does not have the necessary financial resources to develop a new product but is confident that its overall business will remain competitive and so it attempts to borrow funds or attract

venture capital. If the firm discovers that these are not viable options, it has to focus more on its current operations.

When a product concept receives favorable internal and external reviews, it will generally be proceeded by comprehensive product development. However, in large diversified operations where many product concepts are being formulated at the same time, individual product concepts may well be ranked and judged relative to each other across several different operations, departments or divisions. Top management ultimately decides which potential products will be developed and in what order.

Furthermore, when a product concept is selected for development, it is officially turned over to product development specialists. The product development specialists may be organized as a unique team formed to develop a specific product, or may be members of a formal department in charge of new product development. Larger firms tend to maintain departments specifically charged with all new product development responsibilities. Some firms prefer to develop their products entirely on the technical side of the firm, while other firms combine the technical and marketing sides of the business and encourage an open and cooperative communication process between the two sides.

For some firms, the preliminary business plan developed for a specific new product idea will have to be developed further, or substantially modified, for the product concept selected for further development. As a product concept is finalized for development and its proposed attributes are finalized for development, its business plan is also evolving into its final form. The business plan not only stipulates what resources will be needed and when the proposed product will be scheduled for development, but it also systematically outlines the individual steps in the development process along with the necessary time lines. Top management periodically reviews the business plan with input from product development managers.

Business plans for individual product concepts are not only used to develop a new product, but they also serve as guidelines for the development of organizations, such as new divisions, departments or even entire subsidiaries depending on the future needs of the proposed

product. New products may have a significant impact on the future make up of a firm. Revolutionary new products may be attractive for new markets with substantial potential for rapid growth. The firm introducing such products on the market must be ready to respond to rapid growth in the market. In reality, top management of such a firm will have to simultaneously make decisions about which new product concept to select, how best to respond to potential market demand, and how to structure the future organization that will be responsible for the future of the new product. These are important and complex decisions even for a large firm that has a strong resource base and is well established in the market.

Smaller firms that do not have sufficient financial resources to develop a new product may have to seek venture capital. Venture capital firms specialize in helping smaller firms develop new products and even build organizations effective in marketing innovative products. Venture capital firms also work frequently with top managers on refining product concepts, reviewing business plans, and verifying market forecasts. Before a venture capital firm agrees to invest in a new project, it will insist on conducting a “due diligence” review which typically is a systematic examination of the firm’s financial and managerial strengths along with its marketing and technological capabilities. Most venture capital firms maintain a staff of highly skilled high-technology specialists, along with financial and marketing specialists, who carry out the entire due diligence process and frequently contribute significantly to the destiny of the product concept under consideration.

There are a variety of sources of venture capital. In addition to the typical venture capital firms, there are large individual investors, professional investment groups, banks, employee trust funds, and even insurance companies that may serve as sources of venture capital. Some large cities may have venture capital groups that are interested in funding new ventures. Individuals or groups interested in more problematic new ventures may be interested in offering initial capital on less favorable terms than the larger venture capitalists; these are generally called “venture capital angels”. If the proposed venture is relatively straightforward and appears to be profitable in a relatively

short period of time, a “bridge loan” may be available from a commercial bank to develop the new product. The problem of obtaining venture capital is frequently more difficult for a smaller start-up firm. Smaller firms sometimes need to search very carefully and exhaustively to find a suitable source of venture capital for their proposed new ventures.

Due to increasing international competition and the rapidly changing technological climate, regional and national governmental agencies frequently have programs designed to assist smaller firms in securing capital or even preparing product concept documentation and business plans. This assistance is sometimes available free or at a nominal charge from designated governmental agencies. Sometimes, this assistance is available from local universities or trade schools. Special university centers, frequently financed by governments, offer services that involve students and faculty. Some of these services are free or also offered at relatively low cost to the firms. Many of these governmental agencies and university centers maintain close contact with a variety of venture capitalists and can assist smaller firms with the process of obtaining venture capital.

Some high-technology firms, particularly those that expect a relatively rapidly growing market share, prefer to engage large consulting companies in assisting them in the process of conceptualization of the product and sourcing for venture capital. This approach, although somewhat expensive, may be more productive for the high-technology firm in the future.

The selection of a product concept and the ability to financially support its development is an important decision for top management, especially in smaller, relatively new high-technology start-up firms. In an increasing number of firms, large and small, top management cooperates closely with marketing and technology specialists in order to make appropriate decisions about new product concepts and sourcing for necessary venture capital. As top management takes on more responsibilities for new product development and management, it requires more and better information from the marketing and technology specialists. An efficient and effective communication process is required between lower level product planning and development

specialists or teams responsible for product planning and development and top management.

Not all firms need to search for venture capital. Some firms have sufficient internal sources of capital. However, in situations where a firm is able to finance product development internally, top management will still insist on substantial documentation of every product concept that is introduced for evaluation and screening. Many such firms maintain committees or management teams that are responsible for examining new product concepts before they are introduced in the formal evaluation and screening process implemented at a lower level of the firm. Individuals responsible for the formulation and development of product concepts are required to appear in front of the top level committees or teams to explain and argue on behalf of particular product concepts that they believe to have better potential for market success.

Formulating new product concepts and developing the necessary documentation for proposed new product concepts is an important step in the entire new product development and management process. Top managers need to understand the potential value of product concepts and the impact the proposed concept may have on the future of the firm. At the same time, top managers need to understand the financial implications on the performance of the overall firm. In some cases, if the financial resources are not available internally and the proposed product concept has a high commercial market value, it may be necessary to seek financial assistance outside of the firm. These are decisions that top managers need to make with substantial input from their marketing and technology specialists along with those who are responsible for product development.

Phytoremediation: A Natural Solution to Environmental Contamination¹

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Managing the Problem of Environmental Contamination

For centuries, humans believed that atmospheric, terrestrial, and aquatic systems could absorb and break down the unlimited amounts of wastes from industries, agriculture and cities. We now know that this is not true. However, at the same time that we grapple with the question of how to dispose of the large and continuously increasing

¹ This case was developed by Bernard R. Glick and Donna M. Penrose at the University of Waterloo, Waterloo, Ontario, Canada and Tom Bramorski, at the University of Wisconsin-Whitewater for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way. The authors wish to thank Steven W. Anderson, Department of Chemistry, University of Wisconsin-Whitewater for compiling the patent summary in Appendix A.

quantities of wastes that are continually being produced, we are concerned with the issue of how to remove the toxic compounds that have been accumulating at dump sites, in the soil, and in water systems for the last few decades.

The problem of toxic waste disposal is enormous. For example, worldwide production in 1985 of pentachlorophenol (PCP), just one chemical that was released into the environment was more than 50,000 tons. Incineration and chemical treatment have been used to break down some toxic chemicals, but these methods are costly and often create new environmental difficulties. The Environmental Protection Agency (EPA) estimates that there are more than 30,000 sites throughout the United States that require environmental treatment. Heavy metals comprise a particularly difficult component of this problem, because many metal compounds resist chemical breakdown and because soil excavation and removal is expensive.

The removal of many potentially toxic chemicals from the environment, often found there in large volumes, is complicated by the numerous classes and types of these chemicals. For example, many soils are contaminated with one or more metals (e.g., lead, zinc, etc.), radioactive (e.g., uranium, cesium, etc.) or inorganic (e.g., arsenic, phosphate, etc.) compounds. Soil may become polluted with high concentrations of metals by either a natural phenomenon such as proximity to an ore body, or as a consequence of industrial activities. The remediation of heavily metal-contaminated soils often involves excavation and removal of soil to secured landfills, a technology that is expensive and requires site restoration.

In addition to the above-mentioned inorganic compounds, soils and water systems may also be contaminated with organic compounds including chlorinated solvents like trichloroethylene; explosives such as trinitrotoluene (TNT) and 1,3,5-trinitro-1,3,5-hexahydrotriazine (RDX); petroleum hydrocarbons including benzene, toluene and xylene (BTX), polyaromatic hydrocarbons (PAHs), and pesticides such as atrazine and bentazon. While certain soil bacteria can metabolize many of these compounds, this process is usually slow and inefficient. However, there is mounting evidence that the biodegradation of recalcitrant organic compounds in the soil is enhanced around the

roots of plants. However, in the past few years several groups of scientists have begun to explore the possibility of using certain plants to remove metal contaminants from the soil.

At the present time, there are no simple ways to deal with vast amounts of toxic waste in the environment. Scientists are currently trying to develop some new and improved methods to deal with both inorganic and organic environmental contaminants. However, most of the procedures that are being used at the present time are either very expensive or not especially effective. One recently developed method of environmental clean-up is called phytoremediation. This procedure may be defined as the use of plants to remove, destroy or sequester hazardous substances from the environment. We now need to decide whether or not phytoremediation can be effective in cleaning up the environment, whether it can be cost effective, and what aspects of the technology can be patented or otherwise protected.

The Alternatives of Managing Environmental Contamination

There are several alternative means of controlling the growth of environmental contamination, which have been largely developed and implemented in the US as well as in many countries abroad, with varying degrees of success. These programs include:

1. Enacting and strictly enforcing increasingly stringent environmental protection legislation and rules at the federal, state and local levels of the government. These organizations include the Federal Environmental Protection Agency (EPA), the State Departments of Natural Resources (DNR) and the local environmental protection bodies. In addition, there are multiple groups, such as the Envirofacts Points, that monitor environmental issues at the local levels. *Envirofacts Points* are maintained by the Envirofacts Warehouse and are available on the Internet. These points provide latitude and longitude coordinates for the following types of regulated facilities: Discharges to Water, Superfund Sites, Hazardous Waste Handlers, Toxic Releases, Air Emissions and Biennial Reporting

System (BRS). In many cases, facilities report more than one environmental activity to EPA. These are designated as “multi-activities” or “multiple-program-system” facilities.

2. Developing and implementing cost-effective bioengineering technologies, such as phytoremediation. The objective here is reducing the amount of toxic environmental waste from the soil by using bacteria. Depending on site conditions and metal concentrations, solar-powered phytoremediation can cost as little as 5 percent of alternative treatment methods. Candidate sites for phytoremediation include homes contaminated with lead paint or leaded gasoline, thousands of government and private firing ranges, as well as industrial facilities used by primary and secondary metal manufacturers, scrap metal recyclers, paint manufacturers, battery recycling and production companies, chemical and petrochemical manufacturers, automobile manufacturers, utility companies, transportation companies, mining companies, and landfill operators. Toxic waste treatment business, such as Edenspace (<http://www.edenspace.com>) use phytoremediation to treat soil and water contaminated with arsenic (an element used in pesticides and wood treatment), and with radioactive elements (residuals at former weapon production and fuel rod assembly sites). The magnitude of the latter is estimated by the Department of Energy at well over \$200 billion.
3. Obtaining an ISO 14000 certification that requires businesses to formally address environmental and safety issues by developing and implementing a set of detailed instructions and operational procedures. The purpose of this documentation is to increase the corporate awareness and appreciation of environmental and safety issues and to ensure that they are followed by appropriated personnel. Information about the details of ISO 14000 purpose, documentation, and the certification process can be found at <http://www.asq.org/stand/types/iso14000.html>.
4. Changing process and product design and manufacturing technologies so as to eliminate the need for using toxic substances in the manufacturing processes. Such processes include etching sheet metal parts of automotive bodies in highly acidic environments

and body painting. In both cases the change of inputs and the process technologies resulted in a significant reduction of active chemicals causing environmental pollution. Other process technology developments reducing environmental pollution include developments in steel production and a transition to minimills. Information about the automotive industry pro-environment initiatives can be found at <http://www.aiag.org> while the information about the competitive and environmental advantages of minimills can be found at <http://www.nucor.com>.

5. Educating and providing incentives to consumers regarding environmentally friendly disposal and recycling methods.
6. Developing and applying niche marketing techniques that are aimed at reaching customers who use environmental friendliness of a product as one of their important competitive priorities used in making purchasing decisions. One example of such an approach is Volvo automotive group that uses environmental themes in their marketing strategy. More information about this approach can be found at <http://www1.volvo.com/frameset.html>.
7. Incineration of toxic waste. While it is a technologically viable alternative, it is also very expensive to construct and operate. In addition, adopters of this method have frequently encountered strong opposition from community groups at the time of making location decisions.

Phytoremediation as a Solution to Environmental Contamination

After several years of investigations, screening and selection, scientists have identified superior metal-accumulating plant lines from known, well-characterized crop species such as Indian mustard and sunflowers. The researchers have shown that such plants can accumulate lead, mercury, arsenic, chromium, uranium, cesium, strontium, gold, zinc, selenium, manganese, calcium, iron, magnesium, and other metals from soils into harvestable leaves and shoots. When combined with proprietary techniques involving soil amendments and hyperaccumulation

inducing agents, the plants were found to be able to take up more than 3.5 percent of their dry weight in heavy metals. Hydroponically cultivated plants rapidly remove heavy metals from water and concentrate them in the roots and shoots. Harvested plants containing heavy metals can be disposed of or treated to recycle the metal.²

Phytoremediation of metals and other inorganic compounds may take one of the several forms: phytoextraction, the absorption and concentration of metals from the soil into the roots and shoots of the plant; rhizofiltration, the use of plant roots to remove the metals from the effluents; phytostabilization, the use of plants to reduce the spread of metals in the environment; or phytovolatilization, the uptake and release into the atmosphere of volatile materials such as mercury- or arsenic-containing compounds. Phytoremediation of organic compounds may occur by phytostabilization; phytostimulation, the stimulation of microbial biodegradation in the rhizosphere, the area around the roots of plants; or by phytotransformation, the absorption and degradation of contaminants by the plant.

Following the testing of a large number of different plants, several that can naturally accumulate large amounts of metal (hyperaccumulators) have been identified and are being used for phytoremediation. These plants are often found growing in the areas with elevated metal concentrations in the soil. Unfortunately, high concentrations of metals are inhibitory to the growth of plants, even metal hyperaccumulating plants. Depending upon the amount of metal at a particular site it could take 15–20 years for complete remediation, even with hyperaccumulating plants; a timeframe usually considered too slow for practical application.

A number of different types of plants, including many common grasses as well as corn, wheat, soybean, peas and beans, are effective at stimulating the degradation of organic molecules in the rhizosphere. Typically, they have extensive and fibrous roots forming an extended rhizosphere. In addition, several varieties of plants and trees can take up and degrade some organic contaminants. For example, plants with phytotransformation activity may contain various

² <http://www.edenspace.com>.

enzymes including nitroreductases for degrading TNT and other nitroaromatics, dehalogenases for degradation of chlorinated solvents and pesticides, and laccases that can degrade aromatic amines such as triaminotoluene.

Plant Growth-Promoting Bacteria

Beneficial free-living soil bacteria (plant growth-promoting rhizobacteria or PGPR) are found in association with the roots of many different plants. While numerous free-living soil bacteria are classified as PGPR, not all bacterial strains of a particular genus and species have identical metabolic capabilities. Thus, for example, some *Pseudomonas putida* strains actively promote plant growth while others have no effect.

PGPR can affect plant growth and development in two different ways. *Indirect promotion* of plant growth occurs when these bacteria decrease or prevent some of the deleterious effects of a phytopathogenic organism by any one or more of several different mechanisms. On the other hand, direct promotion of plant growth by PGPR generally entails providing the plant with a compound that is synthesized by the bacterium or facilitating the uptake of nutrients from the environment by the plant.

There are several ways in which different PGPR have been reported to directly facilitate the proliferation of their plant hosts. They may: (1) fix atmospheric nitrogen and supply it to the plants; (2) synthesize siderophores which can solubilize and sequester iron from the soil and provide it to plant cells; (3) synthesize several different phytohormones which can act to enhance various stages of plant growth; (4) provide mechanisms for the solubilization of minerals such as phosphorus which then become more readily available for plant growth; and (5) synthesize some less well-characterized low molecular mass compounds or enzymes that can modulate plant growth and development. A particular bacterium may affect plant growth and development using any one, or more, of these mechanisms. Moreover, since many plant growth-promoting bacteria possess several traits that enable them to facilitate plant growth, a

bacterium may utilize different traits at various times during the life cycle of the plant. For example, following seed germination a PGPR may decrease ethylene inhibition of seedling root length. Once resources contained within the seed are depleted, a PGPR may help to provide the plant with a sufficient amount of iron and phosphorus from the soil. Through early plant development, PGPR may promote tolerance to a variety of environmental stresses such as flooding and drought by control of ethylene levels.

It is likely that the impact of all of the mechanisms by which the bacterium provides a compound or nutrient such as fixed nitrogen, phosphorus or iron to the plant, varies considerably depending upon the soil composition. For example, the growth of cactus plants that are cultivated in extremely nutrient-poor sandy soils is dramatically enhanced when the plants are inoculated with a PGPR but lends no effect when cultivated in nutrient-rich soil under optimal growing conditions.

The mechanism most often invoked to explain the various effects of PGPR on plants involves the production of phytohormones. Responses of plants treated with a PGPR may vary from one species of plant to another depending upon the existing hormonal levels within the treated plant.

It has been recently demonstrated that 1-aminocyclopropane-1-carboxylate (ACC) deaminase, an enzyme found in a number of PGPR, can cleave the plant ethylene precursor ACC, and thereby lower the level of ethylene in a developing or stressed plant. For many plants, a burst of ethylene is required to break seed dormancy but, following germination, a sustained high level of ethylene may inhibit root elongation.

It is well documented that plants respond to a variety of different stresses by synthesizing "stress" ethylene. Stress ethylene is thought to act as a secondary messenger and can stimulate senescence, leaf or fruit abscission, disease development, inhibition of growth, and/or antibiotic enzyme synthesis.

Treatment of a plant with a soil bacterium that contains the enzyme ACC deaminase should provide an effective means of limiting the damage to plants which occurs as a consequence of stress

caused by pathogen infection, drought, flooding and the presence of heavy metals. Indeed, in one application, this has been effective in protecting mustard, tomato, canola and oat plants grown in the presence of heavy metals.

The Use of Plant Growth-Promoting Bacteria in Phytoremediation

We have seen that metal-hyperaccumulating plants can take up significant amounts of the metal from the environment yet can be severely inhibited when the concentration of available metal in the contaminated soil is very high.

While plants grown on metal-contaminated soils might be able to withstand some of the intrinsic inhibitory effects, two features of most plants could result in a decrease in growth and viability. At high levels of metals most plants would (i) synthesize stress ethylene and (ii) become severely depleted in the amount of iron that they contained. Moreover, PGPR might be used to relieve some of the toxicity of metals to plants via the use of ACC deaminase-containing PGPR. In addition, plants are able to take up and utilize complexes between bacterial siderophores — low molecular weight iron chelators — and iron. Plant siderophores bind to iron with a much lower affinity than bacterial siderophores so that in metal-contaminated soils a plant is unable to accumulate a sufficient amount of iron unless bacterial siderophores are present.

Initially, our work was undertaken in conjunction with a company that was involved in the mining, processing and industrial use of nickel. Our primary objective was the development of a phytoremediation system that could be used to help to remove nickel from soil as inexpensively and as quickly as possible. Prior to our work, there were reports in the scientific literature that indicated that *Brassica juncea* (Indian mustard) was a nickel-hyperaccumulating plant and could be used for this purpose. However, our preliminary laboratory experiments indicated that the growth of Indian mustard, and the related plant *Brassica campestris* (canola), which could also accumulate high levels of nickel and other metals, was significantly inhibited

by the presence of moderate amounts of nickel in the soil. In an effort to overcome the inhibition of plant growth by nickel, we isolated a bacterium from a nickel-contaminated soil sample that was: (i) nickel resistant, (ii) able to grow at the cold temperatures that we expected to find in our nickel-contaminated environments, and (iii) contained ACC deaminase activity, i.e., was able to grow on minimal medium with ACC as the sole source of nitrogen. In laboratory tests we ascertained that the bacterium that we isolated not only had the above-mentioned traits but could also promote plant growth in the presence of high levels of nickel. To improve the performance of this strain, we grew the bacterium on a minimal growth medium that did not contain any measurable amounts of iron. Only a few bacteria were able to grow under these conditions. We reasoned that these bacteria contained a spontaneous mutation that caused the overproduction of the bacterial siderophore. It appeared that this siderophore overproduction enabled the bacterium to sequester a sufficient amount of iron, even though the iron was present at extremely low levels, to permit the bacteria to grow. Later, when we examined one of these siderophore overproducing mutants in more detail, we found that the siderophore level had increased about 100-fold.

When the wild-type bacterium and the siderophore overproducing mutant were tested in the laboratory, we found that both of them promoted the growth of plants in the presence of inhibitory levels of nickel, lead or zinc, as expected. In addition, the siderophore overproducing mutant decreased the inhibitory effect of the added metal on plant growth significantly more than the wild-type bacterium. Importantly, when the siderophore overproducing mutant was tested in the field with soil that had been contaminated with nickel over a period of many years, we observed that both the number of Indian mustard seeds that germinated in the nickel-contaminated soil, and the size that the plants were able to attain was increased by 50–100 percent (i.e., 2–4 fold) by the addition of the bacterium to the soil.

While additional laboratory and field testing of the selected bacterium is necessary, at this stage the data look sufficiently promising to consider commercialization. However, before commercialization of this technology can proceed, it is important to apply for patent

protection both for the selected bacterial strains and for the process of utilizing bacteria to facilitate phytoremediation.

The Market for the Use of Plant Growth-Promoting Bacteria in Phytoremediation

Without question, phytoremediation is at a very early stage of development and currently occupies only a very small fraction of the total amount spent each year for the remediation of hazardous sites. Thus, in 1998 an estimated \$8–9 billion was spent on hazardous site remediation and of this phytoremediation accounted for approximately 0.5 percent of the total. However, the world remediation market, currently (early 2001) estimated to be \$25–30 billion, is expected to grow to nearly \$100 billion by around 2010, and it is estimated that somewhere between 2005 and 2010 phytoremediation could account for 5–10 percent of the total remediation market.

At the present time, by far the largest number of sites being remediated contain organic contaminants, probably because organics are easier and less expensive than metals to remediate or clean-up. However, it is expected as various technologies develop, and pressure from government agencies increases, that the removal of metal contaminants from the environment will receive more attention.

A comparison of the costs associated with remediating soil that contains organic contaminants suggests that phytoremediation is a very attractive alternative to the more conventional technologies. For example, to remediate a ton of soil that contains organic contaminants the cost is estimated to be in excess of \$200 for incineration, \$80–200 for soil washing, \$50–150 for *in situ* bioremediation, and \$10–35 for phytoremediation. On the other hand, to remediate a ton of soil that contains metal contaminants it is estimated to cost \$100–500 for landfilling, \$50–150 for soil washing, and \$25–100 for phytoremediation. In addition, with phytoremediation, the resale value of the recovered metals may be subtracted from the cost of phytoremediation.

Phytoremediation is still a developing technology and it is reasonable to assume that advances in this technology such as the use of

appropriately selected or engineered soil bacteria will increase its efficiency and thereby decrease its cost. This is likely to make phytoremediation even more attractive and hasten its adaptation.

Patenting the Use of Plant Growth-Promoting Bacteria in Phytoremediation

When a person works for a company, the company owns the rights to all their results and discoveries. And, when a person works for a university, the university usually owns the rights to their results and discoveries. However, at some academic institutions the rights to any and all discoveries made during the course of research work reside with the inventors. The consequence of this far-reaching intellectual property rights policy has been the development of a large number of highly successful “spin-off” companies that were formed as a direct result of discoveries made at the university. The university and the community have both been indirect beneficiaries of this policy. The new companies have created a boom in the local economy; the university and the companies have developed research partnerships, and recent graduates have found employment.

Following the isolation, characterization and testing of the bacterium that was shown to facilitate plant growth in the presence of normally inhibitory levels of metals, we prepared a detailed description of the experiments that had been performed. This report, which took on the same format as a scientific manuscript, was submitted to a patent attorney who put it into appropriate legal language. For example, the introduction and review of the scientific literature, as well as a search of the patent literature to make sure that no similar patents had been awarded, were reformulated as “prior art”.

In many ways, the most important part of a patent application is the list of claims at the end of the document. Generally, claims are written to be as broad as possible with the expectation that the patent examiner may allow only a portion of what is claimed. For example, although only one bacterium and a mutant of that bacterium were actually tested, in the patent application discussed here,

the patent application also claims any similar bacteria that can promote plant growth in the presence of high concentrations of metals and might, at some time in the future, be isolated and used as part of a phytoremediation protocol. In addition, while the isolated bacterium was tested with a limited number of concentrations of nickel, lead and zinc and with three different plants, the patent application claims that the invention is (should be) valid with a wide range of metals at different concentrations and with many different plant species.

In any patent application of the type that we have described, at least one example of the type of bacterium described must be deposited in a public culture collection. In this instance, the siderophore overproducing mutant was deposited (for a small fee) with the American Type Culture Collection (a non-profit organization) in Washington, DC. Thus, although this bacterium is itself a “product of nature”, in this case an application is being made to patent its use as part of a particular process. A comparison of patent laws in the US, European Union, and Japan is provided in Appendix A.

Summary

The following problems and issues need to be considered:

- How effective is phytoremediation in the removal of metals from contaminated soils?
- Is it economically feasible?
- Can metal concentrations in contaminated soils be reduced to governmentally mandated levels?
- Is the use of bacteria as an adjunct to phytoremediation a scientifically and economically justifiable approach?
- Is the market for phytoremediation too fragmented to make a profit?
- How much capital input is required?
- Is patent protection of all or parts of the process necessary or desirable?
- Is the approach being considered acceptable to the public?

For a company that developed phytoremediation as a cost-effective and friendly technology for the purpose of reducing the environmental impact there are several strategic choices to be made:

1. Patent the technology and decide to market it alone. This alternative is costly from the business point of view and requires appropriate business and legal expertise that may not be available to small- and medium-size companies.
2. Patent the technology and decide to market it jointly with another business using distributorship or licensing agreements. This alternative seeks to minimize the business and legal expenses for the business and diversify the business risks by creating the win-win scenarios.
3. Sell the technology without obtaining appropriate patents and move on to other R&D projects. This approach is appropriate for a company that from a strategic perspective focuses solely on developing new technologies and is neither interested in nor capable of commercializing the outcomes of R&D.
4. Disseminate the technology for free to a global user base. An inventor who strategically focuses on improving the global environmental situation may select this approach. The business benefits are disregarded at least in a short run in the hope of broad global adoption and the creation of secondary revenue streams resulting from the maintenance and service of hardware by a broad class of users.
5. Enter a joint venture agreement with a complementary partner(s) immediately in order to gain access to financing, marketing and manufacturing expertise.
6. Obtain appropriate certifications and approvals to establish credibility in the market place with the hope of establishing a viable market for the technology either individually or through a strategic partnership to be formed in the future.

Appendix A

	United States (US)	European Union (EU)	Japan (JP)
Patentable items	Manufactured articles, machines, improvements, some business methods (e-business), animals, asexually reproduced plants, ornamental designs of useful objects, software.	Same as US and JP except that all software is excluded.	Same as US except that some limits are imposed on acceptable software.
Non-patentable items	Obvious devices, useless devices, perpetual motion machines, printed matter, nuclear weapons.	Software.	Certain software.
Utility patents	Granted for a new and useful process, machine, manufacture, or chemical compound. Patents last for 20 years from the date of filing.	Same as US.	Same as US.

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	United States (US)	European Union (EU)	Japan (JP)
Design patents	A patent granted for a new original, and ornamental design for an article of manufacture; granted to protect the appearance rather than the function of a product. Patents last for 14 years from the date of issue.	Same as US.	Same as US.
Plant patents	Granted to whoever invents or discovers and asexually reproduces any distinct and new variety of plant, including those such as grafts or spores. Patent lasts for 20 years from the date of filing.	Same as US.	Same as US.

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	United States (US)	European Union (EU)	Japan (JP)
Requirements	New, unobvious, useful, not already patented, published, or available. The inventor must agree to disclose any and all information about the patent at the time the patent is granted. Patent claims include the absolute minimal set of items that differentiate a new invention over what came before.	Same as US.	Same as the US except that patents cannot be granted to inventions which contravene public order, morality, or public health.
Best mode requirement	Inventor must include best way to practice invention in the patent application. Avoids concealment of essential or advantageous aspects.	At least one way of practicing the invention must be included in the application, but there is nothing that states this way must be the best way, or even a good way.	Same as EU.
Novelty	Invention must be new and unobvious to “one skilled in the art”. Inventor’s use applies as well.	Same as US except that an invention must be novel and involve an inventive step. The latter means it <i>solves a technical problem</i> in a non-obvious way.	Same as US.

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	United States (US)	European Union (EU)	Japan (JP)
Utility	Invention must be useful and do what it says it does. Not to be confused with practical.	Same as US.	Same as US except that the invention must have an industrial application and utilize a law of nature.
Who may obtain	The real person or persons who first made the invention (i.e., the first to invent), or his/her assignee, is entitled to a patent. This usually involves examining laboratory logbooks, establishing dates for prototypes, and so on. If the person who filed later is found to have invented earlier, they may be awarded the patent.	The first to file a complete application is entitled to a patent, provided the invention was not copied from another. This holds even if the second person did in fact come up with the invention first. The only thing that counts is the filing date.	Same as EU.
Excludes	Making, using, offering for sale, importing or selling in the granting country.	Same as US.	Same as US.

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	United States (US)	European Union (EU)	Japan (JP)
Breadth	Patents are a property right which is enforceable in the whole territory of the country. It allows the patent holder to prevent anyone from making, using or selling in the country of the patented invention.	The European Patent Convention (EPC) is a treaty signed by 20 European countries. Patents under the EPC are granted by the European Patent Office (EPO) in Munich. A granted European patent under the EPC confers to its owner the same right as a national patent in those EPC countries elected in the application.	Same as US.
Infringement	Unauthorized: use, making, selling. It is the inventors/ owners responsibility to “police” their own patents.	Same as US.	Same as US.
Options	Developer can develop other products directly derived from original invention.	Same as US.	Same as US.
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	United States (US)	European Union (EU)	Japan (JP)
Grace period	A one-year grace period allows the inventor to freely publish their invention without losing patent rights.	If the invention has become publicly available in any way before the patent application was filed, the application will be rejected.	Same as EU.
Limitations	A patent does not assure that the patentee can practice the invention during the entire patent term. There may be a dominant, or “background,” patent owned by another, which must be honored, until that patent expires.	Same as US.	Same as US.
Patent examination	The application is automatically examined.	Same as US.	Separate request necessary. Request may be made by anyone, including third parties, at any time within seven years from filing date. Otherwise application is considered to be withdrawn.

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	United States (US)	European Union (EU)	Japan (JP)
Publication of patent applications	Applications published 18 months after filing date unless withdrawn or filed with a non-publication request, stating that application is US only.	Applications are published 18 months after their filing date, unless they have been withdrawn.	Same as EU.
Opposition after the grant	Re-examination allows anyone to present reasons and evidence to USPTO to challenge the validity of a granted patent. Patent holder then engages in a discussion with the USPTO examiner to establish the validity of the reasons. The challenger is not a part of these proceedings.	Nine months after the granting of a patent, anyone can file an opposition with the EPO with arguments and evidence. Patent holder and opponent then debate with each other in writing and orally before the EPO. Usually a final decision is made by the EPO, although sometimes a continuation is made in writing. Both parties can appeal the decision, which once again results in an exchange of letters followed by oral proceedings.	The procedure is quite complicated but has some similarities to that used in the EU. The patent is valid unless declared otherwise. Oppositions must be filed within six months.

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	United States (US)	European Union (EU)	Japan (JP)
Appeals	Four to five years	Same as US	Same as US
Filing and search fees ³	690	810 + 532	210
Examination fees ³	—	1,431	1,100
Grant fees ³	1,210	715	850
Renewal fees ³	2,730	16,790	5,840
Translation costs ³	n/a	12,600	n/a
Agent's fees ³	5,700	17,000	8,450
Total cost for obtaining patent ³	10,330	49,900	16,450
Time period for granting a patent	Two to five years.	Two to five years.	Three or more years.

¹ US Patent and Trademark Office.² European Patent Office (headquartered in Munich).³ Cost in euros at 2002 prices.

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Commercialization of Refractory Innovation¹

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An idea which guided Fredrich and Henry's actions for last two years was to setup business with own insulations for industrial furnaces. There has been a stream of often bold ideas like the one generated upon Henry's return from Japan where he was working for four years on his academic degree. It was Fredrich's decision to meet the financing need for the venture by pooling private resources and to stretch the retiree's budget to co-finance the project. The initial idea of running both production and sale had been pervasive but after experiencing difficulties with obtaining financing for their plan, they had to consider sharing the business with another company, keeping only the production and primarily supply the company. This plan was to provide appropriate facilities for production. Unfortunately, this cooperation as well as an effort undertaken with several other parties has

¹ Dr Švéda is associated with Accenture Research in Prague, Czech Republic. Although the case is based on real experiences this version of the case was developed for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the author or be reproduced in any way. All names in this case were changed.

been unsuccessful in securing the much needed financing. Because of a lack of funding the project was temporarily halted. Currently, the work has been restarted with the goal to ultimately sell the invention.

The Problem Background

Fredrich is an engineer, who throughout his working life worked for a company producing chamotte firebricks used in facilities for production of glass, steel and iron. He began as a University graduate in the 1960s initially overseeing start of production in several new high-temperature industrial furnaces in areas of Czechoslovakia. Later he supervised mining processes of clay materials, worked on development of applications from the waste mining materials, and for a short time worked for the development department focused on improvements in the design of industrial furnaces. Over the years, he developed several improvements for his company products bringing in new earnings. However, his own benefits were meager, given that he was all the time in conflict with the communist ideology and the company management. When he retired, he began to freelance designing systems for using waste energy in companies and building non-typified fireplaces for houses. Also, he tried to elaborate on some older puzzles from his professional career. Among them, one was related to insulations for high-temperature furnaces. Eventually, he conceived idea of a different approach to production of the insulation firebricks which led to the product unique characteristics. Based on his past experiences and despite management and ownership changes, Fredrich had reservations regarding collaboration with his previous employer. Instead, he discussed the invention with his son Henry hoping to get him involved in the project.

Henry was educated as an economist and at the time his father retired he was pursuing postgraduate study. He obtained a scholarship to study in Japan, where he worked on research models studying consumer demand for new hi-tech products, economics and marketing of new products. At the end of his fourth year in Japan he decided to return to his hometown to help determine whether his father's idea was commercially feasible.

In spring 2005, Fredrich and Henry got together and began intensive experimenting with new materials, producing variants of firebrick insulation via the new production process. Additionally, Henry began to collect market intelligence. Within six months they produced samples of an insulating firebrick which could be offered to customers. These team completed the patent application and found an attorney who provided the legal advice. They managed to receive measurements of their products' thermal conductivity in the research laboratory of a nearby Technical University. Also, through Fredrich's friends in the previous employer company they were able to get precise data on the product properties, such as crushing strength, permanent linear change during and after product exposure to high temperature, and precise chemical content of their products. The entrepreneurs were able to calculate savings gained through their products' better insulating property and this together with researched competitors' product prices led to suggestions for pricing of their own products. They calculated the costs of the production and sale, and determined that the business idea was feasible. Then Henry began contacting potential customers to present the product.

The Role of Insulation in Thermal Equipment

Heat insulating materials are important parts of thermal equipment, e.g., furnaces and kilns. Such materials decrease energy losses during the equipment operation and protect equipment construction from the heat effect. Thermal and mechanical attributes of the insulating materials have a large influence on the design of the whole equipment. Traditionally, thermal equipment has an internal wall made of dense refractories, middle layer made of insulating materials, and external wall made of construction materials. Modern equipment has an internal wall made of thermal insulating materials and an external wall made of construction materials. Such a design is possible if insulating material has great thermal, mechanical, and chemical characteristics. This is advantageous primarily for periodically operating equipment or for the equipment working in variable

heat regimes. High-quality insulating materials have the following characteristics:

- Low thermal conductivity;
- Low density;
- High strength;
- Minimal linear changes during and after heat exposure;
- Ability to be cut and ground easily;
- Dimension accuracy;
- Ability to be applied under various working conditions.

The above characteristics are typical of lightweight insulating firebricks, produced from natural and synthetic materials. Compared to ordinary brick, lightweight insulating firebrick is very light because it has many pores inside. The pores are filled by air, which has the great insulating property. The insulating firebricks are used at temperatures from 850°C to 1,650°C (from 1,550°F to 3,000°F) in glass furnaces, ceramic kilns, steel furnaces, reactors and stills in chemical and petrochemical industries.

Refractory Innovation

Production of lightweight insulating firebrick has usually the following phases: material mixture preparation, forming of a desired shape from the prepared mixture, drying, firing and final adjustments. Essentially, there are two methods to obtain the porous structure:

- *Foaming* — adding foam-formatting agent into material mixture; this agent creates small bubbles (pores), and
- *Burn out* — adding organic particulars into material mixture; these particulars burn out during firing stage and in their places appear pores.

Usually, the material mixture is bulk or elastic containing less than 20 percent of water. Fredrich and Henry's innovation is linked to a new way, forming shape out of a material mixture of which water

makes up at least 60 percent. The novelty of this approach lies in the use of elastic, porous form able to absorb into its pores liquid, ceramic mixture. The elastic form is squeezed and sunk in the liquid, ceramic mixture. When the pressure on the form is released, the insulation gets its initial shape and simultaneously absorbs liquid ceramic mixture into its pores. After the pores have been filled, the form must be able to also keep the mixture inside for the next production phases and manipulation. This effect is due to appropriate selection of material of the elastic form, size, and shape of the form pores, appropriate density and viscosity of the ceramic mixture.

The porous structure is then created in a new way, due to the release of water from the liquid ceramic mixture during drying and firing. During drying phase, the liquid mixture, which filled the initial pores of the elastic form, starts to create new porous structure. New pores are bounded by ceramic material, which is stacked on the surface of the form pores. Water released in the process creates more pores. The structure is created during drying as most water is released up to temperature 105°C. During firing, the rest of the water (chemically bonded) is released, the creation of the porous structure finishes, elastic form burns out, and the ceramic material sinter and strengthen. Porous ceramic material with high pressure resistance is created. As the initial ceramic mixture contained high percentage of water, there are large weight and volume changes during drying and firing when the water is released and it is possible to produce articles with very low density and low thermal conductivity.

An important factor related to the usage of elastic form (apart from its ability to absorb and keep liquid ceramic mixture) is allowing for large size changes during drying and firing without disturbing (rupturing) the porous ceramic structure.

Compared to the traditional production process of lightweight insulating firebricks in temperature of about 1,540°C (industry standard 2,800°F), the new production process results in a product with quality superior to all producers worldwide. Value of a lightweight insulating firebrick for a particular temperature is given by a low thermal conductivity (related to bulk density of the brick) and a high

Table 1. The technical parameters of insulating products.

Producer	Fredrich and Henry Novak	Thermal ceramics	PD refractories	Refrasil	Promat
Product		JM 28	SL 10–50	HB 7/15	Promaton 28
Hot face use limit [°C]	1,538	1,538	1,500	1,500	1,540
Thermal conductivity [W/m·K]	0.25	0.39	0.47	0.7	0.38
Bulk density [kg/m ³]	600	881	1,000	700	880
Cold crushing strength [MPa]	7.6	1.51	6	2	2.4

pressure resistance. The two properties are traded off when firebrick is produced by the two classic methods, so they cannot reach the low thermal conductivity and the high strength of the innovated firebrick. Table 1 shows the comparison of technical parameters of the new firebrick and competing products.

Value and Pricing

The lower measure of thermal conductivity translates directly into savings for energy per brick. This value, together with the price of the competitors' products, is used as a base for pricing the new product. Additionally, the furnace designer can use the innovated firebrick in places, which are more stressed or where a risk of damage caused by improper manipulation exists. In these places, a designer had no option but to use combination of dense firebricks (withstand the higher stress but does not insulate well) and supplementary insulating material. Instead of this costly scenario, now a designer can use the new firebricks and save additional money. Importantly, the innovated product gives a designer freedom for his work because he does not need to consider the restraint given by trade-off between insulating and strength parameters of a material.

Example of energy savings: middle-sized industrial furnace — eight cubic meters

Consider internal size $2 \times 2 \times 2$ m and the typical wall thickness 46 cm. Four walls of the furnace have area 16 m^2 (insulating firebricks are usually not used for the floor and ceiling of the furnace; floor is from high strength material and ceiling from fibrous material). Figure 1 shows the design of the furnace walls.

Notation and parameters:

Coefficient of thermal conductivity for the innovated lightweight firebrick with density 600 kg/m^3 is $\lambda_{600} = 0.24 \text{ W/m}\cdot\text{K} = 0.2064 \text{ kcal/m}\cdot\text{C}$.

Coefficient of thermal conductivity for lightweight insulating firebrick of the market leader Thermal Ceramics with density 880 kg/m^3 is $\lambda_{880} = 0.39 \text{ W/m}\cdot\text{K} = 0.3354 \text{ kcal/m}\cdot\text{C}$.

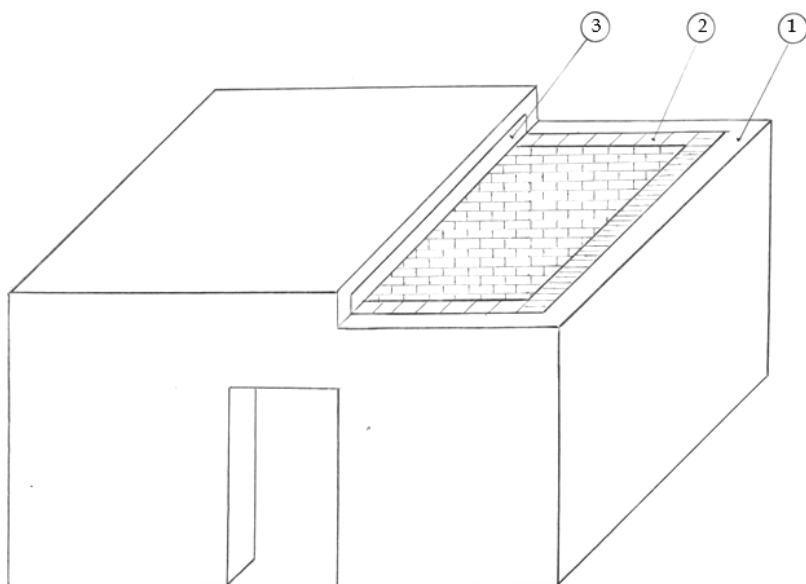


Fig. 1. The usage of lightweight firebricks in furnace design. *Legend:* 1 = the external wall; 2 = internal wall of insulating firebricks; 3 = ceiling.

The difference in energy consumption is made by (a) difference in heat transmission out of the furnace, and (b) energy needed to heat different mass of lining to the desired temperature.

Savings through better heat transmission

The heat transmission can be calculated using the following formula:

$$Q = S \cdot \Delta t / (s/\lambda + 0,1),$$

where S is the area of walls, s is the thickness of the wall Δt is the difference between temperature inside the furnace and the external environment (for temperature inside of furnace, about $1,500^{\circ}\text{C}$, we consider $\Delta t = 1,450^{\circ}\text{C}$).

For lining from firebricks with density 880 kg/m^3 :

$$Q_{880} = 16 \cdot 1,450 / (0.46/0.3354 + 0.1) = 15,767 \text{ kcal/h}$$

For lining from firebricks with density 600 kg/m^3 :

$$Q_{600} = 16 \cdot 1,450 / (0.46/0.2064 + 0.1) = 9,920 \text{ kcal/h}$$

$$\text{Then, } \Delta Q = Q_{880} - Q_{600} = 5,805 \text{ kcal/h.}$$

Assume that a typical firing cycle duration in a furnace is 100 h. In a one-year period a furnace typically goes 50 times through the cycle. Then,

$$\Delta Q = 5,805 \cdot 100 \cdot 50 = 29,025,000 \text{ kcal/year.}$$

Savings through energy needed to heat the mass of lining

The energy needed to heat 1 kg of lining, with the internal side temperature of $1,500^{\circ}\text{C}$ and external side temperature of about 50°C . (The average temperature for the profile of the lining is equal to $(1,500 - 50)/2 = 725^{\circ}\text{C}$)

$$\text{is } Q = 0.27 \cdot 725 = 195.75 \text{ kcal.}$$

The difference in weight between the linings with density 880 and 600 kg/m³ for the four walls is

$$(880 - 600) \cdot 4 \cdot 4 \text{ m}^2 \cdot 0.46 \text{ m} = 2,061 \text{ kg}.$$

Thus, the energy saving is

$$\Delta Q = \Delta m \cdot Q = 2,061 \cdot 195.75 = 403,441 \text{ kcal}.$$

For 50 cycles a year this produces savings of

$$\Delta Q = 403,441 \cdot 50 = 20,172,038 \text{ kcal}.$$

The total savings

Total energy savings consist of the sum of savings from heat transmission and energy needed to heat the lining mass:

$$\Delta Q = 29,025,000 + 20,172,038 = 49,197,038 \text{ kcal/year}.$$

Assuming the energy price of 1 CZK for 1,000 kcal (kWh) this translates to the yearly savings of

$$49,197,038 / 1,000 = 49,197 \text{ CZK/year}.$$

For the four walls of the furnace with size 2×2 m and thickness of lining 0.46 m, the designer needs 4,280 bricks with a standard size of $230 \times 114 \times 64$ mm. The yearly savings per one brick are

$$49,197 / 4,280 = 11.50 \text{ CZK/year}.$$

Thus, the new firebrick that costs 30 CZK more than the traditional one has better insulating properties. At 2006 prices, this produces a payback in three years for furnaces with a typical life span of 15 years and more.

The Market Structure

Market with lightweight insulating firebricks has a complex structure. Figure 2 depicts a chain, through which the product is marketed. Demand for the new insulating products in the Czech Republic is mainly determined by economic conditions in ceramic and steel industries. Ceramic and steel companies (the upper most part of Fig. 2) use this type of insulations in their high-temperature furnaces. The steel and ceramics manufacturers outsource furnace design, construction, and often maintenance to specialized engineering firms.

Designers from the engineering firms decide which material is used for construction and maintenance of the furnace. The engineering companies operating in the Czech Republic can be classified either as companies with own production of insulating material and reaching global markets or regional firms which purchase the insulating material. Frequently, regional engineering firms own their own construction departments, which build the furnaces. On the other hand, global engineering companies sometimes outsource the construction work.

The decision on insulating material is never made by a firm, which constructs the furnace (third level from the top in Fig. 2).

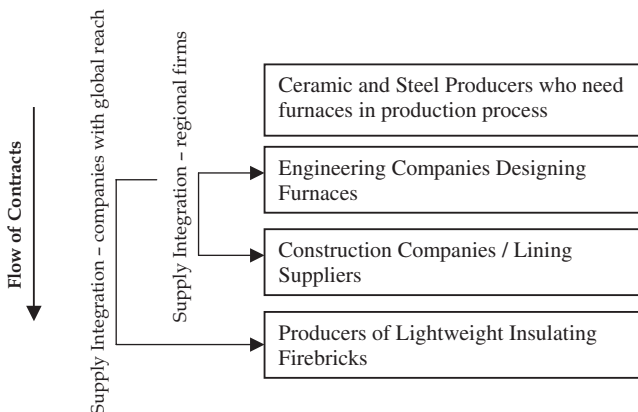


Fig. 2. The market with lightweight insulating firebricks.

The firm may be given an outsourcing contract from the engineering company to build the furnace but even though the construction firm has its engineering department it never decides on the applied material.

In the bottom of the supply chain are large companies which produce the firebricks together with a broad range of other refractory or ceramic products.

The structure of the industry presents major problems for the entrepreneurs. First, larger engineering companies usually use their own insulating materials. Second, the entrepreneurs' products are used as components in products marketed by a different company: a furnace engineering company.

The industry structure was a surprise particularly for Fredrich who had worked on a broad range of technical issues related to furnaces but had not deep insight in current business issues among the market participants. The supply chain relations and communications differ largely from communist and early post-communist transition times. The originally planned direct selling model to end-users primarily for furnace maintenance applications was found unrealistic. Today the end-users apply materials according to maintenance plan prepared by specialized engineering maintenance vendors.

Thus, an engineering company, which bids to supply a furnace project, would need to specify the new insulation product: The challenge for the entrepreneurs is convincing customers that a higher price of furnace that is built with innovative insulation will be recovered in energy savings over a period of approximately three years from installation or a quarter of a furnace lifetime. According to experienced bidders the selling task would be extremely difficult in a price-sensitive market. Decision-makers on the end-users' side are typically inexperienced in the technology of industrial furnaces. The purchase decisions are made based on simple criteria and aim at achieving short-term goals. This approach leads to a suboptimal equipment selection decision that is based solely on price alone rather than on considering the total of acquisition and operational costs over the lifetime of a furnace.

Market Structure Implications for Demand and Financing

Henry has contacted four furnace engineering companies with the regional reach and one with the global reach. All the firms expressed interest to examine samples of the product to verify the claimed technical parameters of the new insulating material. Provided that the test results confirm the claim they would proceed to use the products for construction and maintenance. However, order sizes and timings could be predicted since the demand could not be reliably estimated. By word of one manager:

We are sure that within two years period we will get at least one contract where we could use your firebricks. But we do not know when this happen. At the time we would come to you and say that we need 30,000 bricks within 3 months. I do not think that you can produce to stock and wait for such order; you need flexible production switching among various ceramics according to demand. That is the business model which works for suppliers of refractory insulations.

If the managers' statement about production volumes were to materialize it would no longer be a small business with differentiated product appealing to a niche market. Clearly, the entrepreneurs have neither capabilities nor resources to enter the high volume business.

The managers of contacted companies have estimated the demand to be at least 30,000–50,000 bricks in a two-year period, which would be enough to quickly secure the breakeven quantity of 60,000 bricks/year. But the absence of the contracts with customers and the volatile nature of demand make it too risky for banks or venture capital to finance the project.

Funds are needed mainly to cover the purchase of the production equipment, which of by far the largest amount is tunnel furnace for firing the bricks. A few commercial banks were introduced in the project but their response for financing were negative. Given a lack of business history it is very difficult for Czech start-ups to obtain a bank loan. Therefore, attention was turned to alternative ways of financing. New financing forms, well established in developed markets, are just

emerging in the Czech Republic. Venture capital funds and business angels are relatively new, which makes the situation complex and loans expensive to use. During a search for investor, Henry entered talks with three business angel funds. One was uneasy with the demand issues and two replied that they preferred to invest in much larger projects rather than in start-ups. The demand for funds from businesses is currently high and providers do not need to enter relatively risky ventures with the start-ups.

Cooperation in Production

Among the contacted engineering companies was one with a global reach and own production of refractories. The new firebricks would be an advantageous extension of their existing refractory line. Exclusive supply of the innovated products for the company was planned in exchange for help on the early development and later production of the firebricks. The new insulations would be fired in the company's furnace placed in the entrepreneurs' facility. The furnace would be paid for by the supply of the innovated firebricks. Initially, the company agreed on the cooperation, but it turned out that the high temperature facility that was to be offered to try the inventors' approaches did not work properly due to the relocation of the company's equipment. As a result, the cooperation was postponed.

The firebrick production process consists of the following phases: preparing mixture, forming, drying, firing and final adjustments. Most problems originate from the firing stage, which has to be completed in a high temperature facility. Such facility is not common in the Czech Republic. Essentially, the suitable equipment for firing is presently in the hands of the potential future competitors who are also well funded. Fredrich initially got help from his former colleagues who informally informed him when a suitable firing cycle was scheduled in a facility of his previous employer. He then added the dried samples to the regular scheduled production batch going through firing. For obvious reasons this approach was not feasible for larger sets of samples.

Unfortunately, parties that would potentially benefit the most from such collaboration were most reluctant to cooperate. A local company producing tiles agreed to help with unused facility because it produced in furnaces with lower firing temperatures. However, immediately there was a problem with their time flexibility, which would affect delivery of samples as scheduled for customer. In the meantime the entrepreneurs have determined that the company had a long history of illegally copying product know-how. As a result cooperation with them was immediately curtailed.

The larger sets of samples were fired in two alternative facilities neither of which had firing conditions optimal for the innovated products. Inappropriate firing conditions adversely affected quality of a part of the production batch, but most of the samples turned out to be of acceptable quality and were used for testing. The trial run results were satisfactory enough to make both companies offer access to the furnace for production.

The Managerial Task

It has been 18 months since the initial contact. High volume production at a company that promised to deliver the furnace for production and received the samples for testing has not started yet. Meanwhile, it was learned that a manager from the potential partner company briefed Fredrich's previous employer about the project. This was done despite the entrepreneurs' requests to keep the business idea in secret. Confidentiality was needed because the past employer company would be a future competitor and the patent application was pending. The manager knew about the entrepreneurs' desire not to advertise their business intentions.

Fredrich and Henry contacted the company a few times for the test results of their firebrick samples and for further discussion on cooperation. They got only responses about additional complications in the company, which further delayed the project. In order to produce another set of samples, the entrepreneurs needed to stop their work temporarily.

With the new funds secured recently, the entrepreneurs decided to pay for the services of a renowned patent attorney. If the patent rights are granted, Fredrich and Henry will probably try to sell the production idea.

Summary

The following problems and issues need to be considered in the case discussion:

- What are the sources of venture funding available to the inventors?
- What are the difficulties encountered by small companies and individuals in commercializing their innovations?
- What are the steps in commercializing the innovations?
- What is the process and expertise needed in selecting partners for idea commercialization?
- Should the entrepreneurs sell their idea? What are the alternatives? In considering the alternatives, justify your choice.

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Management Training Issues in Engineering-Driven Companies: The Case of Ultrahone, Inc¹

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The need to develop management expertise in engineering-driven companies is an important strategic issue that concerns many of today's businesses. The most urgent case for such programs can be made for government-controlled businesses located in Central and Eastern Europe (CEE), the former Soviet republics (CIS), as well as businesses located in Latin and South Americas. The privatization programs introduced there have led to a drastic change in the ownership structure of many industries and increasing market liberalization. The creation of open markets has suddenly exposed these traditional manufacturing businesses long accustomed to receiving unconditional government protection in the form of tariffs, quotas and duties to global competitive

¹ This case was prepared by Professor Tom Bramorski of the Department of Management at the University of Wisconsin-Whitewater for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the author or be reproduced in any way.

threats. The engineering-educated management of these companies has sometimes failed to recognize, in a timely fashion, the magnitude of this competitive threat. This has led to the demise of numerous businesses that failed to find a niche for themselves in the new economy.

The change of ownership of existing manufacturing companies through privatization has been accompanied by an increasing trend in the number of new small- and medium-sized businesses (SMEs) that are privately owned. In Poland, for example, these businesses currently contribute in excess of 60 percent to the nation's GDP with a growing trend as the privatization programs of government-owned businesses progresses and new business start-ups intensify.² New start-ups are often able to attract managerial talent much better than the former state-owned enterprises and produce an increase in demand for individuals with knowledge of open market business management practices. One of the most difficult problems for privatized companies in this new business environment has been developing, recruiting and retaining employees with good managerial skills. The problems in this area necessitate the creation of human resource management and development programs as a necessary condition to make possible efficient operation in a way that would enable them to achieve a sustainable competitive advantage in an open market.

The problem of making an effective business transition from that of engineering-driven to market-driven is also an important issue in North America and Europe. Manufacturing businesses in these markets have faced intense competition from the Far East for years and many of them have not been able to find a winning formula to stop and reverse their market share gains.³ The traditional manufacturing base in the United States has been declining while the market share of imports from the Far East has been steadily increasing over the last decade. As evidenced in Exhibit 1, this trend has been accompanied by higher productivity improvements in Far Eastern plants compared to facilities in Europe and North America.

² Country-specific pages of United States Department of Commerce website at <http://www.commerce.gov/>.

³ Source: Industrial output statistical data available at OECD's website at <http://www.oecd.org/>.

Exhibit 1: Automotive plant productivity comparisons.

Regional location		Vehicles per employee (1977)	
Parent company	Manufacturing plant	Best	Worst
European	Europe	70	26
Japanese	Europe	98	58
	Japan	147	99
	North America	87	72
North American	Europe	77	59
	North America	87	50
South Korean	South Korea	103	98

Source: Hill, T (2000). *Manufacturing Strategy: Text & Cases*, 3rd Ed. Irwin/McGraw-Hill.

This case focuses on the issues that need to be addressed in the process of development of effective management training programs for engineering personnel. Understanding a broad spectrum of managerial issues will help improve competitiveness of manufacturing and engineering driven businesses that choose to adopt them. The issue of economic survival of manufacturing and engineering driven firms is an important issue of concern to the general public as it directly determines the firm’s ability to compete on manufacturing-related and manufacturing-specific order-winning criteria in the future.

Competitive Priorities of Engineering Businesses

By using long-term strategic planning and competitive analysis tools, businesses determine the markets in which they intend to compete, the products and/or services to be offered in these markets and the set of competitive priorities that they will need to support. From the manufacturing perspective, these priorities include:

- *Manufacturing-related and manufacturing-specific criteria.* This category includes criteria that are specific to manufacturing and will usually form part of the manufacturing strategic role. They

include price, delivery reliability and speed, quality of design and quality of conformance, volume flexibility, and product range.

- *Manufacturing related but not manufacturing specific criteria.* This category includes criteria that are specific to manufacturing but do not usually form part of a manufacturing strategic role. They include low cost manufacturing, product range, lead times, and distribution advantages.
- *Non-manufacturing criteria.* This category includes criteria that are not specific to manufacturing. However, manufacturing will typically be required to support one or more of them. They include design leadership, being an existing supplier, marketing and sales strengths, brand name, technical liaison and support, and after-sales support.

Engineering businesses naturally tend to emphasize competitive priorities that are determined to a large extent by design and engineering functions. These priorities, which are underlined in the above list, include quality of design and quality of conformance, product range, design leadership, and technical liaison and support. While supporting this fairly narrow subset of competitive priorities may be sufficient for some highly technical and industrial products in some markets, it is generally not sufficient in most others. For example, the definition of quality that needs to be supported in today's markets is the quality of performance that is determined by the customer rather than the design, engineering, and manufacturing departments. Many businesses that do not perform well in today's dynamic markets fail to take this into account. In order to maximize the engineering firm's chances of achieving business success as measured by business results there is an urgent need for business knowledge transfer to engineering people who often own or manage these businesses.

The management staff of successful engineering businesses need to identify the factors that should be used to estimate the probability for an engineering firm making a successful transition from a technocracy to a flexible business that is inherently adaptable and is always attuned to current and future customer needs. The literature on the prediction of business success identifies 15 predictor variables that include

the following business variables: measures of capital, record keeping and financial control, industry experience, management experience, planning, professional advisors, education, staffing, product/service timing, economic timing, age of owner and ownership structure, minority and race factors, and marketing skills.⁴ A recent study compared the findings available to date on the subject and identified several factors as useful predictors of business success for SMEs operating in the United States and Central and Eastern Europe⁵: These findings reaffirm the importance of training engineering personnel in the managerial issues of process improvement and productivity development as well as instituting appropriate employee recruitment and retention programs in organizations. The factors facilitating the transition identified in the literature include:

1. *Availability of capital.* Small engineering businesses that are undercapitalized have a greater chance of failure than firms that have adequate capital availability.
2. *Management experience.* Businesses managed by people without prior management experience have a greater chance of failure than firms managed by people with prior management experience.
3. *Planning process sophistication.* Businesses that develop and follow strategic business plans have a greater chance of success, compared to those that operate without strategic plans.
4. *Use of professional advisors.* Businesses that use professional advisors have a greater chance of success than firms that do not use them.
5. *Record-keeping and financial control procedures.* Businesses that keep updated and accurate records and use appropriate financial controls have a greater chance of success than firms that do not use them.

⁴ Lussier, RN and S Pfeifer (2000). A comparison of business success versus failure variables between US and Central Eastern Europe Croatian entrepreneurs, *Entrepreneurship Theory and Practice*, 24(4), 59–67.

⁵ Lussier, RN and S Pfeifer (2001). A crossnational prediction model for business success. *Journal of Small Business Management*, 39(3), 228–239.

6. *Industry experience.* Businesses managed by people with relevant business experience have a greater chance of success than firms managed by people without it.
7. *Education.* People with at least some college education who operate a business have a greater chance of success than people without it.
8. *Staffing.* Businesses that attract and retain quality employees have a greater chance of success than firms that do not do this. The successful owners or managers tend to understand the value of good employees better than their unsuccessful counterparts.

Other factors that may be perceived as relevant to an engineering firm's business success were found to be either statistically insignificant or their importance has not been validated across several cited studies. The conclusion to be drawn is that successful engineering firms must first identify the challenges presented to them by the market and then appropriately address these challenges to align current and future market needs in selected market segments with their capabilities. Successful businesses realize that customer preferences in market segments in which they operate are dynamic and the strategy alignment process should be ongoing to keep capabilities compatible with changing preferences of customers. In order to be able to achieve these goals, engineering firms need to acquire managerial expertise.

Company Background

UltraHone, Inc. was incorporated in the Midwestern United States in 1957 as a closely held family-owned small corporation specializing in custom design and engineering of metal sheet products. In its early years the company employed 12 to 20 engineers — most of them on a part-time contract basis. As the price-based competition in the industry intensified, the company decided in 1975 to shift its interests to designing and manufacturing custom honing machines

that are used in manufacturing automotive engines. This major strategic move was made after conducting a detailed market study that was completed with the assistance of a respected strategy consulting company. The consultants also provided UltraHone with guidance in making the transition. Over the years, the company has grown from a small business to a nationally recognized and respected design and engineering firm with 250 employees. Today, the company still remains closely held and continues to locate its facilities in the same general Midwestern location. However, since its incorporation the company has made significant capacity and capability investments adding land, several buildings and modern engineering technology infrastructure.

Robert Green, the owner of UltraHone is especially proud of their latest 2001 technology acquisition, the multi-CAD engineering process management platform for multi-site product teams. He notes:

The deployment of these systems should have enabled us to dramatically improve the development speed and quality of our designs and to implement team engineering throughout our organization. We have several buildings here but our engineering teams no longer have to be physically in one location to work on projects. Even though they can now collaborate entirely in an electronic domain they seldom take advantage of the new systems capabilities. This new system has cost us a lot of money and we should now be able to get custom design solutions to customers on average 30 percent faster than before the CAD system implementation while reducing our development and manufacturing costs by 25 percent. But right now we are nowhere near these targets!

The multi-CAD system implemented by UltraHone was expected to accelerate new product introductions while increasing the innovative capabilities of engineering processes. The system enables electronic communication and collaboration for complete digital product development in all phases of product development from initial concept to finished machine. It provides complete digital documentation

and communication support between engineering teams at different physical locations. The system also makes possible the creation, simulation, optimization, documentation, manufacturing, and testing of new product solutions within a fully integrated digital environment. These features should produce significant quality, cost and speed advantages for the entire organization.

Robert Green added:

With so much depending on the effective system performance, particularly in the early stages of our product lifecycle, we needed to find ways to establish sustainable competitive advantages in several areas. We have retained the services of the same consulting firm that helped us make a successful transition to custom honing machines back in 1975. They have helped us identify opportunities to build a sustainable competitive advantage in the following areas:

- Integration of all of the CAD designs created by the value chain to define our product's engineering content;
- Synchronization of the engineering processes and data that require the participation of the entire value chain and efficiently managing their access to our entire product information database that they need to access to get their jobs done. Our design and manufacturing engineers are now able to synchronize design data, share design models in workflow-driven processes, and collaborate in an entirely digital environment. By combining these capabilities our company is now able to improve product quality, and reduce time and cost to manufacture;
- Enabling secure, effective and coordinated access to all information related to the product definitions by all engineering project teams irrespective of their physical location or the physical location of any of the team members. This feature ensures that everyone in our value chain is working from the same product assumptions;
- Establishing product configurations that can be managed, tracked, and re-used across an entire product lifecycle, and across multiple product offerings;

- Accelerating product delivery and the introduction of new product offerings by enabling design and engineering teams to seamlessly collaborate with manufacturing teams; and
- Leveraging technology acquisitions and enabling efficient cooperation by tightly integrating existing CAD system platforms, specifically including the existing IMAN PDM CAD/CAE/CAM Unigraphics and AutoCAD systems while allowing for future system expansion.

Robert Green continued:

After UltraHone installed the new multi-CAD process management system we expected to quickly realize significant strategic and operational benefits. We anticipated major increases in product innovation and engineering design process flexibility with improvements in quality and concurrency in design and manufacturing. We also wanted to be able to overcome the traditional barriers to communication among OEMs, suppliers, and their partners. Internally, similar communication problems exist between our engineering, manufacturing and managerial staffs. After the system deployment each group suddenly began to vigorously protect their turf. This has resulted in the anticipated productivity improvements of engineering teams going unrealized. Our new system has the ability to improve product dimensional quality through digital simulations, which was found to be a valuable tool allowing engineers to catch costly design mistakes early in the product development process. These software tools support visualization, dimensional analysis (3D tolerance analysis), quality data viewing, digital mockup, publishing, collaboration and project management. With the new system we should be able to serve our customers faster, and cheaper. Yet, with some exceptions, such as data security, these high expectations have not materialized. Our engineers continue to operate the same way as before the new system implementation and refuse to utilize the new system's capabilities. I guess I will have to personally fire a few of the most stubborn ones to show the rest of them that they will have to use the new system from now on or find a job elsewhere!

Market Highlights

UltraHone offers designing and manufacturing honing machines for industrial customers worldwide. It competes with many similar firms to win contracts to provide such equipment. Its primary customers are the government military and all major combustion engine manufacturers for the Big Three US automakers. When UltraHone receives a contract, it creates a project to complete the work. Most projects for new custom-designed machines cost from \$2 million to \$15 million and last from six months to two years. The total cycle time for these projects includes designing, engineering, manufacturing, testing, shipping, with assembly and installation on the customer site. Some machines have considerable size and weight that severely limit the shipping options. All machines include precision-machined components and electronic controls that eliminate shipping by rail and river barges. As UltraHone aims to achieve 100 percent conformance quality for their products, all machines are assembled at the company for testing purposes prior to shipment to the customer. If the machine passes the rigorous performance test it is then shipped to the customer. For machines that cannot be shipped as one unit to the customer, special crews disassemble the equipment that was tested and pack the components into major modules. These modules are carefully wrapped, packed, labeled and loaded on trucks for shipment. After the equipment arrives at the customer's facility, it is installed and calibrated by UltraHone's setup crews. The firm provides maintenance and service support for equipment under warranty and out of warranty. UltraHone can have 6 to 10 projects going on at any one time, in various stages of completion.

Another segment that has been growing steadily in recent years has been servicing and repairing of the installed product base of UltraHone's own and the competitor's equipment. Despite a recent slowdown in the economy following the electronic business bubble burst of 2001 and the events of 9/11, the UltraHone service and repair business has been doing very well. Robert Green attributes this to the fact that his major customers have recently become more fiscally conservative given the slowdown in the

economy and market uncertainties. He noted: "Our customers prefer to keep whatever equipment they have and postpone major equipment purchases until the situation stabilizes." But older equipment is more prone to breakdowns, which creates an additional niche for us, he added.

Problem Overview

UltraHone has several project managers who report directly to Robert Green. Other employees report to their functional manager. For example, the electronic engineers all report to the manager of electrical engineering, who reports to the general manager. The functional manager assigns individuals to work on the projects. Some employees work full time on a project, while others split their time among two or three projects. Although individuals are assigned to work for a project manager on a specific project, administratively they still report to their functional manager.

George Magnusson has been with the company for six years, since graduating summa-cum-laude from a leading engineering college in the US with a BS degree in mechanical engineering. He has gained significant experience on several projects and has worked his way up to senior mechanical engineer. He now reports directly to the manager of mechanical engineering, has worked on many projects, and is well respected within the company. From the time he joined the company, George has been seeking an opportunity to become a project manager. In early 2002, UltraHone was awarded a \$15 million contract by one of the Big Three US automakers to design, manufacture, and deliver 50 special-purpose honing machines for the manufacture of their newest generation DOHC 32-valve 4-cam V8 variable valve lift engine cylinder blocks. Robert Green promoted George to the position of project manager and asked him to manage this project.

George works with the functional managers to get the best people available assigned to the project. Most of the people are his good friends who have worked with George on several previous assignments. However, with George's position as senior mechanical engineer now vacant, the manager of mechanical engineering has no one with the

appropriate level of expertise to assign to George's project. After a brief assessment of his staffing needs and a rush recruitment process the manager quickly hired a new person, Ted Hancock, to fill the vacancy. Switching jobs on such a quick notice was a painful experience for Ted. He had a promising career with a competitor located in the general proximity of UltraHone right in the center of the modern industrial park. Even though his new assignment did not involve household relocation, Ted is beginning to have second thoughts. Ted has a PhD in mechanical engineering and 23 years of industry experience as a designer and product engineer. Because of his impressive education and experience portfolio he was able to negotiate a much higher compensation package compared to what he was making at his previous employer. His contract with UltraHone also includes a \$75,000 sign-up bonus and a profit-sharing plan — an option usually reserved only for top management. In addition, his medical and retirement packages offered by UltraHone are much better than in his previous job. These benefits, he figured, more than justified a jump. "I left a good group of colleagues and professionals," he said, "but here they made me an offer I could not refuse!" After several days on the job Ted realizes that his high salary and generous fringes are much more than all other professional employees outside of UltraHone's top management are making. Since he was hired to replace George's expertise he is promptly assigned to his project on a full-time basis as the senior mechanical engineer.

George takes a special and unusual interest in Ted's work. He often asks to meet with him to discuss his design approaches. He often wants Ted to explain to him the multi-CAD system capabilities and operational features. He admits openly: "We did not cover these systems at college." Most of these meetings turn into monologues with George always taking the control position and suggesting how Ted should do his design work. He rarely pays attention to what Ted has to say on the subject of his innovative design approaches and new CAD technologies. Ted is growing increasingly impatient with the situation and after some deliberation confronts George and asks why he is spending so much more time reviewing his work compared to the contributions of the other engineers on the team. He responds: "I do not have to check their work. I know how they do their work and

what their capabilities and limitations are. In the past I worked with them on multiple projects.” Then George adds: “You are a new hire and I want to be sure you understand the way we do business here at UltraHone. This is probably much different than at your previous employer. On the technology issue, it seems to me that you are quite knowledgeable in the particulars of our new multi-CAD system, but in my view, there is no future for this toy at UltraHone.”

A few days later Ted shows George a unique creative design approach that will, in his opinion, result in significant quality improvements and a cost reduction for the company. This new approach takes full advantage of the new multi-CAD system capabilities. We will be able to deliver the project to the customer two weeks before it is due and well within budget, adds Ted enthusiastically. George responds, “I do not even have a PhD in mechanical engineering and I can clearly see that your proposed idea will not work. Do not be so sophisticated in your design approaches! You better simply follow the basic sound engineering approaches that we have developed and refined here over the years.”

Ted’s frustration with the situation is becoming apparent. During a business trip to a customer with several colleagues from the mechanical engineering group assigned to the project, Ted confides that he is extremely frustrated with the way George treats him. Ted resents the fact that George shows little or no confidence in his work and that he conducts himself like the mechanical engineer rather than the project manager. He also adds with a smile:

This guy is an obvious ignorant in new engineering systems and modern design technologies and systems. Worse yet, he thinks he knows it all and does not want to learn. I probably know more about complex design and engineering issues that we are facing at UltraHone than he will ever comprehend. I could single handedly propose immediate changes to the designs of our equipment. I am confident that these changes would save our customers and us a lot of time and money. They would also improve conformance quality of our machines, speed and on-time delivery performance. As long as he is going to be at the helm I will rather lay back and enjoy the ride! I do not have to put up with this pushy incompetent!

Ted adds angrily:

“After some extensive soul searching I decided to take the issue up with my immediate boss, the manager of mechanical engineering. I hope that his involvement is going to solve the problem and get George off my back. If the situation does not improve I will have take it further all the way to the top executives of UltraHone. You are great colleagues but I would never have taken this job had I known the details of the situation. Unfortunately, now it is too late.”

Robert Green has retained you to help him solve the new multi-CAD system implementation and operational problems. Can these problems be attributed to a lack of appropriate training of engineering and managerial personnel in the capabilities of the new system emerged? What needs to be done to facilitate communication between project teams and functional departments? How about designing managerial training programs for our existing engineering staffs? What should be done about managing conflict between newcomers and existing employees? These are some of the thoughts that are going through Robert’s head.

Appendix 1

Most readers of this case are probably not engineers and are not familiar with the particulars of the honing process. This note is provided here for their reference and convenience. Honing is defined as an abrasive machining process that rounds, smoothes, and enlarges bores in end products such as engine cylinder blocks, cylinder crankcases, etc. Honing produces much better geometry and surface quality of the machined parts compared to traditional turning or milling processes. Honing machines are used for precision finishing of hydraulic/pneumatic cylinder barrels, compressor bodies, engine blocks, cylinder liners and bushings, diesel engine liners, conrods and rocker arms, valve and pump bodies and other custom

applications. The process generally requires a single-purpose single or multi spindle machine that can be operated manually or can use automation to reduce cycle times, improve quality and reduce manufacturing costs. Exhibit A.1 shows an example of a multi-spindle honing machine. All honing machines have standard features that are listed below:

- Guided sliding head design
- Variable hydraulic reciprocation and rotary drive
- Self-expanding hydraulic hone expansion
- Short-stroking (jogging) for bore corrections at a specified zone
- Automatic cycle timer and stroke counter
- Variety of manual/hydraulic fixturing options
- Linear shuttle/rotary indexing tables for efficient part handling
- Honing tools to suit application
- PLC/CNC system for machine/process data control with online diagnostics, interactive graphic interface and simulation, etc.

The following optional features are also available on most honing machines:

- CNC servo system for reciprocation, rotation and hone expansion
- Double expansion honing tool for rough/fine honing with plateau honing provision
- In-process/post-process automatic bore sizing
- Coolant filtration system
- Hydraulic/honing oil cooling units.

Today's honing machines are typically built from standardized components that can be purchased from specialized industrial suppliers. These components include power modules, electronic control modules, hydraulics, control panels, etc., that can be assembled in a way similar to the way we assemble Lego blocks. A representative sample of these components is shown in Exhibit A.2.



Exhibit A.1. The multi-spindle honing machine.

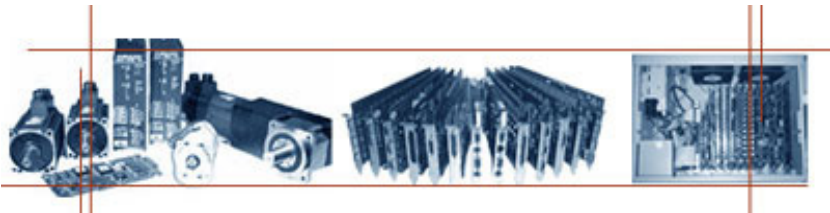


Exhibit A.2. Typical honing machine electronic control components.

To illustrate the details of the honing process, consider the cylinder crankcase. During honing of cylinder crankcases different local stock removal rates arise due to variable parameters like wall thickness, openings, honing stone overrun, etc. As a consequence,

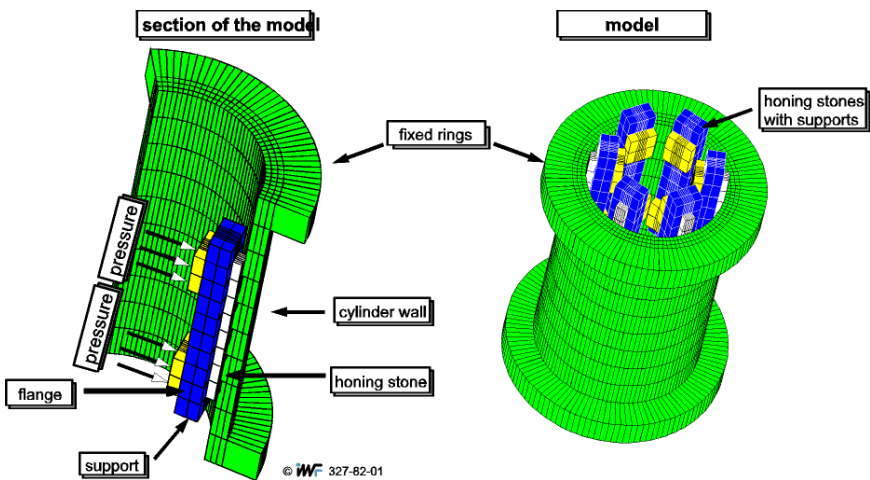


Exhibit A.3. The Finite Element Analysis (FEA) honing process simulation (click on the Animation hyperlink here for illustrative simulation animation of the honing process).

Source: <http://www.iwf.ing.tu-bs.de/Mitarbeiter/Weber/englisch/ehonen.htm>.

shape deviations from the ideal cylinder geometry emerge. On the left of Exhibit A.3 only a part of the model is shown. A pressure is loaded on the two flanges of the honing stone, which again builds up a pressure between the honing stone and the inner cylinder wall. This pressure is equivalent to the contact pressure of the resistive honing experiment. On the right, the entire model with six honing stones in the upper turning point is shown. The straight-line movement of the honing tool is taken into consideration when the honing stones move up and down and rotate during the simulation.

As shown in Exhibit A.4, the pressure from the honing process results in a deformation of the work piece. It is clearly noticeable how two radial maxima of displacement occur due to pressure stress on the two flanges. The value of the lower maximum of displacement was lower than the upper maximum, because the honing stone was closer to the fixed outer ring and the displacement was reduced through higher stiffness. The calculated elastic displacement showed a maximal value of $0.7 \mu\text{m}$. Therefore, the displacement ranged in the

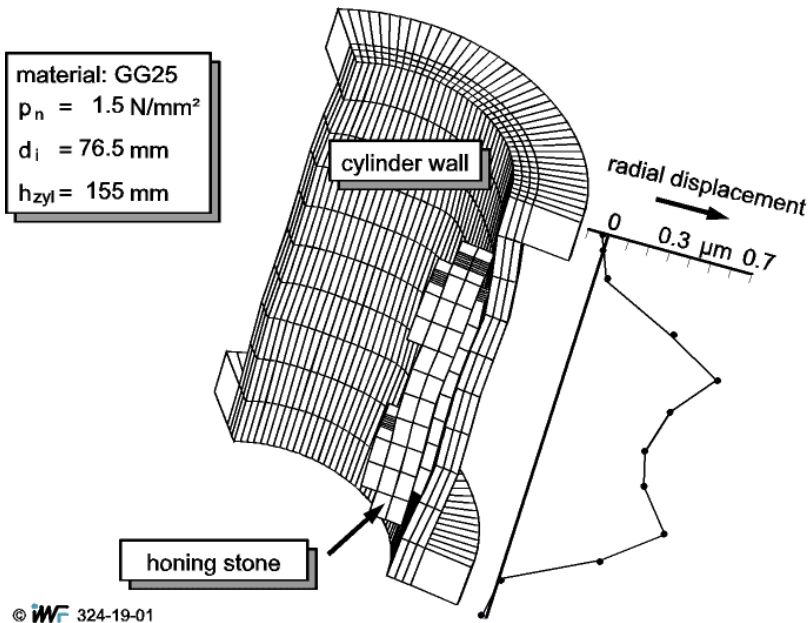


Exhibit A.4: Deformation of the cylinder wall and the honing stone support.

Source: <http://www.iwf.ing.tu-bs.de/Mitarbeiter/Weber/englisch/ehonen.htm>.

medium radial cutting per rotation of the honing stones — about $1 \mu\text{m}$. The influence of the local displacement on the local cutting value and the resulting geometry deviation can be integrated into the honing process simulation.

The Rover Project: A Corporate Start-Up Within TechCo¹

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“The failure of Rover is particularly noteworthy and fantastic because it had a good marketing team and still failed! Typically you see one of two things. Engineering has technology and gives it to marketing to find a way to sell it. We like to think of this as ‘TechCo solutions in search of problems.’ Or, on the other hand, there is a more market-focused model that argues for the marketing team to define the

¹ This case was developed by Professors Teresa M Pavia of the Marketing Department in the David Eccles School of Business, at the University of Utah, and Kimberly J Dodson of the Marketing Department of Westminster College in Salt Lake City, Utah for instructional purposes only. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way. TechCo’s true identity is disguised in this case as is the name of the project, together with the names of any particular individuals. These details are not critical to understanding the role of the new product development process exhibited by this group.

product concept/idea/requirements and then have engineering build a product to match that. With Rover, you had marketing involved in the process—from the very beginning! They identified a legitimate market opportunity and tried to reach it. But they missed it.”

TechCo Marketing Research Specialist, December 1998

The Rover Group was a well-funded corporate start-up that, on its surface, seemed to do many things right in its attempt to develop a product for a viable market opportunity. The group adopted a market-oriented approach that was consistent with the stated desire of TechCo, Rover’s parent company, to become more customer-focused and different from the technology-focused process common within TechCo. To create their business, the Rover Group studied the market thoroughly, analyzed customers to reveal needs Rover could address, identified service applications that would meet these needs, and defined the technology needed to support these services. The team itself was composed of skilled marketers and technologists who had their sights set on creating an end-user product positioned for a distinct market opportunity. They emphasized the importance of market research and sought consulting expertise. In the end though, after months of development work, they found themselves with a product that did not have a market, was categorized as an inferior “me too” offering and represented a disappointment to the team as well as to TechCo. In addition, the product they found themselves holding was not the one envisioned early in the process.

The way in which the group got off-track, and then eventually realized their distance from their original product concept, was a slow process. Toward the end, this disparity manifested itself as confusion, discouragement, and desperation. It culminated in a sweeping reorganization of the Rover Group in which the Marketing team was removed and replaced by a sales organization. The functional groups, originally designed to create a product to meet a mass market, were replaced with project-related teams developing custom solutions in response to customer proposals.

The Parent Company: TechCo

TechCo is an established international electronics and telecommunications company. Some of TechCo's revenues result from electronics sold to consumers (through retailers), but the majority of their business comes from selling large network systems and support to the companies TechCo calls "carriers" (what most consumers would simply call "the phone companies"). Numerous authors have focused on TechCo's engineering feats, culture, leaders, and the impact of its products on the world. One writer identified TechCo's culture and engineering success this way: "This is the paradox of TechCo: Unchanging values create the environment for discoveries that have changed the way the world operates."

Overall, the company holds very high standards for their technical staff and reinforces this value through company documents and statements. The CEO at one time noted: "We believe in excellent performance delivered by excellent people. Average people will do an average job and the result will be an average company. Ask for perfection in all that you do. Don't settle for average performance. Don't believe that you can't win 'em all." In response to this, one longtime TechCo manager noted: "There are a lot of engineers that, while they may well believe that they're about the best there is technically, they know they're not perfect, and they're really afraid of the consequences when they make a mistake. Particularly in a perfectionist culture, as engineering tends to be. And certainly that is the case at TechCo. I mean, engineering at TechCo is a perfectionist culture."

Beginning in the late 1980s TechCo recognized the challenges of an ever-changing technology market and started to assert that it was implementing an internal culture that would strive for constant renewal and work to "rapidly meet changing market demand". Capitalizing on "entrepreneurial spirit" was one suggested way to achieve this end. As such, TechCo effectively threw down the gauntlet to internal entrepreneurs. During this time, a senior TechCo executive was quoted in an external media source saying, "TechCo is one of the few big companies where you have a pretty good chance of

starting up your own business and running it.” Those individuals who were able to innovate and successfully open whole new markets quickly found themselves promoted within TechCo.

While the entrepreneurial attitude of “constant change with unchanging values” was tendered as the ideal culture of the firm, the real, day-to-day culture reflected many previous years of doing and thinking about things a certain way. For example, TechCo was built on technological prowess. Even though marketing is truly the key to entrepreneurial success, marketing continued to remain the poor stepchild to technology at TechCo. In TechCo’s internal assessment of their strengths and weaknesses, they noted: “We often hear TechCo is a product/technology-driven company and should be more market-oriented...We could be better at marketing, but our customers say technology leadership is key.” Those within Rover understood TechCo’s historical focus on technology. As one Marketing team member explained: “In a strong technology-driven company like TechCo you do two things: (1) build a product and (2) sit it on the street until somebody walks by and buys it. The whole concept of a marketing function is not part of our thinking, our culture, or our fundamental structure.”

A Corporate Start-Up: The Rover Project

The Rover Group represented a small, entrepreneurial team striving to launch a new services business for TechCo. Initiated first as a skunkworks² project within a large TechCo division in late 1995, the team had taken its product idea, campaigned throughout the company for support, and gained distinction as a corporate start-up by May 1997. Although always associated with its parent company, TechCo, Rover relocated off the TechCo campus, and adopted the style of dress, working hours, and socialization patterns of other

² One definition of a skunkworks is a group of people who work on a project in a way that is outside the usual rules. A skunkworks is often a small team that assumes or is given responsibility for developing something in a short time with minimal management constraints. A skunkworks is sometimes used to spearhead a product design that thereafter will be developed according to the usual process. A skunkworks project may be secret.

1990's start-ups. Members of the Rover Group believed they were in the perfect position to create a unique start-up culture that would be able to meet extremely aggressive time-to-market objectives with a user-focused product based on the implementation of cutting-edge technology. They assembled a team composed almost exclusively of talented, experienced software developers and marketers, mostly from outside TechCo, and provided them state-of-the-art tools and financial support. Their vision was to grow to be a billion-dollar business for TechCo within five years.

Feeling separate and distinct from the influence of TechCo had some of the most far-reaching implications on the group's efforts to develop their business idea and implement it. According to one manager, "I felt that we could not create this new business if we had the overhead of this old, stodgy organization". Being free of TechCo's traditional business models, channel relationships, customer definitions and attitudes, and general technology-driven mentality was the only way the Rover Group believed it could be successful. Once it was separate from the corporation, the team felt empowered to design their own business model and product that was truly market-driven.

General Manager, Annie Carter, who was a Vice President within TechCo before assuming command of Rover, led the Rover Group. Her team adopted a somewhat flat organizational structure. In May 1997, when Rover achieved start-up status, the team had 13 members (five in marketing, two developers, and the rest in support staff and management). By summer 1998, Rover employed 10 marketers and 83 employees assigned to Development or Operations teams (plus an additional eight senior managers and four administrative assistants). By December 1998, the number of marketing employees had fallen back to five and the number of developers had grown slightly.

The Five Phases of the Rover Project

The actual new product development process for the Rover product spanned five years, 1995–1999. Team members themselves indicate that during that time the group went through five distinct phases. These phases are represented in Fig. 1, using the phrases that the

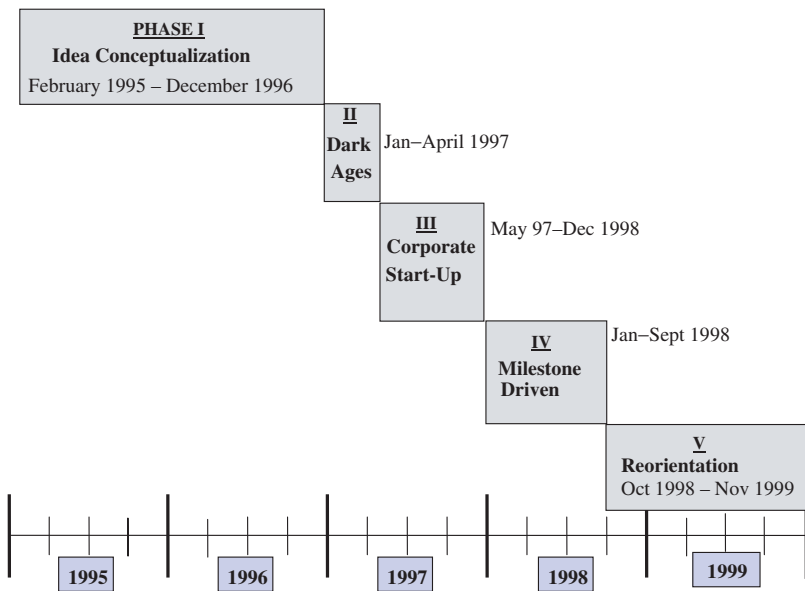


Fig. 1. The Rover Group — A five phase life cycle.

team itself used to describe the intervals. Table 1 compares various goals put forth by both TechCo and Rover and demonstrates the strategic fit between the two.

Phase I (1995–1996) spans almost two years and represents the initial idea conceptualization of the Rover product. The group was still a skunkworks within a TechCo sector during this time. As the product concept evolved, changes in the overall structure of the TechCo organization led the team to seek separation and status as an independent start-up.

Phase II (January 1997–April 1997) is called “The Dark Ages” and encompasses the four months during which the group was campaigning to become a start-up. The lack of stability and corporate identity is reflected in the name of this phase. It was a time when members of the fledgling group feared for the project’s future.

Phase III (May 1997–December 1997) was initiated by Rover’s official distinction as a funded corporate start-up. This distinction brought with it pressure to get a product to market. Consequently,

Table 1. Excerpts from TechCO and Rover presentations.

Statements from TechCo Executives	Presentations from Rover Managers
TechCo's ability to survive is greatly dependent on how well we build our expertise and abilities in software. <i>Internal Corporate Publication, 1998</i>	Assumption: Rover must be a software business. <i>Internal Rover Presentation, July 1997</i> Our strategy is to be the catalyst for TechCo to enter the software applications market. <i>Internal Rover Presentation, August 1997</i>
At TechCo we need to include the software solution as part of our repertoire of capabilities. <i>Internal Corporate Publication, 1994</i>	
To win against the competition, TechCo must create platforms for future growth. <i>CEO Statement, 1998</i>	The Platform product was the opportunity TechCo had in this space! <i>Business Manager</i>
We develop platforms for future technology leadership. <i>CEO Statement, 1998</i>	We have the opportunity to be the platform owner. We want to provide a software platform to integrate existing applications and offer a whole product and common, easy-to-use interface. <i>Internal Rover Presentation, January 1998</i>
To win against competition, TechCo must work to provide our customers with <i>total solutions</i> . <i>CEO Statement, 1998</i>	We want to simplify the offer and provide a whole-product solution. <i>Internal Rover Presentation, March 1998</i> We need to create technology with 100 percent reliability and then we can lock in the carrier channel with the first "whole solution". <i>Internal Rover Presentation, October 1997</i> Current products on the market have failed to reach a broad market because they lack integration and are clearly not a whole product solution. <i>Director of Marketing, July 1997</i>

the focus of this phase was to define a viable business plan, determine the marketing strategy, and provide proof-of-concept by year-end.

Phase IV (January 1998–September 1998) is remembered as the time in which the group became “Milestone Driven”. It was during these 10 months that the team worked to meet aggressive internal milestones leading toward a projected commercial launch in October 1998.

Finally, Phase V was a period of “Reorientation” for the team and was instigated by a massive reorganization of the group at the end of September 1998. The perceived failure of the Rover team at this point, led to the restructuring of the group. Employees from the parent company, TechCo, who were brought in to help save the situation, replaced Rover employees. During Phase V, Rover became a very different business (different employees, different product, different culture) and was later absorbed into the traditional TechCo structure.

Phase I: Idea conceptualization (1995–1996)

Phase I began when Annie Carter, a dynamic, successful, charismatic, and driven Vice President of TechCo’s sector SG, retained a group of consumer-focused consultants in early 1995 to help her respond to a TechCo proclamation that the company had entered the “Age of the Consumer”. The consultants were asked to help generate ideas about new ways for SG to approach the market. They encouraged Annie’s sector to recognize the changing nature of communications by providing new, value-added services that would meet the latent, real needs of consumers. They argued that the best way to sell large network systems, such as those created by TechCo, was by including value-added services with them that met the needs of end-users. This would act to differentiate TechCo technology from the competition and drive consumer demand for TechCo solutions.

Responding to the consultants’ suggestions, Annie, and selected people from her staff, decided to explore market opportunities that centered on creating value-added services. Annie described her decision in 1995: “We decided to explore applications and services for the

mobile end-user. We wanted to deliver value to the end-user while at the same time remembering that this was to be a (telecommunications) services business!" Annie chose a very small, talented group of employees to work on this concept. Thus, the skunkworks that would eventually evolve into the Rover project was born.

During 1996, the members of the skunkworks team realized that they needed to strike a balance between the end-user focus suggested by their consultants and the essential business-to-business telecommunications environment of the SG systems they were charged with differentiating. It was easy to get caught up in brainstorming sessions centered on creative ways of changing the nature of communication through radical services, but the team knew they could never compete by actually creating new end-user communication "applications" themselves. As members of sector SG and TechCo, their competencies resided in the network layer of the business. In response to this, they developed an idea for a services product that was based on a technological platform. Their vision was to provide a network services platform that could bridge the store-and-forward and real-time communications environments for messages and information, work across multiple networks, and provide the means of integrating them. Simply, they wanted to create the invisible technological layer that would one day unite consumers' cellular and landline phones with their varied e-mail, fax, voice mail, and personal computer applications. It was not their intent to actually create any of these applications, but rather be the means of allowing existing ones to be united. They would partner with third-party developers and existing application providers to gather the actual services to run on their platform.

As the network services platform idea evolved, the group named it Rover and started referring to themselves as the Rover Group. Due to the inherent technological complexity of an integrative platform, the Rover product was not easy to understand or conceptualize. The founders of the idea themselves often referred to the complexity of Rover and how difficult it was to truly understand. This was a particular problem when trying to explain Rover to someone who might lack the technological education to really grasp the vision. An analogy that some found useful was to think of the platform as a figurative

highway that would enable end-users to access and connect to a variety of communication services that, using the highway analogy, would be represented as the on-and-off ramps. The Rover Group sought to create the highway that applications developers could then build onto. Telecommunications carriers could integrate this highway into their networks. One of the system architects explained: "We wanted to provide the foundational system upon which new applications would expand". In 1999, looking back on the Rover project, one of the founders of the project said: "The original concept, vision and platform product was innovative and had market potential. It was developed in response to the definition of a legitimate market need and the potential customers [the carriers] responded positively to the prospect of a platform for applications development".

Phase II: The dark ages (January–April 1997)

Phase II of the Rover project was initiated by problems within the SG sector and a subsequent internal reorganization. Annie Carter, Rover's managerial patron was reassigned in a manner that she did not feel was to her career's advantage. Annie contemplated leaving TechCo. The new supervisors who inherited the skunkworks project were at a lower administrative level than Annie. As Rover's fate hung in the balance, other parts of SG got excited about Rover's work and asked pointedly why it was Rover, and not their own groups doing the work for this project. As one of the Rover employees recalled: "During these months, January to April, we just kind of floundered...and the issue seemed to be focused on *where* we were located in the organization rather than on any kind of real business or marketing issue." Members of Rover recognized that if the project, as they knew it, was to push forward, they needed Annie, or someone at her level, to champion the team. They pleaded their case to Annie. John Morris, then the leader of the skunkworks, recalls telling Annie: "Look! We can make something out of this! You've got the stripes, you have the connections, you know what the vision is, you're passionate about it!" Annie responded by asking: "If I leave, do you think you can turn this into a billion dollar business?" He responded: "No way!"

Shortly thereafter, Annie reassigned herself to Rover, took over the title of General Manager from John Morris (although John retained his duties), and began to seek high level, internal funding to allow her to lead the team as a corporate start-up separate from Sector SG.

When Annie took over Rover, she effectively opted out of the traditional confines of the organizational procedures by turning down her new job assignment, but not leaving TechCo. Annie's behavior was like a very bold bet in a card game. She could lose everything, or she could win it all. By breaking the rules, she and Rover were disassociated from the formal structures of the company. Detaching allowed them to reposition their endeavor as independent and separate from SG, under the dominion of Annie. However, the risk lay in the knowledge that Annie's efforts would all be moot if the Rover Group could not find a way to still be part of TechCo. Securing executive support was the essential next step to legitimize their position and fund their efforts, and Annie knew that it was this support that would either leave her with a new business to manage or render her looking for a job with another company. Already working at the margin of expected behavior, Annie and John took a radical approach to gain exposure and establish a funding source. As John explains: "The question was, 'Where should the rest of the money come from?' We agreed that it should not come from a single sector within TechCo. We should create our own organization funded by various groups. So we came up with the idea of, 'Why don't we go to sector presidents of various areas and see if they'll each pitch in some money to get us through 1997?'"

Pursuing a diversified funding scenario required that each potential sponsor be introduced and sold on the vision for the new business. Confident in their concept for new user-centered network services, the team members and the user-centered consultants created a demo video to support Annie and John's effort to find funding. As described by one of the system architects: "Up to the point that we got booted out of SG we were doing architecture for the platform, then we spent the next three months doing demos, trying to get money".

The demo was a theoretical portrayal of the sorts of service the envisioned platform would ultimately support. It was composed of a

series of vignettes, presented through video clips, based on brainstorming sessions held during concept development. The demo presented the concept as it related to the potential services, and did not include any architectural or network details. As was common with most dot com start-ups at that time, almost all of the technological capability shown in the demo was simulated and meant to serve an illustrative function only. Rather than focus on the technological intricacies necessary to create the proposed platform for services, the team instead showed people using the services in a variety of ways. This made sense because the project being pitched was really meant to be an invisible, technological layer linking people, devices, and information. And, anyway, no actual development had been started yet, so there was nothing tangible to show. Even though the network would require a high level of complexity and advanced programming, what was in the demo appeared simple and straightforward — just as it would ideally seem to future users. The demo was a visible representation of the concept Annie and John were hoping to pursue and create.

Consistent with their espoused user-centered approach, the Rover team created staged scenarios for the demo that integrated system capability and potential services into real-life situations. It showed people using services like outbound calling, accessing a personal address book, and requesting personalized information from the internet while they were participating in common activities such as driving a car or walking through the airport. Most important, the demo showed the services from the user perspective, i.e., it effectively put the viewer in the “driver’s seat” of the car. The result was a presentation that members of the audience could personally relate to and apply the value of the proposed solutions to their own lives.

The demo script was customized to include specific TechCo products, people, and issues. This helped Annie and John to get the executives — potential users themselves — caught up in the excitement of what the group was proposing to do. After watching a vignette personalized to his own name, business, and concerns, one executive exclaimed, “I pay somebody \$100,000 a year to do that for me... If you have that service, I’ll definitely buy it!” Other compelling

elements of the group's pitch, as reinforced by the demo, included their focus on consumers and inclusion of TechCo technology. The business proposal presented by Annie and John offered an opportunity for the company to segue into a more user-centered mind-set and explore early opportunities for mass customization through personalized, value-added services.

A second component of the presentation by Annie and John that piqued the interest of the corporate executives was their proposal to incorporate TechCo technology (specifically advanced voice recognition technology) in the Rover platform. The services they envisioned were largely dependent on the implementation of cutting-edge technology being developed by TechCo. They intended to reach into the corporate laboratories, the home of TechCo's extensive research and development, and "productize" some of the work being created there.

The TechCo technology Rover targeted had been investigated for over a decade by TechCo technologists. Even though leading developers in the field were working in-house at the company, no one in the industry had been able to prove the technology was robust enough for use in a commercial release. If TechCo could claim this feat and create a product for the market through Rover, then TechCo's reputation as an advanced, high-tech company would be strengthened. Seeing the state-of-the-art, just-out-of-the-laboratory technology presented in life-like scenarios through the demo fueled the executives' enthusiasm, as did the general sexiness of the technology itself and the pride of knowing such cutting-edge things were happening in their very own company. The untried nature of the technology made the proposal both intriguing and risky, which certainly appealed to TechCo's culture of entrepreneurial risk-taking.

It was May 1997 when the efforts of Annie and John paid off and they achieved the financial support they sought, as well as corporate distinction as an independent group. With this, the Rover group was free to pursue its vision as it best fit the market opportunity, separate from obligations to any particular organization or any specific TechCo technology. Their initial distinction as a group evolved, and

quickly they achieved recognition as a separate division within the corporate organization.

The process to branch off and establish themselves had not been an easy one, but Annie's determination to create a new place for herself and the services business kept her focused on that end. In addition, the unusual nature of Annie's approach (e.g., defying her job reassignment, thinking really big, making it happen, etc.) added to her aura of vision and power. The legend of how she defied the odds and broke away from TechCo was a story that anyone newly hired at Rover heard sometime within their first few days on the job.

Phase III: Corporate start-up (May–December 1997)

Once the team gained formal separation from SG and had the necessary organizational and financial support to be a development group within TechCo Corporate, they had more freedom to pursue new ideas and real market opportunities. Executive sponsorship provided the group tacit authority in the eyes of others to pursue their vision. Mark, one of the first marketing people associated with Rover, believed: "The biggest implication was that we developed a kind of anti-SG attitude...we developed this independent, network-independent architecture. That was a good thing. It forced the engineers to say, 'okay, we're not going to be tied to any one device or network or anything.' This, in theory, would provide us access to a broader market and more customers and all that".

The small marketing team, Rich, Mark, and Kathy, were at first working to build the marketing case to support what they hoped to do. Similarly, John and the two system architects, Pete and Jose, had sketched out the system architecture. According to John: "We developed the architecture before we started the whole campaign thing — before Annie joined the effort. It turns out, that is the architecture we would ultimately execute. We had the technical architecture finished when we became a start-up, but needed to work on the business model."

Once the group was officially recognized as a start-up, they had to take their initial ideas and decide how best to turn those into a

business. As John recalls: “We had the architecture nailed. Pete, Jose and I had spent a lot of time developing the architecture. But it was an architecture that could be applied to lots of different business models. The key then, was what business model are we going to be in? So as a group we brainstormed possible business models.” Jim, a developer who joined the team in August 1997, described this as the “wire framework of the system” and explained how the group had everything on paper when he joined but did not have any actual development underway.

This was a time when the group was evaluating three different business models. Model A involved developing and selling the platform, as a product, to carriers — allowing the carriers to sell more services to their users and decrease churn. Model B proposed offering the platform as a wholesale services bureau that TechCo/Rover would offer to carriers on a “hosted” basis. In this model TechCo/Rover would actually be the service provider, but would not have direct contact with the end-user. And Model C was to become an independent service provider and go direct to the end-consumers. One concern with direct-to-consumer sales was that Rover knew TechCo did not want to actively compete with their largest customers, the carriers.

Throughout the discussions at Rover, the dominant question was: “What will get us to a billion-dollar business quicker?” According to John: “Simply selling the platform as a product was not very jazzy and not very attractive to us. But services were a different story. If we got into the service revenue stream, then you get a small amount per transaction and there’s a much bigger pie than the product scene.” Besides, as John explained: “Being a service bureau, Option B, would be a whole new business for TechCo. It would certainly be notable in the company!”

While John concentrated his effort on finding qualified developers and system designers, Annie, too, was seeking candidates to fill available positions on her executive management team. As General Manager, she designated John the Director of Development, and established that Gary, the Controller who was on assignment from TechCo, would report directly to her, as would an open Director of

Human Resources position. In June 1997, she hired Sue to be her Director of Marketing and Business Development with the charter to decide how to turn this into a business. Rich, Mark and Kathy (part of the original Rover team) were all slated to report to Sue. Annie hired Bob to be the Director of Operations. Although having no direct-reports initially, Bob's responsibilities increased as Development and Operations grew.

In June 1997 Sue hired a second team of top-notch Silicon-valley consultants to help with the business model (this team, Team Strategy, was from a different firm than the team used for concept development in 1995). Sue, herself had previous consulting background, and used her contacts to retain this consulting group. The team's immediate objective was to assist Sue in creating a successful executive presentation, which was slated for delivery at the Rover Group's first milestone meeting in August 1997 (see Fig. 2 for a timeline of all the meetings Rover had with various parts of TechCo management). At this meeting the group would meet with their sponsor, a TechCo Executive Vice President, and present their proposed business model in order to gain incremental funding for the remainder of 1997. Sue set the consultants to work and guided their efforts by

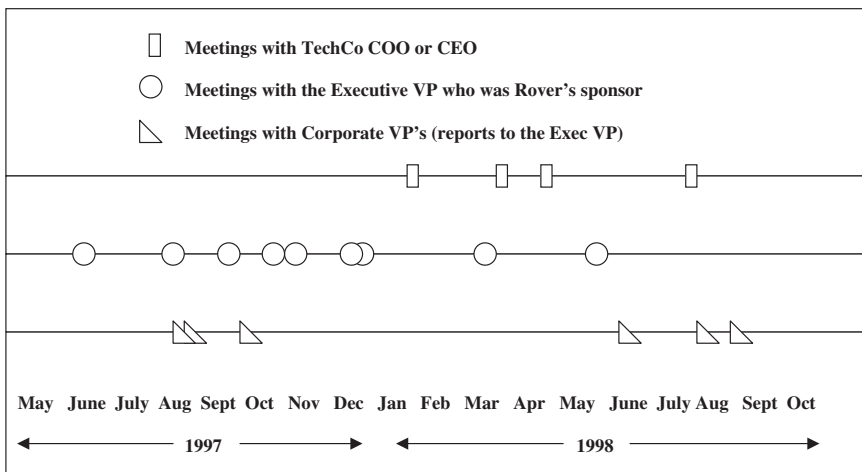


Fig. 2. Frequency of contact between the Rover Group and TechCo executives.

defining the following prerequisites: The Rover Group must make money and capture a billion-dollar market space, be self-sustaining/self-funding, be a software business, and must capture a global opportunity. Upon hearing the constraints and assumptions, the consultants started exploring the business opportunity through brainstorming sessions with the Rover team. They also initiated their “interview project” which entailed 42 interviews with carriers, potential customers, application developers, and industry analysts. One basic assumption the consultants and Rover used in this analysis was that competitive service offerings had complicated interfaces. Team Strategy assumed that applications available on the Rover platform should be free or inexpensive for end-users and the product should focus on end-users rather than addressing carrier problems.

After investigating the market (see Fig. 3 for an overview of all Rover marketing research activities), the consultants discovered that there was a definite market need to integrate existing, partial solutions into a whole solution and offer real-time communication through an easy-to-use interface bridging multiple communication networks.

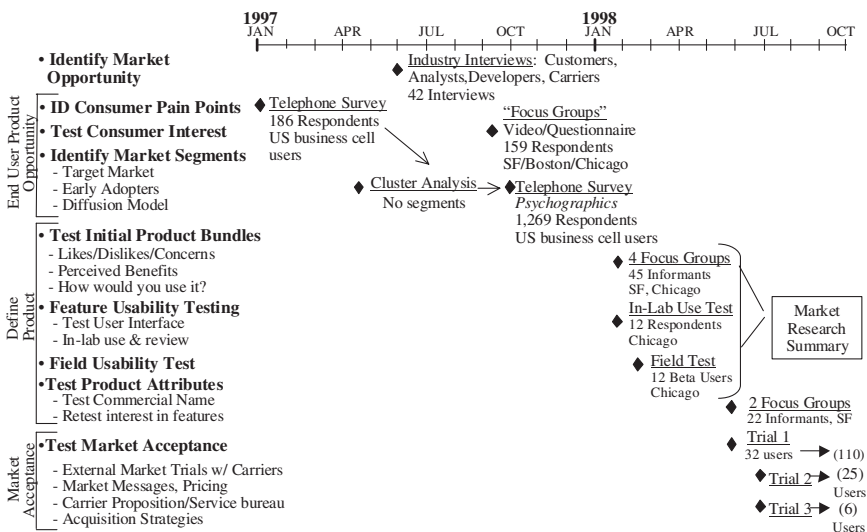


Fig. 3. The Rover Product Market Research process.

The key to the message in the consulting report of June 1997 was the potential for a common platform and the importance of simplifying feature sets, the user interface, and the product offering, while at the same time being cost-effective. The consulting team agreed with the Rover team that Model B was the business plan that fit the objectives of the Rover group, although they did comment: "This is really complex!" With this professional endorsement of their concept, the Rover Group embraced the technological platform as their intended product. Rich remembers that after the consultants endorsed Model B, "the platform idea got a huge boost, like it was being shot out of a cannon!" The ultimate objective was for Rover's platform product to become the industry standard platform and Team Strategy committed time to educating the Rover Group about what it meant to market a standard platform.

In addition to the other pressures on the Rover team at this point, the presence of several critical milestones loomed on the horizon. During the search for corporate sponsorship, Annie and John had committed to meeting specific goals as a means of justifying future funding. The Vice-President with responsibility for overseeing this project had told them: "Look, I don't care what you've committed to. You make some timelines. I trust you to make commitments that are the right ones, don't come back and edit those. Show me that you can deliver what you say you can, whether it's useful or not." John recalled: "Annie and I created a letter of agreement with each of the sponsoring executives. I came up with the Milestone that on December 15, 1997, we would show them a system up and running with basic functionality. There were interim Milestones in August and October, but the December 15 Milestone was the big one. We committed to basic functionality by December 15." It was in writing that Rover would cease existing as a separate group if they were unable to meet their Milestones. In addition to the three milestones in 1997 (August — Business Plan, October — Financial Projections, and December — Working Prototype), there were three milestones in 1998 (April — Go/No Go for Commercialization, June — Market Trials, and September — Commercial Launch).

When the Rover Group met with their executive sponsor in August 1997, they presented Model B as their business plan. Sue recalls: "We pitched that this was a fabulous market because of the complexities and changing communication needs." During this meeting the Rover team also identified no dominant players in the market and emphasized the importance of "moving quickly for first-mover advantages."³ They acknowledged that they should not initially develop applications themselves, and should instead leverage strategic partnerships with developers, while at the same time knowing that some applications should be offered for free through carriers to entice end-users to adopt the services. The Rover group promised \$500 million in gross revenues and profitability by Year Five, but also admitted they had some weaknesses. These included limited experience with alliances, no current relationship with application developers, and inexperience with the software market, especially end-user applications. The corporate sponsor himself was skeptical whether there really was a viable business opportunity and suggested that maybe Rover should just create a voice browser for the internet. None of these concerns was fatal to the funding, though, and ultimately the August meeting was successful. Financing was approved for the next three months and the next milestone meeting, to present the financial model, was scheduled for October 1997.

The October meeting to present the Financial Projections went well. Rover's presentation of the financials was optimistic, partially because it reflected the group's perceptions that "TechCo has a history of saying, 'You have a certain period of time to deliver 'x' amount of revenue or we'll sell the business or turn the lights off.' They're not into money losing or marginal businesses. They have to have a return on investment or they will get rid of the business" (Rover Financial Officer). However, an internal communication from TechCo to the financial officer at Rover indicated TechCo was concerned about the

³ Actually a competitor had emerged and planned to launch a similar application in July 1998. During a visit to the Rover site, this competitor claimed not to be concerned about Rover since the competitor was focusing on world class applications and Rover was developing a platform. Rover's assessment of this competitor was that "their vision is similar to ours, but their ability to execute is questionable".

optimistic numbers. The memo said: "We know you feel constricted to break-even in three years, but even then, try to do your financial model as realistically as you can."

In the remaining months of 1997 the Marketing group focused on gathering the information the team needed to be truly market-oriented (see Fig. 3). Research done earlier in 1997 found that among Rover's potential customers, the telecommunications carriers, there was skepticism regarding whether the Rover Group could actually complete what they were proposing to do. The demo was certainly compelling, but the carriers were less persuaded by the demo than previous internal TechCo viewers were. It was important that Rover be able to show an actual, working product. Many of the potential carriers themselves had tried unsuccessfully to work with Rover-type technology and maintained serious doubts as to whether the technology was robust enough for the mainstream market. They also worried that this type of product would not have mass appeal, as both Rover and their consulting team projected, but would instead remain a niche product. As one of the major carriers told them: "We're happy to be second — demonstrate market acceptance and then we'll talk".

In addition, carriers and industry analysts agreed that products such as those offered by Rover would need to have a price point of less than \$10; most likely less than \$5/month. However, because of the long adoption rates of these types of services by consumers, it was recommended that the basic applications should be offered for free, and any provider should anticipate a long lead time for initial adoption. The Rover Group was advised to determine price points from existing similar alternatives. Rover's own survey and focus group market research showed that end-users were very interested in this product and said they would be willing to pay between \$30 and \$60 a month for it. Rover therefore settled on an anticipated price point of between \$19.99 and \$29.99 a month and calculated that after splitting the fees with the carriers, by Year Five they could reach \$1 billion in revenues with over five million subscribers.

Sue synthesized all the market research information and concluded that no carrier would buy a platform without applications to run on it. Similarly, end-users were not going to demand the services

proposed for the platform without first experiencing the services or by hearing about them through word of mouth. She recalls: “Business people look to see where there’s a lot of activity and if they see enough activity, that’s where they’ll make the big investment. We needed to show that there was a lot of activity in the Rover marketplace. So, to stoke the fire, I thought we could add more critical mass and accelerate the market growth by introducing some end-user applications we created ourselves.”

Meanwhile, in the remaining months of 1997, the development group focused its efforts on ramping up and hiring the resources necessary to create a prototype. In September 1997, John made the decision to split the small development group into two teams — a December Team and a March Team. The December team would focus solely on delivering a working prototype by the December 15th Milestone, while the March Team, in parallel, worked on the scalable architecture that would be the basis of the commercial product. In making this decision, John realized he needed something to guide the December team since there were actually no written requirements or architecture documents. John knew how favorably TechCo execs had responded to the demo video of the Rover concept, so he recalls saying: “All right, we’re going to implement what we are showing in our demonstrations. The demo is now our requirements.” He told the engineers to do as much as they could to recreate it. As Pete remembers, “For many of the developers, the down-and-dirty element of the prototype development was not all that surprising.” Craig, an Operations manager, added: “We were a start-up...you slap something together for the proof-of-concept and if it looks good, you then turn it into a product.” Bob, the Director of Operations, agreed with these sentiments saying: “I knew when I was getting into this that it was something new and different. Something entrepreneurial. That was my expectation. I knew it wasn’t going to be a classical model of product development.” But for others, like a development consultant on loan from TechCo, the lack of process was disconcerting.

By November 1997, the December development team had completed enough of the project that they were able to surprise Annie on

her birthday with the first, working event on the prototype. Then, through continued hard work and focus, the December team was able to successfully reproduce enough of the video demo to provide a working prototype for the December 15th Milestone. Everyone at Rover shared in the sense of achievement that came with meeting this particularly challenging objective. According to Sue, the Director of Marketing: "When we had the prototype finished it was very powerful! I think we were all excited that we actually had something that was working. It wasn't just a smoke-and-mirror type of thing, it was a physical manifestation of what we had been talking about for so long." And Gary, the controller on loan from TechCo recalled, "The demo in December was a really slick thing. It proved to TechCo management that this concept could be pulled off." Rover sailed through their December Milestone meeting and was assured funding until their next Milestone in April.

Phase IV: Milestone-driven (January–September 1998)

Phase IV began in January 1998. During this time, the Rover Group was focused intently on meeting its 1998 Milestones. The 1998 Milestones were set in September 1997, while the Marketing team was conducting market and user research and the development team was just realizing that it needed to split apart in order to meet the December prototype objective. Because the Milestones were established prior to any actual development of the system, they were based largely on speculation of what was reasonable for the group and assumptions regarding the progress of development.

Throughout Phase IV, the Milestones were never re-evaluated or changed. Consequently, as development got underway and the team started to encounter obstacles, certain dysfunctions arose as the group continued to be driven toward Milestones that became increasingly irrelevant. Chloe, Rover's internal legal counsel, remembers telling management: "We know we're not going to make the Milestones. We're smarter now than we were before, so let's negotiate the goals." She continued: "My answer was silence. We missed the goal just as we expected and in so doing, we missed out on our bonus. But we'd

known for five months that we were going to miss the goal. Why couldn't we modify it?"

Sometimes meeting the Milestone requirements effectively set the different functional groups against one other. Rather than having objectives that built on each other, each team had objectives that seemed to work against the others. For example, the Marketing team was pushed to add more and more users to the system, while the Operations team was rewarded for minimizing errors on the system. The more users Marketing added, the more errors Operations would inevitably incur. Much later John confided that the Milestones were purposively designed to create interfunctional competition in the hopes that this would drive the team to greater levels of accomplishment and esprit de corps.

The completion of the prototype in December, and the subsequent pressure to produce an early commercial version by March 1998, collided with the reality that the March Team was nowhere near as far along as John had projected they would be. During the push to get the prototype completed, John had only been able to direct the March Team from a distance. He told them to focus on designing architecture for a scalable product. However, John notes: "As we looked at the development plan and got started we realized, there's no way on God's good earth that we can do what we need to do by the specified time. So we started scaling down the architecture and adjusting the development schedules."

In light of the lack of concrete progress from the March Team and the looming March Milestone, Annie started calling the prototype "Release I". John recalls this moment saying: "I believed so much that we should not turn the prototype into a product. But it got taken away from me. I believed the prototype had served its purpose, but Annie did not. I focused my energies on creating Release II [the new name given to the work being done by the March team] and Bob, Director of Operations, was given authority over Release I." Because the prototype was available and had minimal functionality, and the scalable version of the platform was still in the lab, the Operations team set to work on making the prototype a stable system for market trials. Marketing was displeased with this, because there had been no

Marketing input involved in creating the prototype (it was based entirely on the video demo). Annie appeased Marketing by giving them a larger role in defining Release II.

Because there had been no formal requirements or engineering specifications documented for the Rover project, several conflicts arose over deciding what features Release I and/or Release II should have. Many of the developers believed that Annie was able to demand certain features herself because “marketing would never provide any requirements to development. Without participation from Marketing, then it was inevitable that the requirements would be driven by whatever the higher level managers thought was cool”. However, Annie’s ability to change the priorities and influence the development process led to a feeling that things were changing so quickly, why write them down anyway? Additionally, John noted: “Features tend to produce ideas about other features. There are ways to manage that through crisp requirements and clear processes. But we let go of the process in order to create the prototype and then never got it back. Sue and I were both guilty of feature creep. Every time she and I sat down, the requirements changed. If she and I were willing to let it creep, we had no hope of preventing others from doing it.”

While development was making changes to Release I for market trials, and John was leading efforts to define and develop Release II, Marketing focused on meeting with potential carrier customers to try to generate sales. Although harboring doubts about the quality of the platform themselves, the Marketing team knew it had to meet a June Milestone for external market trials, so they continued to meet with carriers in the hopes of signing one of them up for a trial. In April, the Rover Group welcomed a new Director of Sales. Hired for his skills in developing relationships, Barry was thought to be what the group needed to actually make headway with the carriers.

Unfortunately, Barry’s arrival coincided with the Rover Group’s first 1998 Milestone in which the Executive Sponsor would determine whether the group was a “Go/No Go” by allocating additional funds and resources. Although the team successfully maneuvered through the meeting, incremental funding allocations came with a new prerequisite from the Executive sponsor — the group must

“Land a Big Fish”. In this context, a Big Fish meant a large, mainstream carrier customer that was, ideally, a customer shared by TechCo’s other businesses. During their research in 1997, the Marketing group had discovered that smaller, less mainstream carrier customers were most interested in the Rover product. Many of the larger carriers did not need the differentiation provided by something as cutting-edge as Rover and were therefore unwilling to take the risk of exposing their consumers to a questionable market trial. Similarly, large carriers were not able to respond as quickly to the Rover opportunity as smaller, more nimble carriers, and if they were interested, demanded six to twelve months preparation time before launching a market trial. Smaller carriers, on the other hand, were in a better position to quickly integrate the Rover product into their systems and were also interested in incorporating it into their service offering. Even with this knowledge available, the group still agreed to the Executive mandate to focus efforts on the Big Fish. As Barry remembers: “Within thirty days of my arrival, everything changed. Suddenly we weren’t going after all the available markets...we were only going after the Big Fish. Sadly, I had a customer interested in doing a market trial with us, but it wasn’t a Big Fish, so didn’t count and I couldn’t pursue it.”

The requirement to “Land a Big Fish” that was announced in April was particularly important in light of the rapidly approaching June Milestone that required external market trials. The market trials were originally designed as a way to allow Operations and Development to test the system, and for Marketing to try out potential marketing messages, promotional strategies, price points, collateral materials, and customer care. Although concerned that the product was not ready, the Marketing team continued efforts to prepare for outside users to subscribe to the Rover service. For Barry, this meant only two months to initiate a market trial with customers who usually demanded a six- to twelve-month lead-time. Barry had very little success in establishing the relationships he needed.

In the meantime, there were a few small carriers who showed interest in the Rover product and provided the means for starting some initial trials. Although limited in size, these were adequate to

reveal that the Rover Group was not fully ready to “go live”. The operations group struggled to keep the system up and operating, while at the same time refining its capabilities and design. They gathered usage data and monitored user experiences — feeding information and insights into the product to improve it. Release II remained far behind schedule. Therefore, Release I continued to be the source for assessing the Rover product’s market-worthiness.

Marketing was struggling to find partners willing to participate in a trial, and even more so, users interested in a trial subscription of the service. With the Milestone deadline looming, the Marketing group entered into some desperate negotiations. An example of this was in the pricing agreement negotiated with one of the trial partners. After testing the system internally, representatives from the carrier partner were unsure whether the system was truly ready for a market test. Through much cajoling (and leveraging of personal friendships with carrier representatives), the Rover Team was able to convince them to initiate a trial on a limited basis. Afraid to actually charge their customers for the service, the carrier agreed to a modified price plan. In the end, this meant that residential subscribers paid a flat-fee and were able to use the Rover service and get “all-you-can-eat” long-distance phone service. As Craig quickly pointed out, “We were having a trial, but all the wrong customers were using our systems. We never accessed our highly-mobile, *Road Warrior*, target market, so aside from strict system data, did we really learn anything?”

By July 1998, the situation at the Rover Group looked bleak. The group had missed its June Milestone. Momentum was spiraling downward and the group realized that although it had started with such good intentions, employees and a market-tested idea, they had gone wildly off base. However, Annie was undeterred by the doubts swirling through the rank-and-file and insisted that the group move ahead with the scheduled analyst tour in July 1998. According to Holly, the Marketing Communications person: “I really questioned whether we should go through with it and wondered if we shouldn’t cancel. But our PR agency thought we were ready. We got slaughtered...We got asked basic questions and didn’t have the answers that should have been in place a long time ago! Basic questions like, ‘What

makes you different from the competition? Why do you feel your product is superior? How did you get to such a high price point? Why is TechCo in this business?’ We couldn’t answer the questions, and we sure didn’t impress them either. I thought it was awful, but maybe it was a good thing because it brought to the surface a whole bunch of things that were lacking.”

Phase V: Reorganization (October 1998 onward)

In August 1998, Barry, the Sales Manager, was asked to leave the organization since he had been unable to land a Big Fish. On 30 September with no successful market trials, an unstable product, and uncertain future, the Rover Group was reorganized. Sue, the Director of Marketing, was relieved of her duties and the marketing function replaced by a sales organization. As Chloe recalls: “On 30 September guess what happened? The entire first-line management team is gone. The core team is gone. Marketing is disintegrated. There is no marketing.”

Annie was shifted deeper into the hierarchical structure of TechCo and no longer reported directly to the executive-level sponsor. Within six months, she was asked to leave TechCo and became the CEO of a small, Silicon-valley start-up. Many of the top-notch developers fled to more attractive, less-confusing opportunities. The Marketing team was positioned throughout TechCo and many left the company.

The overall complement of employees within the Rover Group did not actually go down after reorganization. TechCo injected a team of long-term, TechCo managers into Rover with the direction to salvage the business. Not surprisingly, the new Rover team started to gain momentum after reorganization. As they did so, they returned immediately to the attractiveness of the platform product opportunity. They approached the platform from a different conceptual and business perspective. Rather than trying to create a market-oriented product designed for a potential mass market, they shifted to become what was essentially a development organization responding to RFPs/RFQs (requests for proposals/quotes) generated by their mainstream carrier customers. Some of the former Marketing staff noted that the project

had transformed from a market-oriented, user-focused effort into a technology-driven, customer-led development shop.

Bit by bit Rover was subsumed back into the TechCo fold. In addition to the tremendous toll taken on employee morale and productiveness (both because their efforts failed and because people immediately realized failure could have been avoided had they not gotten off-track), the trajectory of the Rover project cost TechCo over \$50 million. It also delayed development effort on the platform product by 20 months. This put TechCo behind the competition in a market it had originally had the potential to create.

One of the new TechCo managers commented: “The Rover group was not typical of a TechCo group. I sense that now it’s changing to be more a TechCo group. The work they’ve done isn’t wasted. The things they’ve learned along the way — I mean, it’s really invaluable and just needs to be redirected and utilized. I think there’s some hope here to take what they’ve learned and transform it into a *real* TechCo business. TechCo and SG know how to do that.”

Topic Area 3

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Business Analysis and Market Potential

New product ideas, and subsequent product concepts, may come from a variety of sources within and outside the firm. They may be the result of many years of laboratory research and experimentation by scientists and technologists, or they may have come from market research studies, feedback from sales personnel, engineering applications, or other activities closely associated with existing products and their use or applications. Regardless of what the source of product concepts for new products is, every product concept needs to be systematically evaluated and screened to determine its market potential. Top management needs to understand whether or not the proposed product concept will eventually contribute to the financial and market success of the firm. Business analysis is a management tool that systematically examines the financial and market potential of the proposed product concept.

Although business analysis for a proposed new product idea, and subsequently the product concept, is conducted on several levels with emphasis on various demands of management, it carries the most weight in assisting with evaluation and screening of product concepts. The typical business analysis focuses on three aspects of potential performance assessment of a proposed product: revenue forecasting, cost estimates, and profit projections. The information generated from these three aspects of business analysis serves as input into managerial decision-making regarding a proposed product concept. Additional factors also enter into the business analysis.

Top management needs to formulate a uniform set of guidelines for the expected financial performance of all proposed product concepts. These guidelines set limits on the acceptable financial performance from a proposed product. A firm's risk tolerance also needs

to be taken into consideration, i.e., how much risk is the top management willing to accept? The risk factor should be factored into all financial projections that are tentatively made for each proposed product. Some firms prefer to assess risk as a separate variable that is closely associated with the overall market performance of the proposed product. A new product can have a significant negative impact on existing products or markets and may cannibalize sales of an existing product. Although these factors relate more to top management's assessment of individual product concepts, revenue forecasting, cost estimates, and profit projections are typically responsibilities of lower level operational specialists or individuals in the firm who are directly responsible for product concept evaluation or screening.

Forecasting revenue for potential products is a complicated process. Revenue forecasts are influenced by the level of technology representing the product, the potential size of the market, and competing products currently on the market. The personal experience of the marketing specialist conducting the revenue forecast is also an important factor in its accuracy.

Preliminary marketing research studies using targeted consumers may provide a relatively accurate estimate of how many units of the product could be sold initially. Even the rate of market penetration, based on consumer expectations, can in most cases, be estimated from custom-designed consumer research studies. Other factors include estimates of how quickly competing products will be introduced in the market and what will be the propensity of the consumers to switch from the proposed product to competitors' products when they are subsequently introduced into the market. Revenue forecasting is an attempt to discover the level of sales that will be achieved at a particular point in time. How many units will be sold at the critical point in time set by the top management? However, the main question that needs to be answered is when will the appropriate level of sales be reached for the potential product to recover all its fixed and variable costs?

In many instances, sales of major innovations or revolutionary new products are especially difficult to forecast. Changing lifestyles,

economic conditions, the technological climate, and even social conditions influence the sales of such products. Potential consumers rely on many sources of information about new products and are not always well informed about how changing environmental forces may impact future products. Marketing researchers occasionally suggest that uninformed consumers may actually hinder the development of a revolutionary new product because they do not fully understand it or the technology on which the potential product will be based.

In order to improve the accuracy of a revenue forecast, researchers need to fully understand the market and be able to segment it in order to identify the target market suitable for the potential product. They need to clearly profile potential consumers who will have a high propensity to purchase the product at various stages of market penetration. Estimated potential sales forecasts can be obtained from reliable external sources such as industry associations or private sources such as industry publications, but more frequently they are generated internally through marketing research studies, as discussed previously, or by estimates prepared by the sales force. Experienced consultants familiar with the industry, its market, or products under development can also occasionally produce sales estimates.

Analysis of market opportunities is one of the essential considerations in determining the market potential for a proposed product concept. From the marketing point of view, analyzing market opportunity for a given product concept begins with a clear definition of the product concept and an examination of the various market segments that might be attracted to the proposed product. Where there is an optimal match between the product concept and potential consumers classified in a given segment, that segment becomes the target market. An accurate profile of potential consumers needs to be developed in that target market. Such a consumer profile should consist of a number of demographic and psychodemographic factors designed not only to understand consumer behavior in the target market, but also for use in developing communication channels with the consumer during the product development process and later in the full-scale marketing of the product.

Comprehensive industry and competitive analyses need to be developed in the context of the selected product concept, the target market, and the profile of targeted consumers. Conducting industry analysis within traditional industries can be relatively simple, however, conducting a similar analysis in rapidly changing industries such as electronics, medical equipment, or biotechnology, for example, may be much more difficult. In such industries, the technology that is imbedded in the proposed product may reach across several industries, or it may be changing, and at the same time replacing, more rudimental technology from a different industry. This suggests that several industrial analyses may have to be conducted to scientifically understand the impact of the proposed product on several industries and to decide on which industry, in turn, will have impact on the development and eventual marketing of the proposed product.

On a more fundamental level, industry analysis may also be useful in examining the future state of the physical properties of the proposed product. For example, the design intentions may be to fabricate the future product out of a particular material such as aluminum and the entire aluminum industry is promoting the material for construction of products such as the one being proposed. However, a competing industry such as the carbon fiber industry is strongly advocating the use of carbon fiber in the construction of this product. The question for product planners and developers becomes, which material will be a success in the future? A detailed industry analysis of both industries should answer that question.

Analysis of competitors is also an essential component of analyzing the market opportunity for a proposed product. Key competitors need to be identified and their strengths and market positions evaluated. It is important to understand the present market positions of key competitors, their market share, and their potential for future growth. Their financial strengths and performance need to be evaluated along with their management capabilities. In high technology industries it is also important to understand the technical capabilities of key competitors. For example, their patent holdings, rate of new product introduction, and even their

cost structures need to be evaluated in order to understand their competitive positions.

Since firms tend to examine many different product and market options, especially the large diversified firms, it is also important to understand which options are more likely to be pursued and by which competitors. This information may be gathered from secondary sources such as industry journals, financial newspapers, reports or public announcements. Firms generally keep a comprehensive file of publicly available information about their key competitors. Commercial services also collect competitive information on an ongoing basis about key competitors and competitors in general.

One of the necessary assumptions about marketing, and the use of market analysis today, is that the new product idea is derived from marketing research studies and, occasionally, from systematic market analyses. Although many new product ideas originate in laboratories, new product ideas and product concepts need to be carefully formulated and tested against market preferences. Even proposed innovative high technology products need to be exposed to real market forces at some point.

Although market analyses can produce a great deal of useful information, eventually cost estimates must be made based on the result of market analyses. Given the results of market analyses, cost estimates can be relatively accurate and easier to produce. Each step in the product development process can be estimated and the associated costs classified for cost allocations. The same approach can be used in the market introduction stage of the product. Some of these costs can be estimated from previous campaigns where similar products were introduced on the market. In situations where external providers of services were utilized, past costs and updated quotes can be used. During the initial market growth period, costs can also be estimated relatively accurately. However, if the market dynamics or competitive conditions change quickly, the accuracy of these estimates may be lower and executive experience can be taken into consideration as a major force in assessing final cost estimates.

Costs associated with the potential development of a new product typically can be categorized into costs related to research, development,

marketing, and manufacturing activities. These cost categories can be tracked from when a specific product concept enters the full product development process.

Depending on the attitudes and expectations of top management, however, profit projections can be more difficult to gauge and evaluate. Furthermore, different industries have inconsistent standards and risk levels, and managers expect to recover investments over different time periods. All of these factors need to be taken into consideration when profit projections are made. Some firms have a specific set of guidelines that even provide financial limits within which new product concepts can be proposed to top management for further development. If product development specialists evaluate a proposed product concept and the projected revenue and cost estimates fall outside of the financial limits, the product concept can be automatically dropped or, occasionally, shelved. If the product concept is shelved, it can be re-evaluated in the future when market conditions or technology might change. The main issue is that the product concept may be evaluated on a lower level within the guidelines and may not necessarily reach the top management level for development approval.

Financial techniques appropriate for analysis of product concepts and eventually new marketable products are: break-even analysis, cash flow, return on investment, and profit contribution. Each financial technique provides different types of information. For example, the break-even analysis is designed to examine when the proposed product will generate a level of sales that will cover all its expenses and become profitable, i.e., how many units of the product need to be sold before the product starts generating a profit? In addition, the future cash flow needs to be discounted to the present rate, a potential return on the initial investment needs to be calculated, and the rate of potential profits needs to be evaluated.

Although business analysis is considered an essential management tool in deciding on which product concept will be developed, the ultimate responsibility for each product concept that enters the product development process is with top management. Even if the financial analysis supporting the potential market success of the

product concept suggests market success and high profits on the initial investment, top management may decide not to develop the product for strategic or competitive reasons. Some of these decisions are made to strategically time market introduction of new products.

In smaller firms the situation may be somewhat different. The top management of a smaller firm is typically closely involved in the entire product development process, even starting with the generation of new ideas. As the product concept is formulated in the minds of the key top decision-makers, they are also thinking about the market potential, forecasting sales, and even calculating potential profits. Top managers of smaller operations, especially high technology firms, frequently carry most of the new product development activities in their minds and tend to make financial estimates as they think about the potential new product. When they are asked for documentation supported by market or financial information, it becomes evident that they do not have it. This becomes a major issue when a smaller firm searches for venture capital or wants to secure a loan. When the smaller firm is asked for its business plan including a comprehensive business analysis, the venture capital firm or the bank realizes that the firm does not have one.

After the business analysis has been completed and market potential determined for a given product concept, the final decision is made whether or not a given product concept should be developed into a product prototype. Since several product concepts may be competing for limited resources, especially in a smaller firm, it is important that the development of product concepts is sequenced over time. This sequencing depends on changing market conditions and competitive positioning as well as the limited resources. A firm may have an inventory of screened product concepts and may develop them according to changes in its long-term strategic position.

Developing a product concept into a product prototype is a systematic sequential process that involves both the technical side of a firm as well as its marketing specialists. The individuals directly involved in the product development process at this point may be structured as a team or may belong to a specific group of product development specialists.

The actual process of developing a physical prototype from an abstract concept may not necessarily be a well-organized process. The engineers responsible for the technical side of the product and the marketing specialists representing potential consumers in the market may not fully understand or be able to communicate the actual product attributes that were initially envisioned by consumers during initial consumer studies.

The engineers and scientists, in some cases, need to follow prescribed rules and conventions in developing a product. Marketing specialists, specifically new product development specialists, like to be flexible in their interpretation of consumer attitudes towards the proposed product. In reality, the actual product prototype needs to reflect both sides and still meet the necessary design and performance criteria for its function, performance, and safety.

Product prototypes can materialize in many different forms depending on the design environment in which the prototype is developed. In the traditional environment the prototype is developed in steps in a design or engineering laboratory beginning with engineering drawings or other technical specifications. In a computer-based environment it is possible to develop a prototype directly in a CAD program and even display it to a variety of audiences for approval or testing.

It is important to document every step in the traditional, non-CAD, environment in the new product development process, especially in the prototype development stage. The development of accurate documentation is important because, as a prototype is developed, many ancillary designs need to be scrutinized and some of them may offer interesting potential in the future. In searching for specific solutions at this stage, new design concepts may be formulated, new technology introduced, and discoveries made that may lead to patents or other forms of legal protection or significant competitive advantage. Because of the possibilities that various unexpected options may be integrated into the prototype, several prototypes may be developed and may, consequently, differ in terms of their level of technology, the material used, or simply their shape. Different scientists, design engineers, or marketing specialists may perceive different aspects of the prototype as more or less desirable for potential consumers.

Prototypes are tested for their performance and market acceptance. Management generally reviews prototypes, and a single prototype may be selected for eventual commercialization. However, in some industries, panels of potential consumers or users routinely screen prototypes and members of the panel make the final prototype selection for commercialization. In the CAD environment, the prototype presentation to the panel and the selection of the prototype for commercialization can be made electronically.

When products are developed for international markets, the simultaneous development of several prototypes may take into consideration the requirements of different international markets. In order to maximize the eventual acceptance of the new product in the various international markets, different sets of attributes need to be taken into consideration early in the new product development process. The prototype development stage is suitable for building prototypes with different options for different international markets.

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Apple Construction Company: How to Stay Away from Low Bid Customers and Non-Valuable Dyadic Relations¹

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The Dutch construction industry is under a lot of pressure: discontented clients, extreme overrun in time and costs, building frauds, and high costs of failure. CEO John de Clerk is facing the enormous challenge to improve the value-adding performance of the Apple Construction Company. He knows that an important weakness of the construction industry is the limited collaboration between the demand and the supply side. Next to that, cooperation between project partners is weak. The dominant form of business in the construction industry is still the transactional exchange. In the Apple Construction Company managers have been rewarded for their own turnover and profits, resulting in an

¹ This case was prepared by Sicco Santema and Jarmila Kopecka, both in the Department of Product Innovation Management at the Faculty of Industrial Design Engineering, at Delft University of Technology, the Netherlands, for instructional purposes only. The case was prepared as a basis for class discussion rather than to illustrate either effective or ineffective management of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

extreme competition, not only between companies in the market but also amongst internal partners in different divisions or regions.

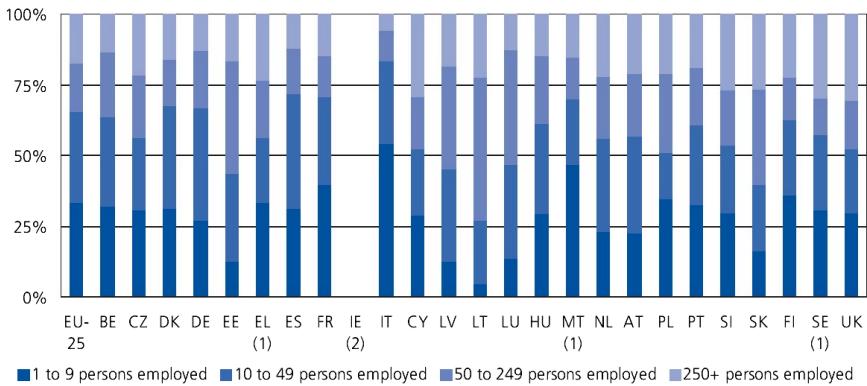
Customers in the construction markets dominantly use tendering procedures to arrive at the lowest price possible. Governmental bodies are even more price-oriented. They are forced by law to put out to tender any project that exceeds approximately \$300,000. To that extent, the market can be characterized as displaying opportunistic behavior. The construction market is mainly based on market forces, the relationship between companies is therefore often distrustful, if not antagonistic, rooted in the fear that the other party might engage in opportunistic behavior. There is a growing demand for more collaboration between partners in the value chain to lower the failure costs in the industry.

John de Clerk has decided to take action and improve both the image of the construction industry as well as the positioning of the Apple Construction Company in the market. To achieve the first objective, he has invited his colleagues from the top three construction firms in the Netherlands for an initial Round Table Meeting, with the aim to start a debate on the subject. For the second objective, he invited Professor Dean T. Kashiwagi from the Arizona State University to begin a Value Procurement Project in order to change some of the prevalent paradigms on profit-making and cooperation in the supply chain. In this case, we first give some background information on the Dutch Construction Industry and the Apple Construction Company. In the next section, we briefly introduce the Value Procurement Principles and describe the actions taken within the Apple Construction Company. Lastly, we discuss the Round Table of Directors from the Dutch Construction Industry.

The Dutch Construction Industry

The market size of the construction industry in the Netherlands is an estimated €65 billion (Source: *Statistics Netherlands*, 2004). The market is fragmented compared to other industries, although it is perhaps less fragmented when compared to the construction industry in other countries. Displayed in Fig. 1 is the share of value-added, per country, by construction firms' size. The first column indicates the average of the European Community (EC). The Netherlands is in the ninth column from the right. It shows a lower percentage of small

Share of value added by enterprise size class, 2003 (%)



(1) 2002.

(2) Not available.

Source: Eurostat (SBS)

Fig. 1. Construction industry by size per country.

companies than the EC average, whereas the contribution of large companies (above 250 people employed) is higher than the EC average.

In the Netherlands, some 1,900 architecture bureau, 7,300 contractors, and 8,400 suppliers participate in building projects (Voordijk *et al.*, 2000). No single party dominates the entire supply chain. Architects, assisted by specialized engineers, are mainly responsible for design. Contractors take care of the site operations; some work is subcontracted to specialized firms, and (multiple) suppliers provide the materials required. There is a well-established supply chain of architects (including engineers and designers) who start the process by drawing and designing the building. From that moment on, most requirements are set. Then the bidding process starts, which means, that at least four companies prepare their bid and that the same kind of work is being done in (at least) four companies. The Bid Preparation includes project preparation, calculation, and offering. By the time the contract is awarded (at least) three companies will have ended up with a loss already. The investment in the bidding procedure has to be recouped in later projects. The construction firm that got the contract usually offered the lowest price. As a result, this firm needs to fine-tune the proposed costs package to the actual work that has to be done, i.e., to recalculate the actual costs. This often leads to lowering of the quality standards used. In 2005, the number of

employees active in the industry was estimated to be 463,000, or 6 percent of the total workforce in the Netherlands. Figure 2 displays the percentage of persons employed in construction in proportion to those employed in the non-financial business economy for Europe.

The Netherlands has one of the highest labor productivity in Europe, as well as high average personnel costs (see Table 1).

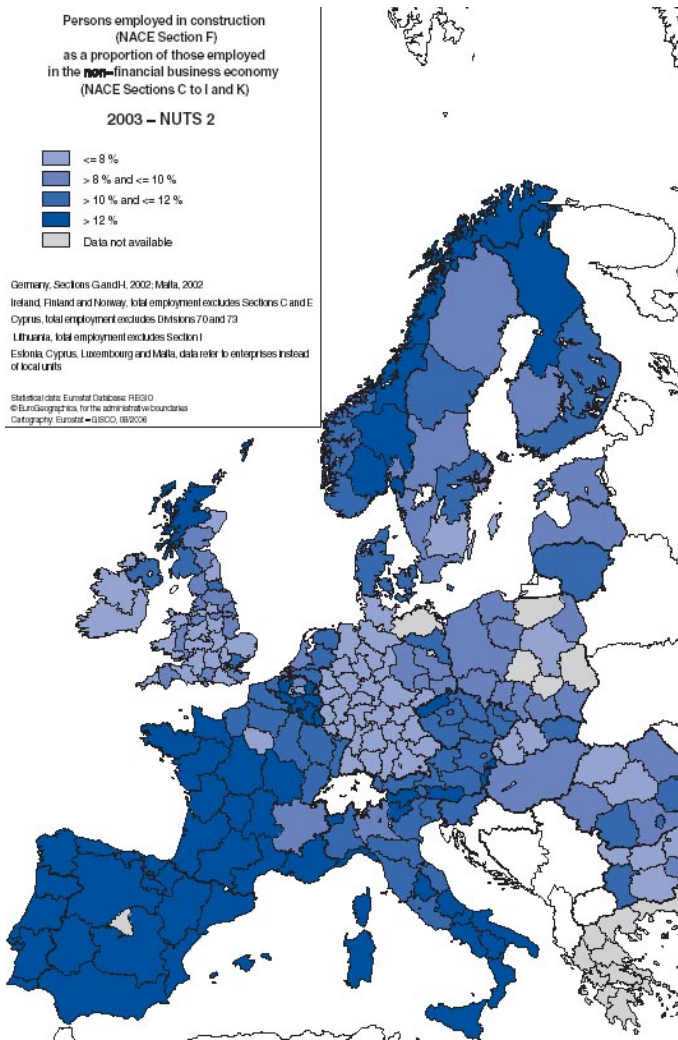


Fig. 2. People employed (Source: Eurostat, 2006).

Table 1. Some Lead Indicators (Source: Eurostat, 2006).

Construction (NACE Division 45)

Cost, productivity and profitability indicators, ranking of the top 5 Member States compared to EU-25 averages, 2003

Rank	Investment in tangible goods relative to total operating costs (%) (1)	Purchases of goods and services as a share of total operating costs (%) (2)	Personnel costs as a share of total operating costs (%) (2)	Apparent labour productivity (EUR thousand) (3)	Average personnel costs (EUR thousand) (3)	Wage adjusted labour productivity (%) (3)	Gross operating rate (%) (3)
EU-25	3.5	74.7	25.3	33.5	27.0	123.9	11.9
1	Latvia (6.2)	Hungary (88.6)	Cyprus (44.5)	Ireland (97.9)	Ireland (46.7)	Latvia (254.7)	Ireland (21.3)
2	Portugal (6.1)	Latvia (88.1)	Germany (35.4)	United Kingdom (57.5)	Netherlands (44.0)	Ireland (209.5)	Malta (18.1)
3	Denmark (5.4)	Czech Republic (86.9)	Luxembourg (35.0)	Netherlands (48.6)	Sweden (38.2)	United Kingdom (165.0)	United Kingdom (16.5)
4	Belgium (5.3)	Estonia (86.5)	Austria (34.3)	Austria (47.0)	Denmark (37.9)	Estonia (154.2)	Cyprus (16.4)
5	Lithuania (5.0)	Poland (84.8)	France (31.3)	Finland (44.8)	Austria (34.9)	Lithuania (153.3)	Latvia (16.2)

(1) Malta and Sweden, 2002; Greece and Ireland, not available; EU-25 is an EU average based on available data for 2002 and 2003.

(2) Malta and Sweden, 2002; Greece, not available; EU-25 is an EU average based on available data for 2002 and 2003.

(3) Malta and Sweden, 2002; Greece, not available.

Source: Eurostat (SBS)

Recent History of Dutch Construction Industry

The sector has been a topic of intense political discussion since 2002. Several investigations by parliament, justice, and antitrust authorities showed a widespread use of cartels and structural bid rigging within the Dutch construction industry. Dorée (2004) gives as one of the reasons for the collusion practices in the industry, which auction systems such as tendering and lowest bid selection, create a risk for the bidders because cost estimates are imprecise and uncertain. The more costs a bidder chooses to ignore, the higher the probability that he gets the contract. To see whether a contractor has grossly underestimated the costs of a project, verification can be sought by comparing the contractor's figures with the other bids. The political discussion resulted in a tougher public procurement policy. Since 2002, there is a consensus that competition between constructors needs to be enhanced. Dorée (2004) argues that a one-dimensional, price-oriented competition only provides a static, project-based efficiency. This is in line with Kashiwagi's (2004) argument about "low bid" thinking vs performance-based bid thinking, and his definition of the Value Procurement Principles.

Since 2002, a number of construction firms have made a change in their strategy toward customers. Contractors attempt to create more value through services offering and by taking a more extended view of the customer project's upstream and downstream, such as design & build (D&B), design-build-maintenance-operation, design-build-finance-operation (DBFO), and turnkey projects. This approach allows the contractors to interact early with their customers. However, these new approaches still largely remain based on a short-term perspective, focusing on each project separately, and using a call for tender procedure. Therefore, the risk of price-competition and tendering for the lowest bid (and low value) remains present.

The Apple Construction Company

The Apple Construction Company is a mid-sized construction company. In Table 2, some of the company's figures are provided. Apple has grown in the past decades through acquisitions (45 percent) and

Table 2. Figures of Apple Construction Company.

Million dollars	2006	2005
Turnover	1.470	1.410
Cost of turnover	1.350	1.300
Gross sales	120	110
Cost of sales	20	25
Overhead	83	77
Profit before tax	17	8

Table 3. Divisions and Directors of Apple Construction Company.

Million dollars	Turnover 2006	Director
Building	380	Robert Eenhoorn
Utilities	240	Jaap de Clerk
Infrastructure	650	Jan Maartenzoon
Services	200	Jolanda Struik
Total	1,470	

through autonomous growth (40 percent). The profitability is satisfactory when compared to other construction companies. However, with regard to the necessary return on investment, Apple is underperforming; the shareholders (nonstock) could have invested their money in better funds. That is why John de Clerk is under heavy pressure to improve the results in terms of return on equity.

Apple consists of four divisions. In addition to the classical divisions for buildings, utilities, and infrastructure, Apple also has a division for services (Table 3). This division provides insourcing services to the owners of the completed buildings (or installations) and pertains to all ownership-related activities.

Preparations in the Apple Construction Company

To learn more about the culture and typical standpoints in the Dutch market, John de Clerk asked his CMO (Chief Marketing Officer),

Table 4. Responses given to the survey statement: “Further Collaboration in the Construction Industry Will Lower the Costs of Failure.”

	Very much agree	Agree	Neutral	Disagree	Very much disagree	Do not know/no opinion
Architects	2	50	12	29	0	7
Building contractors	5	38	23	26	2	7
Craftsmen	2	45	18	25	1	9
Building completion companies	1	43	31	13	5	8
Providers of technical services	5	46	17	22	1	9
Total	3	44	22	21	2	8

Adriaan de Vries, to carry out a market survey among all participants in the construction supply chain. Table 4 shows the response given to the survey statement, which read: “Further collaboration in the construction industry will lower the costs of failure.” Both John de Clerk and Adriaan de Vries were very much surprised that only 47 percent of all respondents agreed with the statement.

The survey confirmed John de Clerk’s belief that it was necessary to start discussions in the industry so as to bring about a shift in thinking from coordination of projects to coordination among firms, but keeping normal competition intact. Further studies by Adriaan de Vries revealed that customer–supplier collaboration in general could result in major benefits, provided the firms made adaptations to one another. He distinguished three main types of adaptation:

1. Technical adaptations connect the production operations of supplier and customer;
2. Administrative routines;
3. Knowledge-based adaptations.

Adriaan also found that companies operating in the UK construction industry derived many benefits from the use of partnering. The

result was a less adversarial environment, increased end-client satisfaction, and an improved understanding of the difficulties faced by other parties.

Furthermore, as Adriaan pointed out, it was expected that the trend to use fewer subcontractors would continue in the UK construction industry. He referred to a survey in the United Kingdom which showed that 77 percent of the respondents had reduced the number of suppliers, while 57 percent had plans to reduce the total number of subcontractors, and favor “partnered” subcontractors in the future. By reducing and changing the partnerships, the respondents wanted to strive for more value in the construction chain. By this stage, Adriaan de Vries started to use the concept of “Best Value”. Best value in a project can be delivered by utilizing the specialist knowledge and expertise of suppliers. Such practice can prevent problems, reduce program complexity, duration and costs, and improve the overall quality of the project. After having studied American literature, Adriaan decided to call in Dean Kashiwagi who had published extensively on the principles of “Best Value” (Kashiwagi and Savicky, 2003; Kashiwagi, 2004a, b; Morledge, *et al.*, 2006).

Best Value Principles

Best Value Procurement is used for securing *performance*-based contracts and focuses on the overall value of a contract based upon performance, quality and price. While using this approach for securing supply performance, purchasers aim for “the overall combination of quality, price and various elements of required products and services that in total are optimal relative to the customer’s needs” (Kashiwagi, 2004).

Best Value Procurement assigns numerical weight for variables other than just the price of equipment. Each quality parameter is assigned an evaluation weight that most reflects the importance of that quality. Because of this weight process on multi-criteria, Best Value Procurement will not always result in an award to the lowest bidder. “How do we know which of our suppliers provide the best

value?” With this question in mind, John de Clerk requested Marianne Witvoet, the Chief Procurement Officer (CPO) of the Apple Construction Company, to outline a set of criteria which, if adhered to, would bring the company best value from its suppliers. She came up with the following set of criteria:

- (1) Life Cycle Cost (LCC);
- (2) Experience of the bidder with providing the specified equipment;
- (3) The extent to which the proposal met the technical requirements;
- (4) The extent to which the requested information was provided by the bidder;
- (5) Referral information, including the validation of the LCC forms.

Furthermore, Marianne stipulated that “Best Value” means the optimum combination of economy and quality that is the result of fair, efficient, and practical procurement decision-making, and which achieves the institution’s procurement objectives.

After having read further about Best Value Procurement, Marianne (together with Adriaan de Vries) has arranged a meeting with Dean Kashiwagi who had already researched and counselled hundreds of Best Value Procurement projects (Cott, 2003). In Professor Kashiwagi’s view, Best Value Procurement focuses on eliminating the source of poor performance in the construction industry by employing the Information Measurement Theory (IMT) and the Performance Information Procurement System (PIPS) which help minimize and solve the problems (Kashiwagi, 2004a, b; Morledge, *et al.*, 2006).

Information Measurement Theory (IMT) is about understanding information. One of the basics is that an individual always takes a decision, whether there is enough information, or not. If one lacks information or misses the necessary processing capabilities, in one’s own perception, one may still believe to have just enough information to take a decision. Most likely, information will be sought in the individual’s database of past experience, or expectations of the future. The use of an individual’s personal experience to arrive at conclusions is based on subjective bias. This is what is commonly known as decision-making.

The purpose of IMT is to (see Kashiwaghi, 2004):

1. Minimize subjective decision-making;
2. Minimize the amount of data required to accurately transfer information;
3. Identify the relationship between information usage, processing speed, and performance;
4. Identify a structure that minimizes the requirement for management;
5. Optimize processes by identifying and removing entities which add no value, or bring risk.

Performance Information Procurement System (PIPS) is about finding the value in the supply chain. The method aims to get the best contractor in a particular purchasing situation. There is pressure on suppliers from four directions:

1. Past performance;
2. Risk identification by supplier;
3. Continuous monitoring of project.
4. Current performance is (heavily) integrated in the next “past performance” indicator.

Actions Taken within the Apple Construction Company

Adriaan and Marianne decided to launch three pilots to improve the value in the supply chain. They formulated an innovative project, a direct supply project, and an administrative project. In the innovative project, the supplier was invited to participate in the innovation of a wall isolation product, used in houses. At first, the supplier was afraid he would lose the intellectual property rights of his knowledge. After the issue of knowledge-sharing had been agreed upon in a Memorandum of Understanding, parties started to innovate. Application specialists of the Apple Construction Company joined the R&D technicians of the supplier. Together, they came up with a very specific innovation, saving up to 35 percent of the total cost in the project realization phase. Now they share the property rights of the innovation.

In the direct supply project, a logistics service provider changed the way of delivering his products to the building site. Instead of bulk delivery, he waited until the site manager had called for the products and then delivered just the amount that was needed for that day. That transferred the inventory control and related management time to the supplier. Although the cost of delivery through these actions increased, the total cost in the built product was reduced.

The third project was about reducing the administrative burden (overhead!!) of the project realization. The simplest action taken was to accept the logistics documents as invoice. So, the “invoice” was paid without quality control, volume control, or administrative approval procedure. This was one of the tricky projects, because nobody believed that it would work. People anticipated fraud, theft, and other mishaps. The contrary was true. People in general acted very responsibly and an enormous amount of administrative costs was saved. At the moment, both parties are experimenting with a so-called insurance on nuts and bolts. The supplier insures the Apple Construction Company that there will always be enough nuts and bolts, and those they never have to place an order for a new delivery. It is a simple example of Vendor Managed Inventory where the product availability is paid as a service, rather than the actual number of nuts and bolts used in a project.

Once the pilots were under way, the Apple Construction Company was asked by one of the suppliers whether Apple would not also like to take part in the chain developments that the supplier was initiating. The main issue was whether the supplier could deliver work packages to workers. The new practice is to deliver work packages at the cabin during the start-up of the work, or at the 23rd floor of a building at the change of shifts. The advantages of this practice are:

1. Reduction of theft;
2. Worker-specific mounting instruction;
3. No internal handling at the constructor's project;
4. Less management attention by project leaders.

John de Clerk's Round Table

John had asked one of his assistants, Geert van Dam, to interview all the CEOs of the participating companies. Among the interview highlights were the following statements:

Karel Overbeeke, CEO of General Contractors, stated: "Suppliers should definitely not interfere with the main processes in the chain as they have no knowledge of project realization."

Chuang Wang, Manager of the Dutch branch of an international contractor, stated: "Integration in the chain could eliminate at least 40 percent of the chain cost, with an extra 20 percent potential bonus, if parties could agree on getting it right the first time."

Klaas Jan Koster, a 35-year-old new CEO of the oldest constructor in the Netherlands TUC (Techno Utility Corporation), was cognisant of the supply chain thinking, for he had trained with Wouter Beelaerts and knew his 3C model of integrating innovation, supply chains, and market share. The 3 Cs stand for Conception, Configuration and Continuation. Koster managed to change around TUC into a 3C company in three years, and was pleased to learn that, in doing so, he had in fact been following the Best Value Procurement principles all along!

The Round Table was a double success. On the one hand, there were in total three CEOs who declared that they would not cooperate with any of the other construction firms, for they were convinced they could outperform the other constructors on their own. The fact, that because they were three in number, this strategy would never work for at least two of them, did not bother them. And so, the three firms decided to leave the Round Table.

The other four stayed, and together they formed the "Best Value Club" in the Netherlands. Since then they regularly exchange information on performance of suppliers, jointly reward value generated in the supply chain, and terminate relationships with typically low bid suppliers.

Intermezzo on Purchasing

Valuing suppliers requires estimating what the value of the purchase can be from the perspective of the Apple Construction Company. Santema and Van de Rijt (2003) used the Kraljic matrix (1983) to indicate how the supplier is valued from a customer perspective (see Fig. 3). The value of the supplier is determined, as perceived by the customer. For example, firms that sell routine products (in the eyes of the customers) should build up resources that help the customer in making it easier to place an order (reduction of processes). In each quadrant of the Kraljic matrix the customer values other types of suppliers. In Fig. 3, the Kraljic matrix is shown, together with the typical value of suppliers for the Apple Construction Company.

The Kraljic matrix (1983) helps organizations identify valuable resources and helps identifying transaction costs. The transaction costs consist of the cost of specifying the details of procurement contracts, the cost of discovering what the prices should be, the cost of negotiating the procurement contract, and the cost of monitoring the fulfillment of the contract. Santema (2006) argues that firms can achieve tremendous gains by deleting certain, non-value-adding, activities.

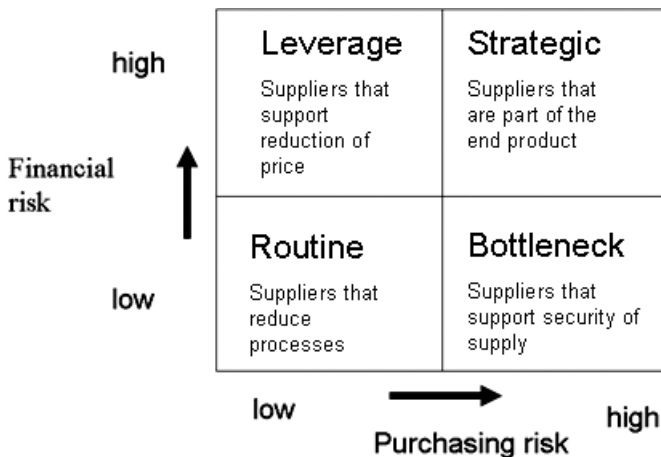


Fig. 3. Winning resources of a supplier (Source: Van de Rij and Santema, 2005; adapted).

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SSI Technologies (A)¹

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It was mid-June, 2000 and Terri Roessler, Corporate Manager at SSI Technologies (SSI) had just returned from a meeting with representatives from a major automotive customer. SSI was a supplier of anti-lock break system (ABS) wheel-speed sensors to the automotive industry, but the current technology no longer provided the capabilities demanded by the industry. Terri had been forewarned that customers were going to request a new active speed technology that the company was developing but at a price that SSI may not be able to provide. It would be Terri's job to recommend moving to the new technology but only if her cost-benefit analysis showed the product provided a positive contribution to the firm.

¹ This case was developed by David C. Porter, Department of Finance and Business Law, and Steven W. Anderson, Department of Chemistry, both at the University of Wisconsin-Whitewater. The authors thank Terri Roessler, Corporate Finance Manager, SSI Technologies, Inc. Janesville, Wisconsin, for providing and facilitating information critical to this case. Without her assistance it could not have been written. This case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

SSI Technologies

SSI Technologies was a privately held corporation with headquarters in Janesville, Wisconsin, a city of about 60,000 people located 70 miles west of Milwaukee, Wisconsin and about 40 miles south of Madison, Wisconsin, the capital of the state of Wisconsin. In 1999, the company had 940 employees located in three buildings with 195,000 sq. ft of manufacturing and office space. In addition, the company operated a 12,000 sq. ft Technical center located in Farmington Hills, Michigan.

The company was divided into two divisions, the Sensor Division and the Sintered Specialties Division. The Sensors Division utilized about 700 employees housed in 125,000 sq. ft of facility space and the Sintered Specialties Division had 240 employees using 70,000 sq. ft of space.

The Sintered Specialties Division

Exhibit 1 shows that although Sintered Specialties was providing a larger proportion of company revenues, it was still the smaller of the two divisions providing about 30 percent of company revenue in 1999. The goal of the division was to provide customers with world-class custom powdered metal parts. Utilizing high-temperature vacuum furnaces and controlled atmosphere (hydrogen, nitrogen, or dissociated ammonia) furnaces, Sintered Specialties could deliver powdered metal components suitable for the most demanding applications. High-temperature sintering produced powdered metal components with superior mechanical and magnetic properties and, in the case of stainless steels, yielded parts with superior corrosion-resistance. The additional benefits of high-temperature sintering were well known and included: increased strength (impact, yield, and fatigue); higher ductility and higher density which increased apparent hardness and hardenability; improved weldability; and higher diffusion rates allowing alloy deployment unique to the powdered metal process. In most instances, high-temperature sintering was the preferred method of achieving increased densification and resulting property improvements. The division also provided some finishing operations including undercuts, cross holes, sidewall grooves, and threads.

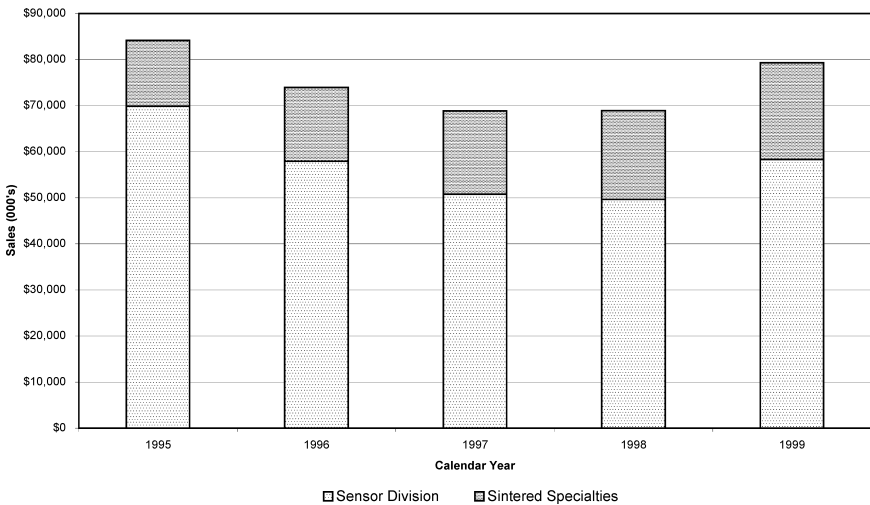


Exhibit 1. Dollar sales by division (1995–1999).

Sensor division and ABS wheel-speed sensors

The Sensor Division designed and manufactured several different types of automotive and industrial sensors including speed sensors, fuel-level sensors, absolute pressure sensors, remote tire pressure sensing systems, and high-temperature-wire coil assemblies for solenoids, actuators and controllers. The Sensors Division was registered to the ISO9001-QS9000 international quality standard.

Exhibit 2 shows that the cabled ABS wheel-speed sensor components were about 77 percent of total Sensor Division sales in 1999 or about 54 percent of total company revenue. By 1999, SSI held an industry-leading 23 percent share of the ABS wheel-speed sensor market in North America and was the world's largest independent supplier of cabled ABS wheel-speed sensors. The company had shipped more than 40 million cabled ABS sensors since 1990 and produced about 8 million cabled ABS wheel-sensors per year. Cabled systems were installed on ABS systems for General Motors, Ford, Chrysler and KIA light vehicles. SSI coil assemblies for ABS modulator solenoids were installed on ABS systems for Ford, Chrysler,

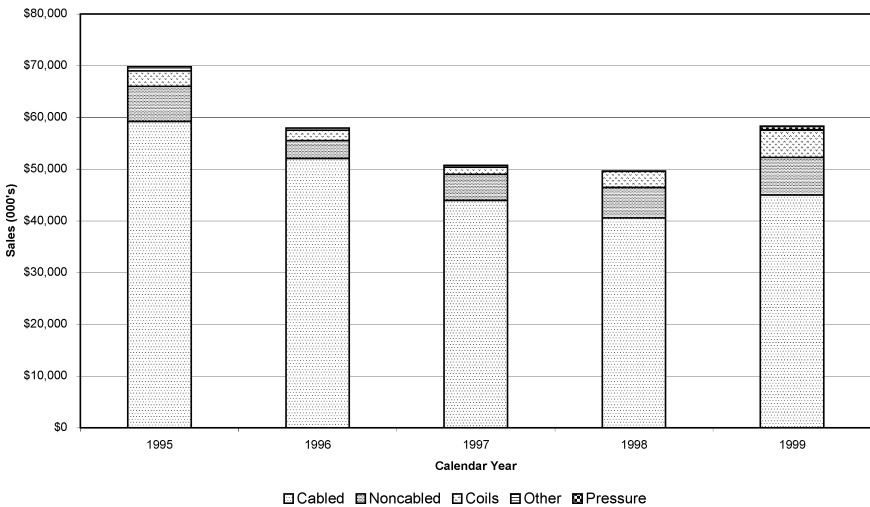


Exhibit 2. Dollar sales by product — sensor division (1995–1999).

Toyota, Fiat and Mazda. SSI had produced and shipped more than 100 million coil assemblies for sensors, solenoids and other applications since 1987. In 1996, SSI was named Supplier of the Year by General Motors in the category of automotive sensors and SSI is quality-certified with General Motors through Targets for Excellence and Ford through Ford Q1. SSI was also quality-certified with ITT Automotive.

Anti-Lock Brake Systems (ABS)²

Wheel-speed sensors are part of the ABS on all vehicles equipped with ABS as well as traction control. The following paragraphs will describe the roles of speed sensors in preventing wheel skid when braking, or wheel spin when accelerating.

All anti-lock brake systems possess the ability to control tire slip by monitoring the relative deceleration rates of the wheels during

² Information drawn from http://trailer-bodybuilders.com/ar/trucks_bosch_presents_vehicle/ and <http://autorepair.about.com/library/weekly/aa052001a.htm>.

braking. One or more wheel-speed sensors monitor wheel-speed. If one wheel starts to slow at a faster rate than the others, or at a faster rate than that which is programmed into the anti-lock control module, it indicates that a wheel is starting to slip and is in danger of losing traction and possibly locking up. The anti-lock system responds by momentarily isolating and reducing hydraulic brake pressure to the affected wheel or wheels, so that the wheel can speed up and regain its grip. As traction is regained and the wheel starts to turn again, the ABS system reapplies brake pressure to manage the stop.

With traction control, the wheel-speed sensors are used to monitor wheel spin during acceleration and normal driving. If the ABS/traction control module detects a variation in speed between the two drive wheels, it will be engaged and apply braking to the wheel that is starting to spin. On many vehicles, the ABS/traction control module is also designed to interact with the powertrain control module (PCM) so that the PCM can reduce engine power by retarding ignition timing, reducing the throttle opening, and/or disabling fuel injectors to further manage the application of power to the drive wheels.

The most advanced applications permit the wheel-speed sensors to play a role in brake-assisted steering. The Bosch VDC system, used in some Mercedes sedans, combines the basic functions of ABS and traction control with the unique ability to brake any of the vehicle's four wheels individually as needed to provide "corrective" steering. This allows the VDC system to use the brakes to help straighten out a vehicle that is in danger of going out of control. If a VDC-equipped Mercedes is driven into a turn at too high a speed and starts to understeer or oversteer, the system senses the problem variations in wheel-speed through steering input and a special "yaw rate" sensor that monitors vehicle inertia and direction. The wheels are then braked individually and automatically without the driver pressing on the brake pedal to keep the car under control so that it can negotiate the turn. Braking the right front wheel, for example, pulls the car to the right which helps correct for oversteer to the left.

System configurations

All ABS systems keep track of wheel deceleration rates through the wheel-speed sensors. Different ABS systems use different numbers of sensors depending on how the system is configured.

In a four-channel ABS each wheel is equipped with its own speed sensor. Each wheel-speed sensor provides input for a separate hydraulic control circuit or “channel”. It is important to note that “channel” always refers to the number of separate or individually-controlled ABS hydraulic circuits in an ABS system, not the number of wheel-speed sensor electrical circuits.

A three-channel ABS has a separate wheel-speed sensor for each front wheel but uses a common speed sensor for both rear wheels. The rear-wheel-speed sensor is mounted in either the differential or the transmission. The sensor reads the combined or average speed of both rear wheels. This arrangement saves the cost of an additional sensor and reduces the complexity of the system by allowing both rear wheels to be controlled simultaneously. It is the most common type of ABS setup that is used on rear-wheel drive applications.

The single-channel ABS is used on many rear-wheel drive pickups and vans. The front wheels have no speed sensors and only a single speed sensor mounted in the differential or transmission is used for both rear wheels. Rear-wheel anti-lock systems are typically used on applications where vehicle loading can affect rear-wheel traction, as with pickup trucks and vans. Rear-wheel anti-lock systems have only a single channel making them much less complex and costly than their three- and four-channel counterparts.

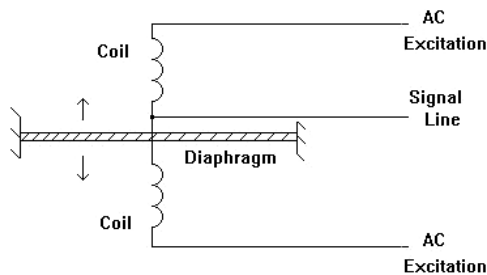
Current ABS technology

Current methods depend on variable reluctance technology. This will be outlined first followed by a description of its application to wheel-speed sensors.

*Variable reluctance speed sensing technology*³

The ability to measure very low speeds accurately, to provide changeable transducer ranges, high frequency response and rugged durability all depend on manufacturing a speed transducer with no linkages or other connections to the sensing element. This is accomplished as follows. A *variable reluctance tachometer* is designed to measure rotational speeds of 10,000–50,000 rpm by detecting electrical pulses generated as an actuating element integral with the rotating body that repeatedly passes through the magnetic field of a variable reluctance sensor; the pulses are amplified and rectified, then used to control direct current to a millimeter, which is calibrated directly in rpm. A *variable reluctance speed transducer* is perhaps best described as an inductive half-bridge, and consists of a speed sensing element and two coils. The coils are wired in series and are mounted such that their axes are normal to the plane of the element (Fig. 1). Clamped tightly between the coil housings, the element is free to move in response to differential speed. The coils are supplied with an AC excitation, typically 5 Vrms (5 VAC) at 3 or 5 KHz.

“The coils are matched so that their impedances are approximately equal. When a differential speed is applied to the sensor, the diaphragm



Variable Reluctance Circuit

Fig. 1. A variable reluctance circuit.

Source: www.validyne.com/tecnotes/theory.htm

³ Information drawn from www.validyne.com/tecnotes/theory.htm#2

deflects away from one coil and towards the opposite. The diaphragm material is magnetically permeable, and its presence nearer the one coil increases the magnetic flux density around the coil. The stronger magnetic field of the coil, in turn, causes its inductance to increase, which increases the impedance of one coil. At the same time, the opposite coil is decreasing its impedance. The change in coil impedances brings the half-bridge out of balance, and a small AC signal appears on the signal line.

The change in coil impedance is directly proportional to the position of the diaphragm, so the amplitude of the signal is directly proportional to the applied speed. The phase of the signal with respect to the excitation is determined by the direction of movement of the diaphragm. The output of a variable reluctance circuit at its full-scale speed is 20 mV/V or more. This output is about 10 times more than that is typical for strain gage transducers which are measuring devices for the electrical measurement of mechanical quantities.”

Variable reluctance speed sensors⁴

Wheel-speed sensors are nothing more than “mini” generators. They produce a very low AC voltage that is directly related to the speed of the vehicle. Speed sensors are generally very simple in design. A variable reluctance (VR) sensor is an electromagnetic device consisting of a permanent magnet wrapped with a very long, thin wire (Fig. 2).

The sensor is used in conjunction with a ferrous target wheel that either has notches or teeth (sometimes called a “tone” ring or “rotor”; Fig. 3). Rotation of the target wheel near the tip of the sensor changes the magnetic flux, creating an analog voltage signal in the sensor coil. This signal is specifically a sine wave output whose amplitude varies with the target speed. VR sensors are considered “passive” since they require no external power. The target must be moving at a minimum speed before they begin working.

⁴ Information drawn from: www.wabashtech.com/vr.htm; www.brakeandfrontend.com/bf/bf89920.htm; www.sensorsolutionscorp.com/VariableReluctance.asp; and www.autotruck.net/ms/archives/2000/1100answ.asp.

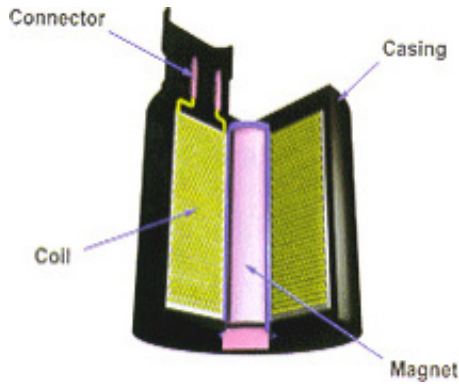


Fig. 2. Sensor cutaway.

Source: www.brakeandfrontend.com/bf/bf89920.htm



Fig. 3. Tone ring and mounted wheel sensor.

Source: www.sensorsolutionscorp.com/VariableReluctance.asp

One advantage is that they do not have to be oriented toward the target. The sensor may be mounted in the steering knuckle, wheel hub, brake backing plate, transmission tailshaft, or differential housing. On some applications, the sensor is an integral part of the wheel bearing and hub assembly. The sensor rings may be mounted on the axle hub behind the brake rotors, on the brake rotors or drums, on the outside of the outboard constant velocity joints on a front-wheel drive car, on the transmission tailshaft or inside the differential on the pinion gear shaft. The tone ring rotates at the same speed as the vehicle.

The sensor pickup has a magnetic core surrounded by coil windings. The magnet composition is typically alloys of aluminum–nickel (Alnico) or samarium–cobalt. The latter is a higher energy product but also more costly. As the wheel turns, teeth on the tone ring move through the pickup’s magnetic field. This reverses the polarity of the magnetic field and induces an alternating current (AC) voltage in the pickup’s windings. The number of voltage pulses per second that are induced in the pickup changes in direct proportion to the wheel-speed. The result is a voltage signal that changes in both frequency and amplitude. Both are proportional to the wheel-speed. The higher the wheel-speed, the higher the frequency of the wheel-speed sensor signal, and the greater is its amplitude. The diameter, and more importantly the number of teeth on the tone ring, varies depending on the vehicle and ABS system.

The signals are sent to the ABS control module where the AC signal is converted into a digital signal for processing. The signal produced by each wheel-speed sensor is monitored. During braking, it is examined to see if a wheel lockup is about to occur. During non-braking it monitors the signal for diagnostic purposes. The PCM is not actually looking at the voltage produced by the wheel-speed sensor. Instead, it is looking at the frequency of the signal to determine what is happening. The control module then monitors wheel-speed by counting the pulses from each of the wheel-speed sensors. When the brakes are applied, the stop light switch tells the PCM to monitor the wheel-speed sensors signals. The PCM looks at how fast the frequency of the signal from each speed sensor changes relative to its pre-programmed memory. If the signal is changing too fast, alerting to an impending wheel lockup, the PCM will “pump” the brakes to that wheel by cycling the appropriate solenoids in the modulator to maintain traction.

The distance or “air gap” between the end of the sensor and its ring is critical. A close gap is necessary to produce a strong, reliable signal. However, metal-to-metal contact between the sensor and its ring must be avoided since this would damage both. The air gap must not be too wide or weak, erratic, or an absence of signals may result.

Wheel-speed sensor readings are affected by the size of the wheels and tires on the vehicle. A tire with a larger overall diameter will give a slower speed reading than the one with a smaller diameter. Because the ABS system is calibrated to a specific tire size, vehicle manufacturers warn against changing tire sizes. A different tire size or aspect ratio could have an adverse effect on the operation of the ABS system.

Wheel-speed sensors are also magnetic, meaning they attract metallic particles. Metal particles can stick to the end of the sensor and reduce its ability to produce a clean signal. Hence, it may be necessary to remove the sensor for inspection and cleaning if it is found that the ABS warning light is on and there is a wheel-speed sensor code in the ABS module's memory.

A high percentage of ABS problems are caused by faults in the wheel-speed sensor circuits. Wheel-speed sensors can and do fail, sometimes as a result of physical damage, an accumulation of metallic debris on the tip or as a result of corrosion. Often, many sensor problems are actually wiring problems caused by loose or corroded connectors, or damaged wiring.

Typical applications for VR sensors include ignition system engine speed and position speed sensing for electronically controlled transmissions, vehicle speed sensing, and wheel-speed sensing for anti-lock brake systems and traction control systems.

A self-generating electrical signal means that no power supply is required. There are only two wires to hook up. VR sensors meet a wide range of output, resistance, and inductance requirements. Hence, they may be custom-designed to meet specific customer requirements. Integral bearing sensors are pre-set for resistance and output, meaning reduced time and effort at installation.

The main types of VR sensors include overmolded and non-overmolded discrete sensors with or without harness for transmission, ABS, and ignition engine speed and position applications. Integral bearing sensors are mainly used for ABS and traction control applications.

The non-overmolded coil design and unique termination technique insure high reliability and low warranty returns. Efficient magnetic circuit design and packaging flexibility permit the custom design of a VR sensor to meet the requirements for each application with

respect to smaller packaging, larger air gaps, higher temperatures, and maximized output.

As mentioned earlier, VR sensors only work when they are in a varying magnetic field or moving through one. As a consequence, they cannot detect static or slowly changing fields. Hence, they cannot distinguish between a wheel moving at constant speed or stopped. VR sensors can have an output as low as 1 mV but it is questionable whether this is a reliable signal rather than an effect from outside interference. Below a certain threshold output ceases. On the other hand, their detectable range is the most extensive of any known sensors spanning approximately 10^{-8} – 10^{10} Gauss.

Active speed technology⁵

This technology utilizes Hall Effect sensors, magnetoresistive ratio sensors, and giant magnetoresistive sensors (Fig. 4). Each of these will be described in the following sections.

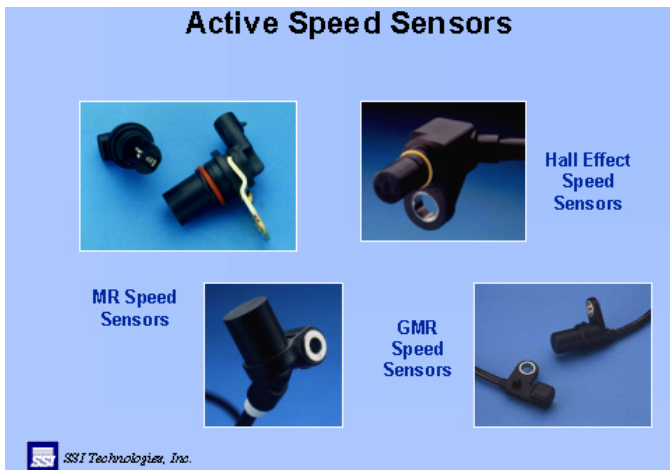


Fig. 4. The three types of active speed sensors. (Used with permission of SSI Technologies, Inc. Janesville, Wisconsin.)

⁵ Information drawn from www.kemparts.com/tt10/tt10.html.

*Hall effect sensors*⁶

The Hall effect (named after the American physicist Edwin Herbert Hall, 1855–1938) involves the generation of an electric potential perpendicular to both an electric current flowing along a conducting material and an external magnetic field applied at right angles to the current upon application of the magnetic field. “The Hall Effect principle states that when a current carrying conductor is placed in a magnetic field, a voltage will be generated perpendicular to the direction of the field and the flow of current. Consider Fig. 5 in which a constant current is passed through a thin sheet of semiconducting material to which are attached output connections at right angles to the current flow. With zero magnetic field, current distribution is uniform and there is no potential difference at the output contacts.

When a perpendicular magnetic field (B) is present, as illustrated in Fig. 6, the current flow is distorted. The uneven distribution of electron density creates a potential difference across the output terminals. This voltage is called the Hall voltage.

A practical equation that describes the interaction of the magnetic field, current and Hall voltage is:

$$V_H = k \cdot I \cdot B \sin \Theta,$$

where constant k is a function of the geometry of the Hall element, the ambient temperature and the strain placed on the Hall element;

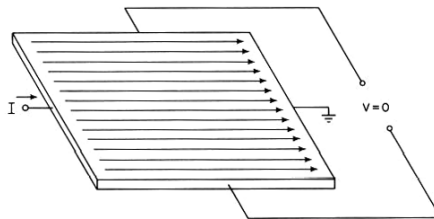


Fig. 5. Semiconductor with a current connection in the absence of an external magnetic field.

⁶ Information drawn from: <http://www.amploc.com/InternetHandbook.pdf> and *Physics*, Part II, D Halliday and R Resnick (1963), pp. 827–829. John Wiley & Sons.

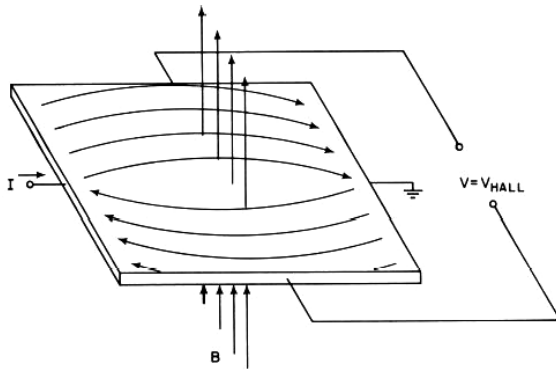


Fig 6. Semiconductor with a current connection in the presence of an external magnetic field.

Source: <http://www.amploc.com/InternetHandbook.pdf>

I is the applied current; and $B \sin \Theta$ is the component of magnetic field perpendicular to the sheet.

If the input current is held constant, the Hall voltage will be directly proportional to the strength of the magnetic field. The Hall voltage is a low-level signal of the order of $20\text{--}30\text{ }\mu\text{V}$ in a magnetic field of 1 gauss. A signal of this magnitude requires a low noise, high impedance, and moderate gain amplifier.”

Hall sensors are activated by magnetic fields only. Because it is a non-contact sensor, Hall sensors do not wear and are unaffected by dirt and other contaminants. Sensor life is virtually infinite as demonstrated by test units withstanding millions of cycles without failure. Table 1 shows that the small size, durability, and low cost make Hall effect sensors an ideal choice for difficult applications.

Table 1. Hall sensors in motor vehicles.

Applications	Specific uses
Ignition timing/Engine position	Crankshaft speed/position
Fuel injection timing	Engine misfire detection
Electronic transmissions	Speedometer/vehicle speed
Emission controls	Tachometer/turbine speed
Anti-lock brakes	Wheel-speed

Many of today's computerized engine control systems are using Hall-Effect sensors, also called Hall-effect switches, to sense crankshaft and camshaft speed and position. These switches vary in design but are similar in operation. The main differences lie in the voltages at which they work, physical configuration, and location on the engine.

"The Hall-Effect sensor is a very accurate way for a computer to 'see' the exact position or measure the speed of a spinning shaft. Most designs utilize a shutter, which passes through an opening in the sensor. The opening has a magnetic field passing across from a permanent magnet to the electronic switch. When the shutter passes through the magnetic field, it is interrupted and the computer senses a change in voltage. With the shutter in the opening, the voltage falls to near zero. With the shutter out of the opening, the voltage rises to the specified voltage level. This voltage is usually equal to battery voltage on GM, Ford, and many Chrysler engines. Some Hall sensors use a moving magnet attached to a timing chain sprocket (GM) or notches in the flex plate (Chrysler) to generate a signal (Fig. 7).

All Hall-Effect sensors utilize three wires. One wire carries the power voltage while a second supplies the sensor ground. The ignition module or computer supplies both. The third wire is the 'toggle'. This wire is the sensor's output to the computer. The voltage rises, usually to power voltage, and falls to near zero with the movement of the shutter as explained earlier. The signal is a square wave and therefore needs no analog to digital conversion to be read by the computer. The computer measures the time between the pulses and calculates RPM for fuel and timing requirements.

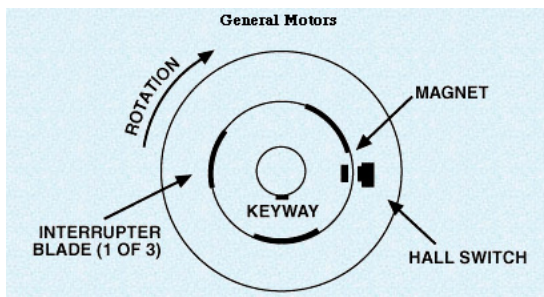


Fig. 7. Setup for a Hall sensor in GM vehicles.

Source: www.kemparts.com/tt10/tt10.html

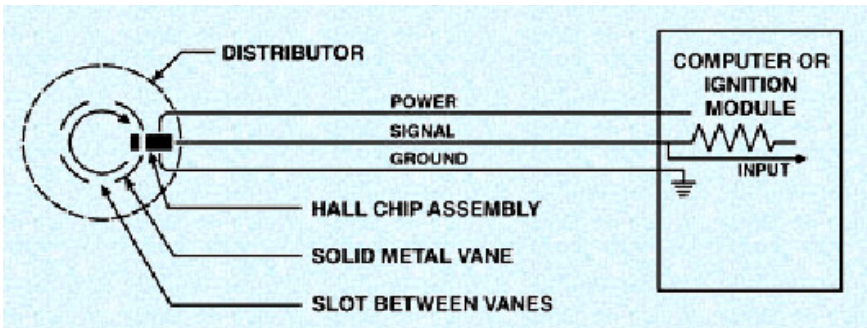


Fig. 8. A typical Hall Sensor circuit.

Source: www.kemparts.com/tt10/tt10.html

Testing a Hall-Effect sensor is simple if they are understood and you have a digital volt-ohm meter or a lab scope. The most difficult part of a test would be accessing the sensor's wires. All technicians require a good set of jumper wires in order to probe the Hall Sensor connectors without damaging the circuit (Fig. 8).

To function correctly, a Hall-Effect sensor must have power voltage and ground applied to it. If the power, ground, or signal wires are open, the sensor cannot operate. A short to ground on either the power wire or the signal wire also eliminates the RPM signal.

Hall-Effect sensors are capable of detecting zero speed up to as high as 50 kHz. Orientation of the sensor to the target is required, but tolerances on orientation are usually $\pm 60^\circ$. The Hall sensor typically detects an external magnetic field created by a ring magnet, and provides two digital outputs: speed ($2 \times$ pole-pair count) and direction. The sensor relies on a proprietary flux reversal to trigger its output; this reversal will only work properly if the sensor is aligned to the target's rotation direction. Hence, the sensor has two alignment flats machined on the housing that should be aligned to the rotation direction. The advantage of this flux reversal technology is that *the sensor operates independent of target speed*, providing a 'true zero' speed capability."⁷

⁷ Information drawn from www.kemparts.com/tt10/tt10.html.

Magnetoresistive ratio sensors⁸

“A magnetoresistor (MR) is a two-terminal device that changes its resistance with a change in magnetic field (Fig. 9).

The sensors shown here are extremely small and thin, freeing up valuable board space. Commercially available current sensors have the high performance of closed-loop Hall sensors, while occupying substantially less volume and consuming less power.

Although the magnetoresistive effect has been known for over 130 years, it is only in the past 30 years that advances in microelectronics have allowed its practical use. Almost every conducting material exhibits some magnetoresistance, but the effect is particularly large in permalloys, which are nickel-iron alloys and other ferromagnetic materials. MR devices are very sensitive to magnetic fields, significantly more so than Hall sensors. A class of magnetoresistors with an even larger sensitivity than standard MR devices is known as giant magnetoresistors (GMRs), whose applications include products ranging from virtual reality position sensors to hard disk drive read/write heads. Because MR and GMR devices change their resistance with magnetic fields parabolically, they cannot detect magnetic field polarity. Magnetoresistors have

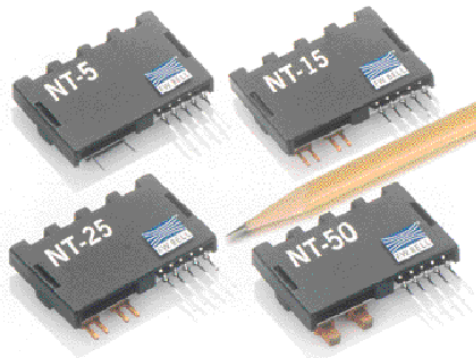


Fig. 9. Typical MR sensors.

Source: www.sensormag.com/articles/0999/84/main.shtml

⁸ Information drawn from www.sensormag.com/articles/0999/84/main.shtml.

other disadvantages including a limited linear range, poor temperature characteristics (2500 ppm/°C typical), a wide range of sensitivities from device to device, a magnetic memory, and high costs. These drawbacks, for the most part, discouraged their use in current sensors.

Recent advances in magnetoresistive technology have minimized the MR disadvantages and capitalized on the high sensitivity of the devices.” Placing four highly symmetrical MR devices in a special configuration (essentially like two “sandwiches” facing each other) eliminates the dependence on sensitivity and offsets variability over temperature. “Although the individual MR devices still change over temperature, they all change at the same rate, yielding a zero net drift at the output. The special configuration has the added benefit of immunity to external homogeneous magnetic fields. Again, all the MR devices will sense the field and change, but the output will remain unchanged — extremely important when measuring small magnetic field gradients in a noisy magnetic field environment. This property, together with MR devices’ high sensitivity, allows a current sensor to be manufactured without a magnetic core.

A magnetic core is typically required in Hall-Effect-based current sensors to both increase the flux density and shield the sensor from external fields. The additional flux density is required due to the lower sensitivity of Hall devices. The MR design, with its high sensitivity and immunity to external magnetic fields, does not need the core. The requirement for a magnetic core has several liabilities: it is costly, it is large, it adds nonlinearities, it has a residual magnetism, and it limits the frequency response due to eddy current heating effects. Getting rid of the core eliminates these drawbacks as well.”

Giant magnetoresistive sensors

“Recent developments in thin-film magnetic technology have resulted in films that exhibit a large change in resistance in response to a magnetic field. This phenomenon is known as giant magnetoresistance (GMR) to distinguish it from conventional anisotropic magnetoresistance (AMR). Where AMR resistors exhibit a change of resistance of <3 percent, various commercial GMR materials achieve a change of

10–20 percent. GMR films have two or more magnetic layers separated by a nonmagnetic layer.”⁹ GMR sensors offer a rugged, low-cost solution to rotational reference detection. High sensitivity and DC operation afford the GMR bridge sensor an advantage over inductive sensors, which tend to have very low outputs at low frequencies and can generate large noise signals when subjected to high-frequency vibrations. Because GMR sensors are field sensors, they do not measure the induced signal from the time rate of change of fields, as is the case with variable reluctance sensors. “The output from a GMR bridge sensor will have a minimum when the sensor is centered over a tooth or a gap and a maximum when a tooth approaches or recedes.”¹⁰ The bridge sensor shown in Fig. 10 is in position for angular position sensing.

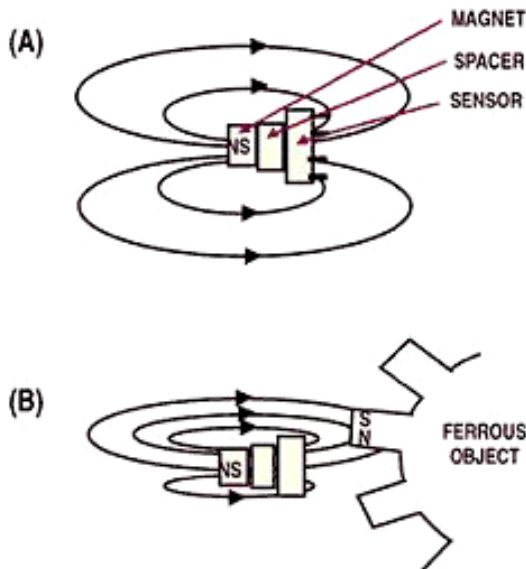


Fig. 10. A GMR configuration designed for proximity detection.

Source: www.sensormag.com/articles/1298/mag1298/main.shtml

⁹ Information drawn from: www.sensormag.com/articles/0999/76/main.shtml.

¹⁰ Information drawn from: www.sensormag.com/articles/1298/mag1298/main.shtml.

The biasing magnet and sensor in an 8-pin package are shown in side view with and without the presence of a ferrous object.

“Small, low-power GMR sensors and their associated electronics, memory, and battery can be packaged in a low-profile aluminum housing the size of a hand.”¹¹ Exhibit 3 shows a comparison of the five different ABS speed sensors. In summary, all active speed sensors have more robust electrical termination and allow for enhanced diagnostics in the field.

The Capital Budgeting Decision

Terri's initial research suggested that two active speed sensor production lines would be required to produce the estimated demand of about 1.5 million units (750,000 units annually for each line). Several calls to suppliers produced an estimate for capital cost near \$1 million for each new line if the lines were to be in place by the beginning of January, 2001. For an initial analysis, Terri thought it was possible to depreciate the capital costs straight line to zero on a 10-year basis and with no salvage value. The Janesville employees had negotiated a wage and benefits package that was consistent with the other area factories including the General Motors plant. With these costs in mind, Terri's estimates of per unit costs were \$0.70 for labor, \$2.71 for material, and \$2.47 for direct overhead (electrical, health care, other benefits, etc.). Each unit would sell for \$6.35 and the effective income tax rate was 35 percent. Because of the large volumes requested by the customer and the competitive environment for automotive parts, the customer usually had power over pricing and there was little, if any room to negotiate prices. Initial net working capital requirements were estimated at \$150,000 (recoverable at the end of the project) and repairs and overhauls would average about \$20,000 per year starting in 2002 (can be expensed in the year they occur). Installation costs would approach \$200,000 which could be expensed immediately. SSI generally used discount rates of

¹¹ Information drawn from: www.sensormag.com/articles/1298/mag1298/main.shtml.

Exhibit 3. ABS Speed sensor comparison.

	VR (gear ring)	Hall-Effect (gear ring)	Hall-Effect (magnetic ring)	MR (gear ring)	GMR (gear ring)
Minimum package diameter, mm	~18.0	9.0	~6.5	~10.0	~10.0
Maximum air gap, mm	2.0	4.0	2.5	2.5	
Power source	None	External	External	External	External
Output	Analog, sinusoidal. digital conversion required for computer.	Digital (two state/wire) voltage or current (20–30 μ V, 6–14 mA)	Digital (two state/wire) voltage or current (20–30 μ V, 6–14 mA)	Digital (two state/wire) voltage or current (20–30 μ V, 6–14 mA)	Digital (two state/wire) voltage or current (20–30 μ V, 6–14 mA)
System factors affecting amplitude output	Tone wheel speed, air gap, tone ring geometry, and temperature	None	None	None	None
Configurations	Single pole, ¹ Multi-pole, ² Annular ³				

(Continued)

Exhibit 3. (*Continued*)

	VR (gear ring)	Hall-Effect (gear ring)	Hall-Effect (magnetic ring)	MR (gear ring)	GMR (gear ring)
IC package (sensor element and signal conditioning electronics)	Separate	Single unit	Single unit	Separate	Separate
Minimum speed, rpm	15–50	Zero	Zero	Zero	Zero
Target orientation	Not required	Required	Required	Required	Required
Signal integrity	More sensitivity to signal “drop out”	Less sensitivity to signal “drop out”	Less sensitivity to signal “drop out”	Less sensitivity to signal “drop out”	Less sensitivity to signal “drop out”
Detectable field range, Gauss	10^{-8} – 10^{10}	10 – 10^6	10 – 10^6	10^{-6} – 10^2	10^{-1} – 10^8
Target speed dependence	Direct	None	None	None	None
Magnetic core	Al–Ni, Sm–Co	Al–Ni, Sm–Co	Al–Ni, Sm–Co	Al–Ni, Sm–Co	Al–Ni, Sm–Co
Relative cost	Moderate	Low	Moderate–high	Low–moderate	Low

¹Utilize a single magnet and pole piece; ²Utilize multiple pole pieces/magnets; ³Utilize a ring magnet with multiple pole pairs.
Information drawn from several sources previously cited in this chapter.

20 percent for projects of this type. Terri had studied several capital budgeting decisions while completing her MBA at a well-known mid-western business school but she remembered the analysis was never as clear-cut as it first appeared. There always seemed to be additional options and ways of looking at the problem that complicated the analytical process.

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Lifton Hydra Team¹

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Lifton Ltd., Bulgaria, is a wholly owned subsidiary of Lifton Industries Plc with Headquarters in the United Kingdom. It has production, marketing, and servicing facilities for hydraulic building equipment. The company is located in the city of Rousse situated on the Danube River in the northern part of the country. Lifton produces a wide range of hydraulic mounted breakers and other hydraulic accessories as submersible water pumps, augers, and a variety of other tools. In May 2002, the company had 2,500 sq. m. production area and 700 sq. m. administration facilities employing a total of 75 people.

¹ This case was developed by Marin Marinov, The Business School, University of Gloucestershire, United Kingdom and Svetla Marinova, Department of Marketing, at The Birmingham Business School, at University of Birmingham from public sources for instructional purposes only. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

Lifton Ltd., Bulgaria, is a successor of a factory named Hydroprobivna Technika, founded in May 1987. It was set up as a small enterprise by the Bulgarian government in the last years of the Communist regime. It was turned into a joint venture between the Bulgarian government and Lifton Industries Plc in the period 1992–1994. The company was privatized in 1994 with the majority shares purchased by Lifton. The support by the parent company, Lifton Industries Plc and the successful partnership with its other subsidiary, Breakers A/S, Denmark, allowed Lifton Bulgaria to increase its product range and gain international reputation by selling products made in Bulgaria worldwide. The major clients of Lifton Bulgaria are mostly construction firms located in Germany, Italy, the United Kingdom, Denmark, Poland, and Turkey. Currently, the company aims at penetrating the markets of the Commonwealth of Independent States, mainly Russia, as well as the Middle East, where Bulgarian production has traditionally been very well positioned.

Lifton Bulgaria designs, produces and markets a range of hydraulic breakers for machine mounting within the mass range from 60 to 1,200 kg. The company carries out marketing activities in Bulgaria and adjacent markets. It markets the products made in Rousse, as well as those produced by Breakers A/S, Denmark. They are hand-held hydraulic breakers, hydraulic power-packs and other hydraulic power-tools and accessories produced under the brand name of Lifton.

Lifton products are used in the construction industry for concrete demolition, road breaking, ramming, underground activities, tunnel and pipeline construction. To assure high quality and performance, all products of Lifton Bulgaria were certified in 1996 as meeting the requirements of ISO 9001.

The Bulgarian subsidiary has its own technical and technological departments, which design new products and adapt existing ones in accordance with clients' requirements. The staff of these departments are comprised of highly qualified engineers. The traditional links between the local Technical University and the company have supported its development over the years. Products are designed and/or tailor-made so that they meet all specific market requirements of the domestic and export markets. There is also a special

system for providing tailor-made products satisfying particular customer needs and wants.

In late 2001 and early 2002, Lifton Bulgaria started an ambitious five-year investment program to modernize and widen its production capacities, developing its own technological base. The money is being invested in new Central Numerical Control (CNC) machine-tools for the transfer of production of all hand-held hydraulic breakers from the Danish subsidiary to Bulgaria. The ultimate goal of the program is to overtake all hand-held hydraulic production from Breakers A/S Denmark by the year 2004. By the end of July 2002, the investment made in Lifton Bulgaria by the London-based parent company was more than US\$1 billion.

Introduction

The industry for the production of hydraulic equipment is relatively new for the Bulgarian economy. It came into existence in the mid-1960s. Hydroproivna Technika SPLTD in the city of Rousse is a successor of a small enterprise for hydraulic drilling and punching equipment, established on 1 May 1987. The company has been a sub-sector of the Bulgarian machine-building industry with the main scope of activity entailing production of a range of hydraulic hammers with stroke energies from 80 to 5,000 J and masses spanning 70 to 1,500 kg. These are mounted on hydraulic excavators or special manipulators. While the company managed to produce durable equipment that was welcomed in the former Council for Mutual Economic Assistance (CMEA) market during the communist era, the collapse of the internal CMEA trading system created a severe problem with the sales of the goods produced. The expected annual demand for such goods on the Bulgarian market was met with less than 20 percent of the capacity of the enterprise. The initial penetration in international markets beyond the limits of the CMEA system encountered difficulties due to the lack of relevant experience and built-up service network. The company management had always used a Foreign Trade Agency owned by the state that organized all international trading arrangements. The management of Hydroproivna

Technika did not have first-hand market intelligence, lacked knowledge of who their customers were and what they required. The existent international market collapsed, the domestic market shrank and new market opportunities were obscure.

At that turbulent time, the company that had provided the technological know-how for the establishment of Hydroprobivna Technika, the Danish firm Breakers A/S, decided that there was a strategic opportunity for a more substantial involvement in a low-cost production base in Bulgaria. The management of Breakers were aware of the technical and technological capabilities of the ailing Bulgarian state-owned enterprise and its highly experienced work-force. Lifton Industries, prompted by Breakers, wished to acquire the Bulgarian operation. However, the transition period at the time was in its first stage with no legal framework allowing for the privatization of state-owned companies. The only possible option that could be pursued was an international joint venture. It could let Breakers increase its involvement in the management of Hydroprobivna Technika incrementally, gaining more experience in dealing with the Bulgarian authorities and making gradual changes in the technological basis of the Bulgarian company.

Hydra Team Ltd. was established as an international joint venture (IJV) on 13 May 1992. The scope of activities of the company enhanced R&D, production, and marketing of hydraulic drilling equipment for the Bulgarian market and for export markets. The fixed capital was 100,000 Bulgarian leva.² Partners of Hydra Team were Breakers A/S, Denmark and Hydroprobivna Technika SPLTD, which was still a state-owned company. The shares of the IJV were distributed between the partners with 80 percent owned by Breakers A/S and 20 percent share of Hydroprobivna Technika. The Danish partner became committed to investment in developing the technological capabilities of Hydrobrobivna Technika, staff training and development, as well as providing market access for the IJV's products that were to become a part of the product range of Breakers.

² At the time this book went to press, the exchange rate was 1 US dollar = 1.88 Bulgarian leva.



Exhibit 1. Product range of Lifton Bulgaria.

The IJV secured the distribution of Hydra Team and Lifton brand products manufactured by Hydroprobivna Technika and Breakers on the markets of Bulgaria and Romania. Hydra Team bought the hydraulic equipment produced by Hydroprobivna Technika and sold it through its distribution network in international markets. As the technology of Hydrobrobivna Technika was lagging behind world standards, there were significant shortcomings in terms of inadequate product quality and product design. Those caused serious problems in the realization of the production on international markets. However, both IJV partners were trying to improve standards and create a win-win operation. Those efforts were actively mediated by the General Manager of the IJV who had the advantage of being well embedded in the Danish and Bulgarian culture, with excellent relationships and networks.

Breakers A/S is a joint-stock company established in 1962 for the development, production, and marketing of manual hydraulic

instruments and hydraulic stations under the name of Lifton. Breakers is a member of the company group Lifton Industries together with Powerfab, a British producer of micro-escalators, and Pocal Industries Inc., Pennsylvania, a US small breakers producer.

Following the establishment of the IJV and the introduction of a legal framework setting up the scene for privatization of state-owned enterprises, in 1992 Breakers A/S, through the parent company Lifton Industries, announced its willingness to privatize Hydroprobivna Technika with the intent to acquire control over the management and make further investments for the improvement of the production technology.

There were many opportunities for Lifton UK to participate in the privatization process in a number of countries in Central and Eastern Europe after the start of the transition. Two major opportunities were considered: buying know-how or acquiring or buy a complete factory. The decision was to give a priority to the purchase of production know-how in the form of work skills and experience. Hence, the investor's incentives were skills and efficiency seeking (at the time of privatization the salaries in Bulgaria were between 25 and 30 times lower than those in the respective companies in Denmark and the United Kingdom). The motives of the state-owned Hydroprobivna Technika for participation in the privatization procedure were mainly to improve its technological level, quality standards and, on this basis, to increase its capacities and market share in international markets. There were no other foreign investors willing to participate in the bid. At a certain stage the Bulgarian Privatization Agency considered other methods of privatization including privatization through management/employee buy-in and/or buy-out. However, Lifton UK was very persistent and offered the best conditions and opportunities for the technological and marketing development of the company. The Bulgarian Privatization Agency invited several other foreign investors to participate in the bid, but they did not show any interest. Several Bulgarian potential buyers were invited by the Privatization Agency, but their financial capabilities were very limited.

On 22 October 1993, the Bulgarian Privatization Agency representing the Bulgarian Government and Breakers A/S, signed a preliminary

Compressed air is still the most common on the market even though hydraulics in modern machines actually is more advantageous. Below are the most important points on a hydraulic solution instead of pneumatic or electric tools.

The high hydraulic performance means that an 18 kg (40 lbs) hydraulic breaker has the same blow energy as a 20–22 kg (44–48 lbs) pneumatic breaker - and that a 20 kg (44 lbs) LIFTON breaker has the same blow energy as a 25 kg (55 lbs) pneumatic breaker. The performance of electric breakers is even lower, and they are therefore not suitable for demanding demolition jobs in concrete and asphalt.

High Performance

Maximum performance and greatest flexibility is achieved when the hydraulic LIFTON tools are connected to one of the reliable and portable LIFTON power-packs (65–116 kg/143–255 lbs). Alternatively, the LIFTON tools can be connected to most construction machines such as mini-excavators, skid-steer loaders, excavators, backhoe loaders and other hydraulic machines.

Flexibility

The mobile and compact LIFTON power-packs can easily be transported in any station wagon, box van, truck etc. The big wheels combined with the foldable handles makes it easy to move the power-pack around on the work site.

Portability

The closed hydraulic system with built-in lubrication and temperature control of all moving parts secures a long and trouble-free operation with no daily service required. The highly efficient hydraulic system requires only small engines for maximum performance and efficiency. With the small light-weight LIFTON power-packs placed away from the working place, wear caused by vibration and dust is eliminated, and subsequently service is reduced to an absolute minimum.

Minimum Service/Long Life Time

The highly efficient and operator friendly LIFTON tools are offering all the features you are looking for:

Why LIFTON Tools

- Low Investment Costs — Fast Return on Investment
- Operator-friendly Construction — Safe Operation
- Easy Transport and Storage — Low Handling Costs
- Compact and Lightweight — Easy Access to any Work Site

Work under all climate/weather conditions

Reliable Equipment — Low Service Costs

You will always find an efficient, reliable LIFTON tool for any of your demolition or contracting jobs.

agreement for sale of 97 percent of the shares of Hydroprobivna Technika. The purchase was made through the IJV company Hydra Team. The deal was for the amount of US\$350,000 payable in cash within a week from the signing of the contract. The money was provided by Breakers A/S. The buyer undertook the liabilities of Hydroprobivna Technika that amounted to 4.8 million Bulgarian leva towards the date of the signing of the contract. Those liabilities had to be covered within a period of four years. The buyer also undertook the responsibilities not to reduce the number of jobs and to make investments from their own funds in the amount of US\$350,000 within three years, according to a schedule attached to the privatization contract.

Environmental Constraints

The frequent changes in the legal framework in Bulgarian had a negative influence on the companies with foreign capital in Bulgaria in the first year of transition. The legal system contained contradictions allowing higher taxation of companies with foreign direct investment. In the early and mid-1990s the government policy clearly favored the state-owned companies. They were given interest-free credits without any complications. Such were easily extended even to companies that were clear loss-makers. Companies with foreign capital were in a severe disadvantage as they were not favored by the credit system, which opposed any credit lines for such firms. In 1995, the then General Manager of Lifton Hydra Team, Mr. Gerhard Hansen, a Danish national who lived and worked in Bulgaria for more than 20 years used to say that the Bulgarian government did not like foreign investors too much, as they were something new for the Bulgarian business context. However, he believed that knowing the local environment and having patience, persistence and networks of contacts were of utmost importance for the success of any business venture in the country. The most severe problems were caused by the differences in the content of the legal documents and the way they were applied. For example, there was a constant

LH 70

The LIFTON LH 70 is a lightweight, boom-mounted hydraulic breaker for mounting on mini-excavators and skid-steer loaders weighing from 0.6 to 1.5 t.

The LH 70 can cope with any breaking job in asphalt, lightweight/mass concrete, and brickwork. The LH 70 is used instead of hand-held breakers and is much more effective especially when higher performance is required and it is difficult or impossible to use a pick breaker. Harmful vibrations in operator's arms and body are avoided as well as the necessity of lifting and carrying the breaker during operation.

The LH 70 requires an oil flow of 15–28 l.p.m. (4.0–7.4 US g.p.m) and works at an inlet pressure of 80–125 bar (1,160–1,810 psi).

**LH 110**

The LIFTON LH 110 breaker can easily be mounted on carrier machines, such as mini-excavators, skid-steer loaders and backhoe loaders etc. weighing 1.0–3.5 t.

The LH 110 can cope with any breaking job in asphalt, lightweight/mass concrete and brickwork.

There are two LH 110 complete versions available depending on the side plates used for mounting the breaker on to carrier machine:

- Breaker with side plates of type “hammer holder” (LH 110K standard) for direct mounting by means of complete outline bushings and pins;
- Breaker with side plates of type “hammer bracket” (LH 110KF optional) for flange mounting by means of additional adapter plates.



The LH 110 requires an oil flow of 20–34 l.p.m. (5.2–9.0 US g.p.m) and works at an inlet pressure of 90–130 bar (1,305–1,885 psi).

Exhibit 3. Description of mounted hydraulic instruments produced by Lifton Bulgaria.

Exhibit 3. (*Continued*)

LH 170



The LIFTON LH 170 breaker can easily be mounted on carrier machines, such as mini-excavators, skid-steer loaders, and backhoe loaders etc. weighing 1.0–3.5 t.

The LH 170 can cope with any breaking job in asphalt, lightweight/mass concrete and brickwork.

There are two LH 170 complete versions available depending on the side plates used for mounting the breaker on to carrier machine:

- Breaker with side plates of type “hammer holder” (LH170K standard) for direct mounting by means of complete outline bushings and pins;
- Breaker with side plates of type “hammer bracket” (LH 170KF optional) for flange mounting by means of additional adapter plates.

The LH 110 requires an oil flow of 25–40 l.p.m. (6.5–10.5 US g.p.m) and works at an inlet pressure of 130–150 bar (1,885–2,175 psi).

LH 300



By means of a universal fixture the LH 300 breaker can easily be mounted on carriers like excavators, skid-steer loaders, wheel loaders and backhoe loaders weighing 3.5–7.5 t.

Thanks to a simple and rugged design, the new LIFTON LH 300 breaker is an efficient and reliable breaker for the breaking of heavy asphalt and reinforced concrete.

LH 300 is the ideal breaker for the rental industry, where the demands on high dependability, easy mounting and limited need for service are high.

The LH 300 requires an oil flow of 40–70 l.p.m. (10.5–18.5 US g.p.m) and works at an inlet pressure of 100–155 bar (1,450–2,248 psi).

(*Continued*)

Exhibit 3. (Continued)

LH 360

Thanks to a simple design, the new LIFTON LH 360 breaker is an efficient and reliable breaker for the breaking of heavy asphalt and reinforced concrete.

Due to its sturdy construction the LH 360 is the ideal breaker for particularly the rental industry, where the demands on high dependability, easy mounting and limited need for service are high.

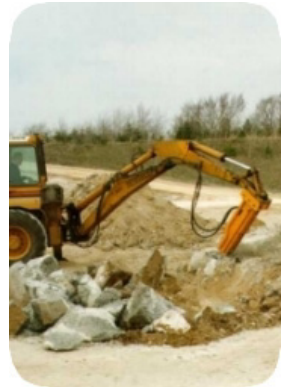
The LH 360 requires an oil flow of 40–65 l.p.m. (10.5–14 US g.p.m) and works at an inlet pressure of 120–170 bar (1,740–2,465 psi).

**LH 500**

The LH 500 is a medium-sized and powerful hydraulic breaker for boom mounting. It can be mounted on excavators and backhoe loaders weighing from 6.0 to 13.0 t.

Thanks to a simple and rugged design, LIFTON LH 500 breaker is an efficient and reliable breaker for the breaking of heavy asphalt and reinforced concrete.

The LH 500 requires an oil flow of 55–100 l.p.m. (14.5–26.3 US g.p.m) and works at an inlet pressure of 140–180 bar (2,030–2,610 psi).

**LH 1000**

The LIFTON LH 1000 is a medium-sized, powerful, boom-mounted, hydraulically operated breaker. It can be used on any carrier machines (mainly wheeled or tracked excavators), which meets the hydraulic and mechanical installation requirements. The LH 1000 breaker can be installed on any excavator that falls within the “carrier weight” of 14.0–24.0 tons (30,865–52,910 lbs). It can also be installed on any carrier, which is hydraulically and mechanically suitable for this particular piece of equipment.

(Continued)

Exhibit 3. (*Continued*)

The optimum breaking speed and utility of carrier machines up to 24 t. The LH 1000 is designed for demolition of buildings, bridges, foundations, bases, floors, walls, etc. and for breaking of asphalt and frozen soil. Breaking up road surfaces and reinforced concrete; trench cutting in soft rock and frozen ground; reducing over-size; breaking soft rock and splitting boulders; clearing quarry floors are other jobs, where the LH 1000 breaker is put to use.

The LH 1000 requires an oil flow of 90–130 l.p.m. (23.7–34.2 US g.p.m) and works at an inlet pressure of 140–180 bar (2,030–2,610 psi).

Hand-held Breakers

LH 10



The LH 10 is a very light hydraulic breaker with vibration dampened D-handle, designed for horizontal breaking jobs in brickwork and light concrete.

The LH 10 requires an oil flow of 18–22 l.p.m. and works at a pressure of 70–90 bar.

LIFTON uses Flat-Face quick-release couplings, which are durable and very easy to clean.

LH 18



The LH 18 is a light-weight hydraulic breaker with a high performance compared to weight. The breaker can be used for horizontal as well as vertical breaking. The all-round hydraulic LH 18 breaker is designed for breaking in brickwork, frozen soil, concrete, and asphalt.

The LH 18 breaker is available in a standard version (LH 18 S) and an ergonomic version (LH 18 E) provided with torsion dampened handles which reduce the vibration level to a minimum and protect the

(*Continued*)

Exhibit 3. (Continued)

operator from injuring his hands and arms. Safety trigger is standard on the LIFTON breakers LH 18, LH 21, and LH 25.

The LH 18 requires an oil flow of 18–22 l.p.m. and works at a pressure of 90–110 bar.

LH 21

The LH 21 is a light-weight hydraulic breaker with a high performance compared to weight. The efficient hydraulic LH 21 breaker is designed for demanding breaking jobs in hard material, brickwork, reinforced concrete, and heavy asphalt.

The LH 21 breaker is available in a standard version (LH 21 S) and an ergonomic version (LH 21 E) provided with torsion dampened handles which reduce the vibration level to a minimum and protect the operator from injuring his hands and arms.

The LH 21 requires an oil flow of 18–30 l.p.m. and then works at a pressure of 105–125 bar.



LH 25

The LH 25 is an efficient and sturdy hydraulic breaker for the breaking of reinforced concrete, asphalt concrete, and heavy brickwork. When fitted with Spike Driver nose part, the LH 25 can be used for spike driving in connection with railway jobs.

The LH 25 breaker is available in a standard version (LH 25 S) and an ergonomic version (LH 25 E) provided with torsion dampened handles which reduce the vibration level to a minimum and protect the operator from injuring his hands and arms.

The LH 25 requires an oil flow of 18–30 l.p.m. and then works at a pressure of 105–125 bar.



(Continued)

Exhibit 3. (*Continued*)

LIFTON LP 9 P



LIFTON LP 9 P is a hydraulic power-pack designed for the operation of LIFTON hand-held breakers and other hydraulic tools with an oil flow of 20 l.p.m. (EHTMA Category C).

The LIFTON LP 9 P is equipped with a fuel-saving POD system (power-on-demand), and for further environmental protection it is supplied with biodegradable hydraulic oil.

The LIFTON LP 9 P power-pack replaces the LIFTON LP 8 P power-pack.

LIFTON LP 11 P



The LIFTON LP 11 P is a hydraulic power-pack designed for the operation of LIFTON hand-held breakers and other hydraulic tools with an oil flow of 20 l.p.m. (EHTMA Category C), but the power-pack can be adjusted up to 28 l.p.m.

LIFTON LP 11 PE

The LIFTON LP 11 PE Twin-Pack is a hydraulic power-pack designed for the operation of LIFTON hand-held breakers and other hydraulic tools with an oil flow of 20 l.p.m. (EHTMA Category C) or 40 l.p.m. (EHTMA Category E).

The double hydraulic circuit makes it possible to operate two tools at the same time, such as 2 LIFTON breakers, cut-off saws or other hydraulic tools requiring an oil flow of 20 l.p.m.

(*Continued*)

Exhibit 3. (Continued)

Alternatively, the Twin-Pack can operate one tool requiring 40 l.p.m, like e.g. a LIFTON rail saw or surface grinder and a number of diamond drilling and cutting machines, etc. It must, however, always be ensured that the connected tool is designed for 40 l.p.m.

**Other Equipment****SUBMERSIBLE WATER PUMP**

The light, hydraulic LIFTON submersible water pump is designed to meet the demand for efficient pumping and offers high performance in relation to weight.

The hydraulic LIFTON submersible water pump is designed for efficient pumping of water in tunnels, draining excavations and cellars, and will pass solids up to 10 mm (0.4").

The pump is equipped as standard with a 2" discharge snap coupling. Being hydraulically driven, the pump is selflubricating and can run dry without damage.

**CUT-OFF SAWS**

The hydraulic LIFTON cut-off saw, which is available in a 14" and a 16" version, is a sturdy and reliable tool easy to use.

The direct drive design provides consistent speed and torque when cutting in concrete, brickwork and cement blocks, etc.



(Continued)

Exhibit 3. (*Continued*)

Both types can easily be mounted in the specially designed LIFTON cart, which as standard is equipped with complete water kit. Mounted in the cart, the LIFTON cut-off saw is used to cut continuous clean lines with precision on roads, sidewalks and floors.

OIL FLOW DIVIDER

The LIFTON oil flow divider is used when the oil flow from the power source exceeds the recommended oil flow. The oil flow divider provides the breaker with a

constant oil flow of 20–25 l.p.m. or 25–38 l.p.m. The excess oil is led back to the tank connection.

The oil flow divider has a built-in adjustable pressure relief valve which opens at 150 bar and a built-in check valve which prevents wrongly connected pump pressure from reaching the tank connection of the breaker.

flow of letters referring to taxes that were interpreted differently by the tax agents when applied to state-owned companies and firms privatized with foreign direct investment. The Bulgarian Ministry of Finance constantly sent letters to Lifton Hydra Team requiring them to pay old due taxes that were owed to the state by Hydroprobivna Technika before it was privatized. The customs regulations created a lot of difficulties with low speed of processing documentation, poor customer service and red tape.

The managers of Lifton Hydra Team were highly successful in dealing with the fiscal, legislative, and regulatory pressures in Bulgaria. The company enjoyed a unique position — it was the only player in its industry that had production facilities in the country. It was supported by the local authorities and had a working relationship with the Bulgarian government. In addition, the management employed legal advisors that were always well informed about the changes in the highly volatile economic and legal environment. The management of the company recognized that there were two problems, which were

crucial for the success of any business venture in Bulgaria. One was related to the need for fundamental changes in the legal system to make it compatible with Western code law practices and the second one was the law enforcement. The General Manager of Lifton Hydra Team was an active member of the Bulgarian International Business Association (BIBA) was trying to create more favorable conditions for companies with foreign investment. They were organizing meetings with government officials and influential members of the legal establishment, lobbying MPs, exchanging information, trying to support foreign investors who needed a particular type of help or advice.

Market Position

The export markets served by Lifton are characterized by demand significantly exceeding supply. Lifton has not faced any significant competition in Bulgaria. More than 95 percent of its production in volume terms and almost 99 percent in value terms is for export. With the rest of the production output the company has managed to achieve between 90 and 95 percent market share in the domestic market. The Bulgarian market for hydraulic breakers is also served by the imports of German and Swedish companies that do not have production facilities in the country. Some very small producers of hydraulic equipment, based on craftsmanship have also appeared and disappeared in Bulgaria throughout the 1990s. Such firms have been either in the form of single proprietorships or family-run businesses. Many of them have not survived for long due to a low technological level of production, competition from bigger players and the limitations of the relatively small, stagnated domestic market. Their current market share is estimated to be around 1.5–2 percent.

Lifton Industries work in very close cooperation with its major competitors worldwide. The internationalization philosophy adopted by the company is to rely on cooperation rather than on competition. They work jointly with the largest hydraulic producers in the world for international standardization of all hydraulic production and technology. They have long-term contracts with their main clients all over the world and provide technical support and comprehensive after-sale

services. Relationship management is considered to be of major importance to the international success of the business.

This approach has also been embraced by Lifton Bulgaria. The Bulgarian subsidiary underwent a gradual culture change that was to enforce the values of the parent company. The management has emphasized the importance of gaining and retaining key clients and managing key accounts. Interactions and exchange of information with key customers have been conducted on a regular basis. The sales contracts with the major clients usually have a validity of several years. The buying center has tried to develop a portfolio of key accounts, which secures the market position of the company. This is a long established policy at Lifton Industries and its subsidiaries. The Bulgarian subsidiary works in close cooperation with other Bulgarian and foreign manufacturers for the implementation of some production operations and metal treatment of machine parts and components.

Compared with the world level of technological development in the hydraulic industry, the technology applied in Bulgaria before the privatization of the company was outdated and in a poor state of maintenance. Most of the production machines were transferred by Beakers A/S but they could be used only for a limited number of operations. The quality of manufactured products was acceptable for the supply deficit in the domestic market in terms of durability and exploitation parameters. However, productivity, efficiency, and effectiveness were not up to the world standards. After the acquisition, Breakers A/S introduced a new production technology and precise measuring instruments. The technological level of Lifton Bulgaria has become far better than the average world standard.

The life cycle of the export products manufactured in Bulgaria are in the late stage of growth or early stage of maturity as perceived by the western developed markets. The Bulgarian subsidiary has been gradually launching a broad range of new products most of which are in the introductory phase of their life cycle for the Bulgarian and most of the former CMEA markets. Some of the new products manufactured in Bulgaria are also in the introductory phase for the western export markets. In the 1990s Lifton Bulgaria

spent approximately 10 percent of their annual turnover on R&D and new product development.

All functions performed in the company are closely integrated aiming at providing the customers with what they want. That is the prime focus of the Marketing Department. The main customers of Lifton Bulgaria are contractors, paving companies, demolition companies, sewerage companies, municipalities, gas, water and electricity boards, telephone and cable television companies, railway companies, machine and tool hirers, and shops dealing in building materials. The LIFTON tools operate under the toughest conditions — and that has demonstrated their reliability and led to a trust among all customers of the company, such as British Telecom, Tele Danmark (a Danish phone company), Danish municipalities, the Swedish Road Maintenance Organization, Ericsson AB (Sweden), CSX (a leading American railroad company), Athens Waterboard (Greece), Ministry of Public Works (Thailand), Ankara Municipalities (Turkey), Korean municipalities, United Nations, National Administration of Roads (Romania), Bulgarian mining, road building and construction companies, Bulgarian municipalities and United Rentals, (US).

Representatives of Lifton Bulgaria visit all their major customers in the domestic and European export markets twice a year. They aim at developing customer relationships encouraging feedback including suggestions and recommendations for improvements in the functional characteristics and range of products. In 1995, the company started tailoring all products to the specific customer requirements in the export markets. This means that relationships with international clients require Lifton Bulgaria to make changes and adaptations in their products to ensure that any specific demands are addressed. All changes are discussed in advance with the customers and the engineers in the company. Lead-engineers work on designing the changes and facilitate their implementation in the production process. In the domestic market the company also works closely with its customers and has applied a tailor-made approach to the key Bulgarian customers since 1998. There is a Customer Complaints Department that deals with all after-sales services. As it is responsible for the maintenance of the products after sales, it is a major source of

feedback to the Construction Department for decision making on product development.

The objectives of the marketing strategy of the company are based on the existing severe shortage of hydraulic products in terms of desirable quantity and expected variety. Through meeting some of the existing demand and high quality standards, the company tries to expand its market share in the export markets.

The major goal for the next two decades is to increase the volume of sales in the export markets five to ten times. With the development of the domestic market such possibilities are explored in Bulgaria as well. However, the potential of the Bulgarian market has been seen as limited. The company has its own distribution network for serving the domestic customers with two regional centers in the cities of Rousse and Plovdiv. While market research data for the domestic market trends is collected by the company itself, market intelligence for export markets has been provided by the parent company.

The major competitive advantage of Lifton Bulgaria in its domestic and export markets is its clear cost leadership balanced with world-recognized quality of products. Based on the cost advantage the company charges significantly lower prices than its competitors both in the domestic and international markets.

Lifton Bulgaria has not invested substantially in promotion as it operates in a sellers' market. In the domestic market the company uses several promotional channels: national and regional TV channels, daily newspapers, weekly business newspapers and specialized journals.

The assets and capabilities of the company changed considerably after privatization. According to the contract with the Privatization Agency the amount of investment that Lifton Industries had to make was US\$350,000 over three years. By the end of 1994, the required amount of investment had already been exceeded. Since the company was privatized the number of working places has increased by 20 percent and the production capabilities of the firm doubled. The working capital has increased more than 30 times considering the inflation of the national currency.

Company Performance

Improved performance stemming from product innovations, quality assurance and employee input has been rewarded financially. The profit generated per unit of production in Lifton Bulgaria has become substantially higher than the one for respective hydraulic equipment produced in the United Kingdom or Denmark.

The management of Lifton Bulgaria has been using sales revenue and profit after tax to measure and monitor company performance, and determine the viability of the company. On the basis of those indicators management makes decisions concerning any investment opportunities. Over the last few years, the company has invested in product development and new product creation at the rate of six to eight times more than the average for the hydraulic industry worldwide, calculated on the basis of turnover and net profit.

In the last two years, Lifton Bulgaria has gradually introduced a market related performance criterion, i.e., market share in international markets. Although turnover and profit criteria are presently of primary importance, parallel to them, the increase in market share is being measured and analyzed.

Company performance is monitored, measured and evaluated relative to objectives that are determined in detail in the yearly budget and plans for the development of the firm.

The opinion of the management of the company is that after privatization it has improved its performance tremendously. So far, Lifton Bulgaria has performed best in terms of turnover and profit and has continuously increased its export market share by an average of 15 percent and 18 percent, respectively, in the last six years.

Before privatization the company had approximately 65 percent of the domestic market and its export was exclusively for Romania and the former Soviet Union. Today, these markets no longer exist in terms of their former potentials. All production for export now is for countries from Western Europe, North America, some former communist countries, as well as Turkey and the Middle East. Prior to privatization the amount of export, in absolute terms, was 15 times less

than it was in the year 2000. Export markets changed totally in accordance with destination and requirements. In the period 1999–2001, the production of Lifon Bulgaria increased more than 250 percent and this resulted in an increase of market share of the company almost exclusively in export markets.

Most of the personnel are highly qualified. After privatization all of them took part in qualification courses. Special attention has been paid to the managers and employees performing the most important production operations.

Constant improvement of the technological and managerial processes has taken place and will continue to be the case in the next two to three years aiming at quality improvement of hydraulic equipment.

Over the last few years all departments in the company work effectively together to serve customer needs. Tensions and rivalries between departments do not get in the way of serving customers effectively. The organization is very flexible to enable opportunities to be seized effectively, not to be hierarchically constrained.

The organizational culture has been transformed from inward looking, focused on the production process to market focused. All employees recognize their role in contributing to creating a satisfied end customer. The reward structures are solely related to external market performance and end customer satisfaction. Senior management in all functional areas give top priority to creating satisfied customers. At their meetings the senior management give high priority to discussing issues which affect customer satisfaction.

The top priorities are the regular assessment of customer satisfaction and constant adaptation to their requirements. Major efforts are put into building stronger relationships with key customers and customer groups. Management believes that the main efforts should be concentrated on:

1. Regularity and completeness of information concerning customer needs and requirements.
2. Assessment of customer attitudes towards the products and their after-sales service.

3. Changes in the market segmentation strategy once the company has diversified its products that will lead to an increase in market share in the export markets.

In terms of the long-term perspectives, the management of Lifton Bulgaria agree that a market share increase in export markets is more important than gaining short-run profits. They are trying to face the challenge of improving market performance and internal efficiency.

The international consortium Lifton Industries, UK has started extension of production capacities in Lifton Bulgaria. All its production of machine and manual hydro-drilling equipments will be transferred from Denmark to Bulgaria. Some 0.7 million euros³ were invested in 2001 and 2002 for new machines and equipment. Following a decision of Lifton Industries, the Bulgarian subsidiary will become the biggest compared with the three other firms of the consortium in the United Kingdom, the US and Denmark by the end of year 2003.

Major Competitors

Demolition projects are being undertaken all over the world. The demolition work requires companies to use specialized demolition and drilling attachments. The most popular attachments for demolition work are breakers (with crushers, cutters and pulverisers to finish). There are sizes available for every carrier from a skid steer loader to a large excavator. One can find the most up-to-date attachments produced by Rammer, Lifton, Soosan, Furukawa, Rock Drills, Krupp Berco, Bautechnik, Taeshin, Genesis, Italdem, Indeco and Montabert. There are also more specific tools from Taets (for piles) and Antraquip (for concrete demolition).

A number of industry players like Atlas Copco, Padley and Venables, and Bosch, have been developing the market for hand-held breakers that can handle many of the smaller jobs. The designs of the

³ At the time this book went to press the exchange rates were 1 euro = 1.44 US dollar = 1.96 Bulgarian leva.

smaller demolition tools have largely improved in recent years to make them attractive alternatives to the traditional, less precise methods of dismantling. The leading companies in this field are Dimas and Partner.

Aquajet and Conjet have focused their product development on hydro-demolition as it causes less vibration damage to adjacent buildings. Splitting concrete (on bridges, parapets, and foundations) with hydraulic splitters dramatically reduces the likelihood of damage to adjacent structures.

The demolition industry is dominated by huge corporations, which invest billions of dollars in R&D, developing carriers and attachments. Among them are Bosch, Bridgestone, Caterpillar, Daewoo, DaimlerChrysler, Deutz, Fiat-Hitachi, Komatsu, Krupp, Liebherr, Michelin, Scania and Volvo.

The middle-sized companies that compete in the breakers world market are Antraquip, Case, Darda, Genesis, Gradall, Grasan, Indeco, Lifton Industries, Padley & Venables, Rammer and Svedala (acquired by Sandvik). Lifton Industries is an established medium-sized producer of demolition breakers with a market share of 16.7 percent in Europe and 7.9 percent of the demolition attachments market in the world in 2001.

Rammer

Today, Rammer, with headquarters in Lahti, Finland, is an integral part of Sandvik Mining and Construction. They operate through a service and sales network on every continent. The backbone of the network are the authorized local distributors and their dealers. These private companies are close to the customers and provide the service which is expected from the dealer of a leading equipment manufacturer. The company tries to be local and global at the same time.

Rammer engineering focuses on hydraulic attachments for rock excavation, demolition and recycling. The products are known for their effectiveness and reliability. They feature noise and dust suppression, electronic documentation, and remote control.

Type	LH 18 S	LH 18 E	LH 21 S	LH 21 E
Weight (Hex 25) (kg)	18.7	19.1	20.9	21.3
Weight (Hex 28/32) (kg)	21.9	22.3	24.1	24.5
Service weight (Hex 25 kg)	22.6	23.0	24.8	25.2
Service weight (Hex 28/32 kg)	25.8	26.2	28.0	28.4
Length incl. chisel (mm)	638	638	682	682
Oil flow (l.p.m.)	18–22	18–22	18–30	18–30
Working pressure (bar)	90–110	90–110	105–125	105–125
Return pressure (bar)	10	10	15	15
Blow frequency (1/min.)	1,600	1,600	1,320–2,160	1,320–2,160
Blow energy (Joule)	65	65	85	85
Vibration level (dB)	138	135	141	134
Measured sound power level (Hex 25) (dB)	106	106	107	107
Measured sound power level (Hex 28/32) (dB)	105	105	106	106
Sound pressure level 1 m (Hex 25) (dB)	95	95	96	96
Sound pressure level 1 m (Hex 28/32) (dB)	94	94	95	95
Std. tool size (Hex/mm)	25 × 108	25 × 108	25 × 108	25 × 108
Alt. tool size (Hex/mm)	28 × 152	28 × 152	28 × 152	28 × 152
	32 × 152	32 × 152	28 × 160	28 × 160
	32 × 160	32 × 160	32 × 152	32 × 152
			32 × 160	32 × 160

Type	LH 10	LH 25 S	LH 25 E	LH 35 S	LH 35 E
Weight (kg)	10.8	25.2	25.6	32.2	32.6
Service weight (kg)	13.8	30.6	31.0	37.6	38.0
Length incl. chisel (mm)	600	760	760	760	760
Oil flow (l.p.m.)	18–22	18–30	18–30	28–40	28–40

Exhibit 4. Comparative technical characteristics of products produced by Lifton Bulgaria.

Exhibit 4. (*Continued*)

Type	LH 10	LH 25 S	LH 25 E	LH 35 S	LH 35 E
Working pressure (bar)	70–90	105–125	105–125	105–125	105–125
Return pressure (bar)	10	15	15	15	15
Blow frequency (1/min.)	2,400	1,140–1,860	1,140–1,860	1,050–1,500	1,050–1,500
Blow energy (Joule)	18	110	110	140–160	140–160
Vibration level (dB)	142.3	141	139	-	-
Measured sound power level (dB)	104	108	108	104	104
Sound pressure level 1 m (dB)	93	97	97	93	93
Std. tool size (Hex/mm)	22 × 82.5	32 × 160	32 × 160	32 × 160	32 × 160
Alt. tool size (Hex/mm)		28 × 152	28 × 152	32 × 152	32 × 152
		28 × 160	28 × 160	32 × 160	32 × 160
		32 × 152	32 × 152		

The product range consists of full lines of hydraulic hammers, cutter-crushers and pulverizers, pedestal boom systems and tools.

Rammer was the first manufacturer to offer heavy-duty rock breaking hammers and the first to offer a full range of silenced hammers. Rammer (Tamrock) also holds the patent for the Constant Blow Energy operating principle. The company is continuing this tradition of technological advancement with the introduction of a number of new systems and solutions, many of which are on show at Electra Mining. These include:

1. City Pro Hammers — Allows the operator to select from three operating modes to ensure that the hammer is matched to the application and material for optimum productivity.
2. City Jet Hammers — Feature an integral dust suppression system for a cleaner environment and greater working efficiency.

3. G100 Tunnel — Specially designed for tunnelling applications; the G100 Tunnel features City Jet dust suppression, Ramlube automatic lubrication and can be used at any working angle for optimum versatility.

Svedala

According to Thomas Older, Svedala Industry's CEO: "Svedala is one of the very few companies in the world that can bring to bear such a wealth of resources to the customers in the industry sectors we serve. We know that our customers want to buy systems and they want to buy from a source that is large enough and diverse enough to provide the entire system. They don't want to have to deal with a host of suppliers."

Svedala develops, manufactures, and markets systems for world-wide applications. These systems are used by customers in mining, mineral processing, crushing, screening, bulk materials handling, and construction. They mine coal, iron ore, gold, and copper. They process food, pulp, waste, and a variety of other materials.

Svedala not only serves the construction industry with its aggregate-producing systems, but with systems to finish concrete and asphalt projects with its world-famous line of rollers, pavers, vibrators and tamperers.

While Svedala is a Swedish-based company, over 90 percent of its sales are outside Sweden, and, further, more than 50 percent of its sales are outside Europe. The largest single market is North America, accounting for about a third of overall sales.

Svedala's market strategy has been to build up a worldwide network of local Svedala companies organized to serve the total needs of customers involved in maintaining and expanding infrastructural facilities in both developed and developing countries. The company has done this through acquisitions, as well as by developing markets through its international operations.

As a full service supplier, Svedala offers a complete spectrum of engineering services including feasibility studies, installation, commissioning, and start up. Lifetime on-site customer support involves

monitoring of performance to insure a maximum return on investment for customers.

Svedala has a matrix organizational structure. Each of the country organizations has access to all of the business areas of Svedala and its product lines. For instance, an Australian customer needs only to contact the Svedala organization in Australia to get access to any of the products and systems offered by the global company.

Case Corporation

Inventor Jerome Increase Case founded Case in Racine, Wisconsin (US) in 1842 to build threshing machines. Later, the company gained global recognition as the first builder of steam engines for agricultural use, eventually becoming the world's largest maker of steam engines.

By 1912, Case had established itself in the construction equipment industry as a manufacturer of road-building equipment, such as steam rollers and road graders. The company built its construction equipment business through several acquisitions, starting with American Tractor Corporation in 1957. By the mid-1990s, Case had expanded to become the world's leading manufacturer of light- to medium-sized construction equipment.

Case Construction Equipment is marketed by CNH Global, which was formed in November 1999 through the merger of Case Corporation and New Holland N.V. Currently, more than 60 products carry the Case brand, in a line-up that ranges from compact trenchers and skid steers to high-power excavators and wheel loaders. The most recent product introductions include rigid and articulated dump trucks and soil compactors, with motor graders to be added shortly.

The manufacturing and R&D facilities of Case Corporation are found all over the world: in Belgium, France, Germany, Italy, Brazil, the United States, India and the United Kingdom.

Darda Corporation

Darda is a mid-sized company with its headquarter in the Black Forest, Germany, with distributors worldwide. It produces and sells

	Contractors	Builders	Rental companies	Asphalt companies	Drain companies	Countries/ municipalities	Supply companies	Salvage corps	Railway companies	Geotechnical companies	Demolition and blasting companies	Landscape gardeners	Cemeteries	Foundries	Mining
LH 10	(X)	X	(X)		X		(X)			X		X	(X)		X
LH 18	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LH 21	X	X	X	X		X	(X)							X	X
LH 25	X		X	X						X	X				X
LH 35	X		X	X						X	X				X

(X) The breaker can be used for demolition of the material. It is however not recommended.

Materials Handled

	LH 10	LH 18	LH 21	LH 25	LH 35
Lightweight asphalt	(X)	X			
Brickwork/lightweight concrete	X	X			
Reinforced concrete/heavy asphalt			X	X	X
Ramming (piles/profiles)		(X)	X	X	X
Ramming (earth rods)	X	X			
Tamping		X	X	X	
Hard material/frozen ground		X	X	X	X
Soil samples	X	X			
Horizontal jobs	X	(X)			

(X) The breaker can be used for demolition of the material. It is however not recommendable.

Exhibit 5. Users of Lifton's products.

unconventional special tools for the demolition of concrete and rock. In 1967, the hydraulic rock and concrete splitter were invented by the company's founder, Helmut Darda. Patents were granted for the quality and uniqueness of the DARDA splitters. Darda has taken on the exclusive distributorship for the Swedish Brokk demolition robots in Germany and Austria. Darda has a distributor network in Australia, Belgium, Brazil, Canada, China, Germany, Norway, Austria, Poland, Oman, Saudi Arabia, Andorra, Portugal and Sweden.

Genesis

Genesis Equipment & Manufacturing, located in Superior, Wisconsin (US), entered the world of hydraulic attachment design and manufacture making available to material processors over the world an extraordinary level of high quality, optimum performance attachments. Genesis has adopted a new approach to attachment design and manufacture. It is a concept driven by personal attention to customer needs, an open mind to new ideas and an uncompromising insistence upon quality. The company is headquartered in Germany, with distribution and service centers throughout Europe.

Gradall

Gradall, located in Ohio (US), is recognized as a leader in the manufacture of hydraulic excavators and material handlers. Today, it is the mission of every Gradall employee and supplier to do their part in enhancing the company's leadership position by meeting the customer's expectations. The operating philosophy of Gradall is to meet customer needs by establishing and then maintaining an environment which encourages all employees to the never ending pursuit of improved quality and productivity of the products and services of the company, its supply base and its distributor organization.

In the beginning the company produced hydraulic excavators, but by 1982, the Gradall product collection grew significantly to include

1. *Customer Orientation*

- 1.1. Information about customer needs and requirements is collected regularly — Agree (4)
 - 1.2. Our corporate objectives and policies are aimed directly at created satisfied customers — Agree (4)
 - 1.3. Level of customer satisfaction are regularly assessed and actions taken to improve matters where necessary — Strongly Agree (5)
 - 1.4. We put major efforts into building stronger relationships with key customers and customer groups — Strongly Agree (5)
 - 1.5. We recognise the existence of distinct groups or segments in our markets with different needs and we adapt our offerings accordingly — Agree (4).
- Total Score for Customer Orientation — 22.

2. *Competitor Orientation*

- 2.1. Information about competitor activities is collected regularly — Agree (4)
 - 2.2. We conduct regular benchmarking against competitor offerings — Agree (4)
 - 2.3. There is rapid response to major competitor actions — Agree (4)
 - 2.4. We put major emphasis on differentiating ourselves from the competition on factors important to customers — Agree (4).
- Total Score for Competitor Orientation — 16.

3. *Long-Term Perspectives*

- 3.1. We place greater priority on long-term market share gain than short run profits — Agree (4)
 - 3.2. We put greater emphasis on improving our market performance than on improving internal efficiencies — Do Not Know (3)
 - 3.3. Decisions are guided by long-term considerations rather than short-run expediency — Do Not Know (3).
- Total Score for Long-Term Perspectives — 10.

4. *Interfunctional Co-ordination*

- 4.1. Information about the customers is widely circulated and communicated throughout the organization — Disagree (2)
-

Exhibit 6. Marketing Orientation Assessment Using a 5 Point Likert Scale for Lifton Bulgaria where (1) corresponds to “Strongly Disagree” and (5) to “Strongly Agree” to the statement. Data were collected in 1997 through a mailed questionnaire filled-in by the then General Manager.

Exhibit 6. (*Continued*)

-
- 4.2. The different departments in the organization work effectively together to serve customer needs — Agree (4)
 - 4.3. Tensions and rivalries between departments are not allowed to get in the way of serving customers effectively — Agree (4)
 - 4.4. Our organization is flexible to enable opportunities to be seized effectively rather than hierarchically constrained — Strongly Agree (5).
- Total Score for Interfunctional Co-ordination — 15.

5. *Organizational Culture*

- 5.1. All employees recognize their role in helping to help create satisfied end customers — Agree (4)
- 5.2. Reward structures are closely related to external market performance and customers satisfaction — Strongly Agree (5)
- 5.3. Senior management in all functional areas give top importance to creating satisfied customers — Strongly Agree (5)
- 5.4. Senior management give high priority to discussing issues that affect customer satisfaction — Agree (4)

Total Score for Organizational Culture — 18.

Total Score for All Questions — 81.

rough terrain material handlers. In June 1999, Gradall was purchased by JLG Industries, the world's foremost manufacturer, distributor, and international marketer of lift equipment. JLG and Gradall are both dedicated to the continuous improvement of products and processes, manufacturing equipment that is the best in its class. The alliance with JLG helps to position Gradall as a powerful player within the construction industry.

Grasan

Grasan was founded in 1970, in Mansfield, Ohio (US), as a manufacturer of conveying, crushing, and screening equipment for coal, aggregates, and construction industries. Now with a 60,000-square-foot manufacturing facility and annual sales of over US\$10 million, Grasan specializes in the design and production of mobile and stationary equipment. Grasan designs and builds complete crushing, screening,

conveying, stacking, and feed/storage systems for quarry operations of all types and sizes. In 1985, Grasan led the industry in developing equipment and systems for recycling concrete, asphalt, and construction and demolition debris. Grasan engineers will investigate equipment, processes, and recent developments and innovations related to your project.

Indeco

Indeco, located in Stratford, Connecticut (US), offers the best demolition attachments in the industry for breaking concrete or rock. Its products include: breakers, compactors, stationary boom systems, and grapples. Indeco, known for value throughout the world for more than 25 years, offers the finest demolition products and attachments built to solve breaking and demolition needs. The company offers a complete line of reliable and heavy-duty hydraulic breakers, compactors, and grapples engineered to fit each specific brand of excavator, loader-backhoe, skid-steer loader and mini-excavators.

The biggest breaker, to get the job done fast, may not be the most practical, just as the biggest truck may not be the most efficient if the wheeled loaders cannot reach high enough to dump over its sides. Indeco has tried to address that special market requirement.

Padley & Venables

Padley & Venables Ltd. (P&V) is the UK's leading manufacturer of high quality tools for use in the rock drilling, quarrying, mining, tunneling, construction, civil engineering and demolition industries worldwide. P&V has been established in the marketplace since 1911 and today is one of the worlds' leading manufacturers of consumables, rock drilling tools, demolition tools and contractor tools.

Continuous research, development and testing of P&V's wide range of products together with ongoing investment in modern technology, reflect P&V's commitment to the manufacture of quality products for customers worldwide. All products are manufactured

from materials within a Quality Assurance Management System certified to British Standards and ISO9002. All P&V demolition tools are totally manufactured and processed within the company's factory, utilizing the very latest machinery and technology, to ensure that the finished products comply with the high standards of quality expected by the customers throughout the world

There are quite a number of niche players focusing on a particular type of technology or product range. Those include Aquajet, Atlas Copco, Bobcat, Brokk, Conjet, Dimas, Montabert and Soosan.

Aquajet

Aquajet systems started out its life as Svensk Vattenbilningsteknik over 15 years ago. The company is based in Holsbybrunn in southern Sweden. It specializes in the manufacturing of high-pressure water jet equipment. Exports account for 90 percent of the company's output and 80 percent of these are dealt with through selected independent local dealers and distributors. The distributors also provide Aquajet's after-sales service. The product line includes high-pressure power-packs — containerized or open skid mounted, computer controlled robots, robotic equipment for industrial applications as well as accessories and equipment for robotic high-pressure jobs. The company also provides engineering, consulting and technical support.

Atlas Copco

Atlas Copco, a leading compressor manufacturer, is a global industrial group headquartered in Stockholm, Sweden. It acquired Chicago Pneumatic India, a pneumatic tool manufacturer. The acquisition increased Atlas Copco's operations, giving it an increase of 80 percent in pricing power and sales in 2000. The sales of its rock drilling equipment showed a significant increase by 24 percent in 2001 compared to 2000. Rationalization of capacities has brought in sufficient cost-efficiencies and an increase in profitability.

Brokk

Brokk AB is a company, headquartered in Skellefteå, Sweden, for the production of lightweight remote controlled demolition machines for working in cramped conditions. The low weight of the machines produced by Brokk makes them easily transportable on a car trailer and flap-down outriggers.

Dimas

Headquartered in Jönköping, Sweden, this company is a manufacturer of diamond tools and equipment that came into existence at the beginning of the 1970s. At that time the sawing and drilling industries were in their infancy. The company supplies diamond tools encompassing dry and wet cutting blades, grinding tools, drill bits and diamond wire for drilling through concrete, stone, brick and asphalt. Since the early 1980s, Dimas has also manufactured sawing and drilling equipment but the emphasis has always been on diamond tools. It acquired Promac, a company that manufactures high-tech and intelligent tools. The move is a part of Dimas' commitment to build a complete product line, which includes a comprehensive range of machines.

Soosan Breakers

This is a Seoul, South Korean manufacturer of demolishing equipment established in 1984. The company has become technically independent by developing a series of its own and has received high recognition for its products originality. Soosan has recently obtained an Impact Energy certificate, which solidified the company's position as one of the leaders in production technology.

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Eggsercizer — “The World’s Smallest Exercise Machine”¹

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Mark Davis, the 41-year-old President and owner of Eggstra Enterprises, Inc. sat in his office late one Wednesday night in late June 1994 and pondered the future of his company. His Marketing Manager Johnny Laskin, had just resigned on that day. Part of the problem, Mark knew, lay in differences in marketing philosophy. He had been accused of using a shotgun approach to selling his main product, the Eggsercizer, a small, hand-held, hand, wrist, and arm exercise devise which had the shape of an egg. It was true, he thought

¹ This case was prepared by Marlene M. Reed at Baylor University, Waco, Texas and Henry S. Maddux III at Sam Houston State University in Huntsville, Texas for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

that some overall marketing strategy was needed. Yet, he also knew that marketing must be based on the overall goal and direction of the company. Then there were the problems with operations and the financing of growth. Sales were growing, and Mark knew that he had to get hold of this growth.

Background

Mark Davis had grown up in Montgomery, Alabama. After graduating from high school and attending a junior college for almost two years, he joined the Navy at the end of the Vietnam War. Upon the urging of a superior, Mark spent a year in the Navy's non-destructive testing (NDT) school and served the remainder of his six and half years of service inspecting nuclear powered submarines. When he reentered the private life in 1979, he worked with power utility companies performing non-destructive testing. From 1985 to 1988, he worked with the Electric Power Research Institute (EPRI). At that time, Mark decided to form his own consulting company, performing NDT testing and training for the nuclear and petrochemical industry. His income from consulting provided a moderate but not lucrative means of support.

The Idea

Mark loved softball, and sought a way to improve his arm strength. In early 1989, he started squeezing a tennis ball as he traveled from nuclear plant to nuclear plant. Then on Memorial Day weekend, Mark was scheduled to meet with personnel from General Electric in Atlanta to set up a training and consulting program worldwide. He went to bed around 10:30 p.m. and woke up around midnight with the idea, "What is a new and novel shape which is better than this tennis ball?" Mark went downstairs and started brainstorming ideas and uses for a new hand and arm exercise device, but Mark knew that he did not have the unique shape yet. Later in the night, Mark got up and went to the refrigerator to get cream for his coffee. It was at that point that he saw an egg in the egg container in the refrigerator. He realized that the egg shape fit the natural contour of his hand. Mark

immediately realized that he had his shape. The rest of the night, Mark started to develop marketing and promotional ideas.

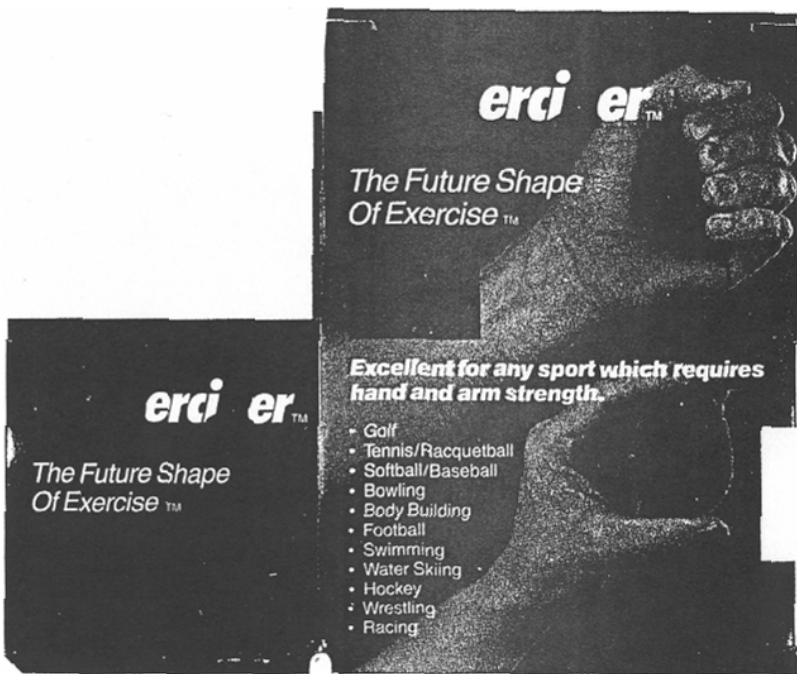
Mark immediately took his idea to a patent attorney, and the attorney told him that he did not have a patentable idea. He said: “It would be like trying to patent this ashtray.” However, Mark was not satisfied. He had a friend who had patented the idea of a baby seat on a grocery store cart, called “The Baby Sitter”. That friend led him to another attorney who was excited about the idea and agreed to conduct the patent search and application for about one half of the fee that the first attorney had wanted. It was now June 1989.

Although Mark now had his idea, the first obstacle he faced was how to make the egg. He approached a rubber company in South Carolina that agreed to build a four cavity prototype mold for \$1,400. The eggs were made from neoprene which is a hard, durable rubber. Mark also wanted the soft, fuzzy coating that came on tennis balls, so he approached another company in Indiana that could apply this coating which is called flocking. Mark had obtained \$18,000 initial financing from friendly investors — friends, training students, etc. This he partially used to finance a production mold which cost \$8,000 and also to purchase some product packaging inventory. Production started in February 1990, and four thousand eggs were made before Mark made his first trade show in July 1990. The eggs were green and purple and fuzzy, but, unfortunately, they were hard.

Mark sold about 600 eggs at that first show — mostly to hospital gift shops. At this time, he was working out of his house. There were expenses, of course, associated with shows and the cost was often \$1,000 just for his booth plus an additional amount for travel expenses.

In late 1989, Mark moved the molds from South Carolina to Alabaster, Alabama, a suburb of Birmingham. Mark had already moved his home to Alabaster earlier that year. He started having a local rubber company make the eggs. After a \$2,000 modification of the mold, the rubber company said they could manufacture and deliver the eggs for \$0.75. The flocking cost \$0.43. In addition, there were expenses such as shipping and packaging. In order to design the packaging, Mark enlisted the help of his brother who owned Krout

Exhibit 1. The gift box.



Davis Marketing, a local marketing company. The first package was a colorful 2" × 2" × 3" gift box which Brookstone, a national gift product retailer and Eggstra's largest customer, continued to use for years. (See Exhibit 1 for a picture of the gift box.) In November 1992, the company started using a clear plastic clam shell or two-sided enclosure measuring about 4" × 8". It fit snugly around the egg and also contained an attractive full color point-of-purchase display tray. Twelve eggs plus a display tray fit in each box.

Mark continued to attend local and regional trade shows, but sales were slow. The product idea seemed right. The packaging was attractive. Yet the egg itself was made from neoprene. In order to get softness in this rubber, oil had to be added. This made the surface slick, and it became difficult to adhere the flocking to the surface. Davis was forced to settle for a rubber that was hard to compress. He started to talk to mold manufacturers. Once, one

manufacturer said: “Mark, you need to make your eggs out of Sorbothane”. Mark had heard of this unique, flexible rubber but had not been able to locate the manufacturer. After some further investigation, he found out that Hamilton-Kent Sorbothane, of Kent, Ohio, was the only manufacturer, and that the material was patented. He called the company in the summer of 1991. They agreed to look into manufacturing the eggs for him. \$600 was spent for a new prototype mold, and then Mark sent a sample of his eggs to Hamilton-Kent for its design. Once Mark received the new egg made of Sorbothane, he knew that he had found the right product. Four production molds, each with six mold cavities, were manufactured. Each production mold cost Mark \$1,500. The eggs were manufactured using the extrusion technique. Rubber material was placed between the two hinged faces of the mold. A hydraulic press placed the mold under pressure and high temperature, and the rubber was extruded into the mold cavities. Eggs were made in production lots of 600 to 1,000 units. The per unit cost to Mark was \$2.74. The flocking process was discontinued. (See Exhibit 2 for a description of the Eggsercizer.)

Sales Growth

Then in the fall of 1991, Mark received his first significant order from HealthSouth Rehabilitation Corporation Company for two cases of 30 units each per month. The price of the eggs was set at \$4.50 each. Mark started his guerrilla marketing. He sent an egg to a Wall Street Journal columnist and heard nothing for six months. In March 1992, the Wall Street Journal columnist, John Pierson, replied by phone. He wanted to feature the Eggsercizer in his column, Form and Function. His article ran on 30 March 1992. (See Exhibit 3 for a copy of the article.) Readers started calling, and Mark began selling the Eggsercizer directly. Each egg sold for \$9.95 plus \$2.50 shipping and handling.

Mark also used the Journal article to create brand awareness. Mark had been trying unsuccessfully for several months to get the Eggsercizer into the Brookstone chain which had one hundred, high

Exhibit 2. Description of the eggsercizer.

New Product!

Made In The USA

The World's Smallest Exercise Machine™

Eggsercizer™

Cash in on an "eggs"-iting new product with large volume potential. Outperforms other hand exercisers... and people like it! High impact packaging for fast turnover and impulse sale.

- Flexible counter displays for your peg board or gift box needs.
- Packaging is "pegable" or will stand by itself.
- Recommended by orthopedic surgeons for building hand and arm strength.
- Exercises hands, fingers and arms.
- Improves hand dexterity, grip strength and forearm.
- Made of a space-age polymer material.
- Patent Pending.



Try Our Introductory 12 Pack Today!

end, novelty and gift stores. For the Wall Street Journal article, Mark conceived the idea of referencing a major competitor, the Grip Gym, currently offered at Brookstone. People started calling Brookstone wanting the Eggsercizer. Of course, Brookstone had no eggs to sell. Just three weeks later, Brookstone tested an order for 2,500 eggs. The price to Brookstone was \$3.60 per unit wholesale, and they sold each

Exhibit 3. *Wall Street Journal* article.

Newspaper Article

THE WALL STREET JOURNAL.

MARKETPLACE

MONDAY, MARCH 30, 1992

FORM • FUNCTION
By JOHN PIERSON

Contoured Exerciser Keeps Hands Full

CAPTAIN Queeg must be turning over in his grave. The antihero of "The Caine Mutiny" used to click two steel balls together in one hand, a nervous habit that helped drive his crew bonkers.

Now comes Mark Davis of Alabaster, Ala., with a hand-held, egg-shaped nerve soother that's too soft to go click in the night. Mr. Davis, who trains inspectors in the nuclear-power industry, calls his invention Eggsercizer and says it's good not just for exercise but also for physical therapy and stress management.

Eggsercizers come in two models: a harder rubber egg cov-

ered with a short, woolly coating and a bare egg of softer rubber. Mr. Davis says his device beats a tennis ball and a spring-loaded hand grip, which he says tire the hand or fail to exercise all the muscle groups.

Maurry Hachey, a boxing coach in Birmingham, Ala., says the egg shape exercises all five fingers, while a ball exercises only two.

Lawrence Lemak, an orthopedic surgeon in Birmingham, says his patients use the eggs to rebuild their hands, elbows and shoulders after surgery. The therapist's catalog includes plenty of other devices, says Dr. Lemak, but Eggsercizer is "novel enough that patients use it more."

The tough, round world of Captain Queeg isn't about to go quietly, however. Brookstone, the specialty chain based in Peterborough, N.H., offers a spring-steel Grip Gyn whose outlines resemble a hand grenade. Spectrum Sports, Twinsburg, Ohio, has a ball-shaped Sport Grip made of Sorbothane, an impact-absorbing plastic that feels like putty.

And China continues to export pairs of shiny metal exercise balls, which have been going click in people's hands since the Ming dynasty.

The Eggsercizer

egg at a retail price of \$7.95. The initial order sold out within one week. It was now May 1992.

The Brookstone account was to provide the national exposure that Mark was looking for. Other stores also began to call him to place

Exhibit 4. Sales activity — 1993, 1994 to date and forecast for remainder of 1994, in thousand of dollars.

MONTH	1993 SALES	1994 SALES
JAN	38.3	159.4
FEB	47.8	70.0
MAR	57.8	148.7
APR	74.9	135.6
MAY	67.6	41.6
JUN	46.1	19.6
JUL	75.6	100.0
AUG	85.9	100.0
SEP	174.7	100.0
OCT	247.7	100.0
NOV	132.5	100.0
DEC	61.9	100.0

TOTAL 1,112.9

NOTE: DAVIS PROJECTED SALES AT A FLAT RATE OF 100,000 FOR THE REST OF 1994

orders. A buyer for a chain of stores might purchase an egg at Brookstone, and then they would call into the company to inquire about ordering the product.

In order to reach the sporting goods retail business, Mark decided to attend his first national trade show, the National Sporting Goods Association Show in August 1992. After this show, sales began to rise rapidly. The 1992 sales volume was approximately 90,000 units. In 1993, sales had grown to 364,000 eggs. (See Exhibit 4 for a monthly history of 1993 and 1994 sales revenue and Exhibits 5 and 6 for financial statements for 1992 and 1993.) Two thirds of the 1993 sales occurred in the last half of the year, and total sales of eggs by mid-1994 were 650,000 units.

The usual order called for boxes of the standard egg. Each box contained 12 packages of Eggsercizers of varying colors and a display stand, if requested. The price of a box was \$57.

Davis knew that his forecasting techniques were very simple. His 1994 projections for \$100,000 did not seem to reflect the cyclical

Exhibit 5. Balance sheet as of 31 December 1993.

	As of 12/31/92	As of 12/31/93
<u>ASSETS</u>		
CURRENT ASSETS		
Cash - AmSouth	12,548.73	20,161.43
Petty Cash	0	250.00
Inventory	14,397.66	112,687.19
Accounts Receivable	76,534.83	54,048.72
Allowance for Bad Debt	0	(620.00)
TOTAL CURRENT ASSETS	103,481.22	186,527.34
<u>FIXED ASSETS</u>		
Furniture & Fixtures	725.00	2,638.76
Accumulated Depreciation	(119.30)	(590.98)
Molds	0	59,899.93
Accumulated Depreciation	0	(40,912.70)
Equipment	34,154.93	11,179.42
Accumulated Depreciation	(13,960.75)	(1,755.43)
Intangible Assets	12,014.99	20,975.39
Accumulated Amortization	(686.18)	(1,856.21)
Deposits	100.00	100.00
TOTAL FIXED ASSETS	32,228.69	49,678.18
TOTAL ASSETS	135,709.91	236,205.52
<u>LIABILITIES & EQUITY</u>		
CURRENT LIABILITIES		
Accrued Wages	0	2,230.00
Payroll Taxes Payable	(1,442.50)	1,278.75
AmSouth - Line of Credit	3,800.00	0
Equipment Lease Payable	0	1,926.37
Accounts Payable	38,771.48	124,561.75
Royalties Due Krout/Davis	0	45,047.39
Royalty draws Krout/Davis	0	(8,000.00)
Royalties due P. Netter	0	15,893.70
Royalty draws P. Netter	0	(39,996.00)
Officer Loans	1,872.07	(20,128.95)
TOTAL CURRENT LIABILITIES	43,001.05	122,813.01
LONG TERM LIABILITIES		
TOTAL LONG TERM LIAB	0	0
TOTAL LIABILITIES	43,001.05	122,813.01
EQUITY		
Common Stock	100,900.00	100,900.00
Retained Earnings	(56,366.90)	(8,191.14)
Current Earnings	48,175.76	20,683.65
TOTAL EQUITY	92,708.86	113,392.51
TOTAL LIAB & EQUITY	135,709.91	236,205.52

Exhibit 6. Adjusted statements of revenues and expenses.

	Year Ended 12/92	Year Ended 12/93
Sales	265,044.90	987,065.42
Cost of Goods Sold	(153,709.07)	(540,866.65)
Contract Labor	0	(21,159.42)
Returns and Allowances	0	(15.90)
Bad Debt Expense	0	(620.00)
Interest Income	164.13	0
Other Income	0	12,992.00
Commissions	0	(3,990.31)
Miscellaneous Expense	0	(500.00)
Freight & Shipping	0	(28,051.87)
Total Income Less COGS	111,499.96	404,853.27
Officer Salaries	0	60,000.00
Salaries & Wages	0	45,552.49
Accrued Wages	0	2,230.00
Employee Per Diem	0	14,108.57
Bank Charges	0	317.81
Payroll Taxes	0	9,445.39
Taxes & License	106.00	1,441.62
Office Expense	3,883.20	16,094.01
Telephone	5,971.91	16,112.52
Charitable Contributions	300.00	565.95
Travel	2,392.70	12,046.48
Meals & Entertainment	295.73	1,347.71
Dues & Subscriptions	20.00	278.95
Auto Expense	477.99	1,036.80
Supplies	433.18	388.44
Equipment Rental	0	401.28
Advertising & Marketing	5,725.80	53,305.63
Insurance	2,350.75	4,860.74
Legal & Professional Fees	8,593.75	42,069.06
Postage & Shipping	4,864.70	1,645.60
Rent	492.80	9,463.95
Trade Shows	3,427.64	19,210.26
Commissions	62.08	0
Royalties	0	54,354.09
Depreciation	4,544.05	29,179.06
Amortization	350.18	1,170.03
Interest Expense	342.68	706.70
Consulting Expense	7,666.00	0
Utilities	11.88	1,457.14
Janitorial & Maintenance	0	628.57
Equipment Maintenance	0	500.00
Contract Labor	11,011.18	1,460.64
TOTAL EXPENSES	63,324.20	401,379.49
NET INCOME	48,175.76	3,473.78

nature of his business. He wondered how he might adjust the forecast for the remainder of 1994 and what his forecast for 1995 might be.

While no formal marketing research had been done, Davis knew the price was an important issue, especially for the mass market business. He did feel that the demand for his product was price inelastic. That is, if the prices were changed by some unknown percentage, there would be a smaller percentage change in the amount demanded. He had no real data to back up his intuition.

Davis found it necessary to purchase an 81 cavity mold to keep up with the production requirements. The mold cost him \$8,500.

During the first two years, Mark did not perform any extensive formal planning or operational analysis. He did obtain advice and planning assistance from the Business Incubator Center at the University of North Carolina at Charlotte before he moved to Alabama. The Service Corps of Retired Executives (SCORE) also assisted Mark in developing a formal business plan and setting goals.

Then in February 1993, Eggsercizer was shown at the World’s largest sporting goods show, The Super Show in Atlanta. There were about 9,000 exhibits at the show which displayed approximately 30,000 sports and related products. Attendance at the show approached 100,000.

Eggsercizer was introduced in the New Products Section of the Super Show. It was picked by *The New York Times* as one of the 10 top products of the show. Television shows wanted to feature the Eggsercizer as a new product, and magazines picked up on the Eggsercizer as well. As a result, product awareness through print and electronic media began to drive the generation of sales to retail customers.

Financing

The company was in need of working capital from the start. Mark had little capital to invest himself. The first investor provided the company

with \$1,400 in exchange for 1.4 percent ownership of the company. Other investors wanted Mark to put up some stock before they invested. Mark declined this suggestion and instead offered stock at a discount. He discounted a share priced at \$25 to \$20 per share to investors who agreed to put up the capital in advance of incorporation. By this method, Mark was able to raise \$20,000 before Eggstra Enterprises, Inc., was formed as a Subchapter S corporation in the State of North Carolina. Thereafter, the company raised an additional \$50,000 from stock offerings to investors. There were finally 25 investors in the business.

The stock valuation process was dependent on various points in product awareness, trade shows and capital needs. At first a 1 percent share sold for \$1,000. Then the price was raised successively to \$2,000, \$2,500, \$3,750, \$5,000 and finally to \$20,000. Davis also bartered some stock in return for marketing and legal support.

In the late 1993, Davis contemplated making an offering of common stock to the public. The offering was for 5 percent of the ownership of Eggstra. Each 1 percent ownership would be valued at \$40,000. The offering would raise \$200,000 in capital. This offering was rescinded after Davis' accountant and attorney advised him that the current earnings of the company could finance its growth. David decided that the 5 percent dilution in ownership was not to his advantage.

When the company moved to Alabaster, Davis had to register it as a foreign corporation doing business in the state. The State of Alabama itself restricted new investors in a Subchapter S corporation to 10 per year. The SEC also set a limit of no more than 35 investors and \$250,000 invested before the corporation was required to register with them. The registration fee was \$20,000.

At the time, the company had a line of credit with AmSouth Bank for \$50,000. As of June 1994, \$40,000 of this amount had been used.

Davis pursued a small business loan through the SBA in 1992. The amount requested was \$195,000. However, Davis had not been able to gain approval for the loan from a bank which was necessary for the SBA to guarantee a loan. Loan officers pointed to the lack of cash

flow history as a primary reason for rejecting the loan. Davis wondered if his recent cash flow and earnings history might overcome these obstacles.

The first business plan developed was for a period of three years. The business plan called for four phases of the business. During the first phase, the product would be brought to market and promoted at trade shows. Phase two would see sales rise to 70,000 units; while in the third phase this number would rise to 700,000 units. In phase four, sales would again rise to 1.5 million units. No time frame for each phase was projected. The plan was based on the initial flocked design of the product. An allowance of \$0.25 for general operating and administrative costs and \$0.80 for profit was included. No specific allowance was made for salaries or any other expenses. Davis admitted that the sales projections on the business plan were somewhat optimistic.

Davis’ plan projected the following amounts for unit sales, total sales revenue, and contribution to GOA and profit:

Sales (In units)	Sales revenue (\$)	Contribution to GOA and profit (\$)
10,000	27,000	10,500
50,000	135,000	52,500
70,000	189,000	73,500

No time schedule was associated with these projections.

Accounts receivable were tracked by an in-house bookkeeper. The accounts receivable were larger than accounts payable. A “Picture of the Company”, encompassing cash account balances, accounts receivable and major accounts payable, was constructed weekly.

The Product

The primary distinctive characteristic of the Eggsercizer was its shape. There was a rubber ball made of Sorbothane which was marketed as a hand exerciser. However, the egg shape had been endorsed by

therapists as being ergonomically correct. (Eggonomical, according to Davis). It allowed all four fingers and the thumb to be exercised simultaneously. It also strengthened 13 muscles in the hand and arm.

The Sorbothane material offered both positive and negative resistance, a feature which the sand-filled and putty hand exercise products lacked. The rubber was resilient, durable, inert and non-toxic. It posed no threat if swallowed and held heat well. Sorbothane was used in US Navy submarines to insulate the engine from the submarine hull in order to achieve maximum quietness during operations. It was also used in jogging shoe soles. The Eggsercizer could easily be cleaned with soap and water. It was heat resistant and was easily stored.

There were three versions of the standard sized Eggsercizer. The red version was the softest and had a durometer reading of 35. The blue version was denser than the red version (durometer reading of 45). The hardest version was purple. The three different versions of the standard model allowed one to scale up as hand strength developed. A fourth model was the Pro Eggsercizer, which was an oversized version for large hands. The Pro Eggsercizer was red, with the same hardness as the blue standard version, and weighed twice as much as the standard egg. (See Exhibit 7 for promotional description of the four versions.)

Markets

Mark had identified four primary markets for the Eggsercizer. One market was the medical and rehabilitation market. Due to the unique exercise characteristics which the egg offered, Davis had been able to establish acceptance of the Eggsercizer as a physical and occupational therapy product. Physicians and therapists had endorsed the product as a therapy device for arthritis, carpal tunnel syndrome, cardiac related problems and recovery from mastectomy surgery (the egg worked on the pectoral muscles). The company had contracted with Hygenics Corporation, an international medical

Exhibit 7. Promotional flyer.



Your customers asked for it!...and we listened. With three resistances and exciting colors, now there's an Eggsercizer for every need.

Progressive Eggsercizer Twelve (12) Pack
The Progressive Eggsercizer Pack includes a 12 pack of Eggsercizers in three different resistances and colors...4 soft, 4 medium, 4 firm. Initial orders include the attractive counter display.



Suggested Retail Price\$ 7.95 per egg

Wholesale Pricing:

1 to 9 twelve packs\$57.00 per pack
10 to 99 twelve packs\$55.50 per pack
100 to 999 twelve packs\$52.00 per pack

Terms: NET 30 days
Shipping is prepaid.

Minimum orderOne twelve pack

Weights and Measures

UPC Code	Description	Weight	Dimensions
52657-34471	12 Pack	4.5 lbs.	8.9"H x 8.4"D x 16"L



It's a new larger size for maximum compression... it's also great for larger hands. The added size and weight make the Pro Eggsercizer great for walking, aerobics, and other sports. The larger size fits completely in your hand for a secure grip during active workouts.

Pro Eggsercizer Twelve (12) Pack
Includes 12 Pro Eggsercizers individually packed in plastic clamshells, with helpful instruction card. Clamshells come pre-packaged in a distinctive counter display...or, individual clamshells can be pegged or stand-alone on the counter.



Suggested Retail Price\$17.95 per egg

Wholesale Pricing:

1 to 9 twelve packs\$107.40 per pack
10 to 99 twelve packs\$103.44 per pack
100 to 999 twelve packs\$ 99.96 per pack

Terms: NET 30 days
Shipping is prepaid.

Minimum orderOne twelve pack

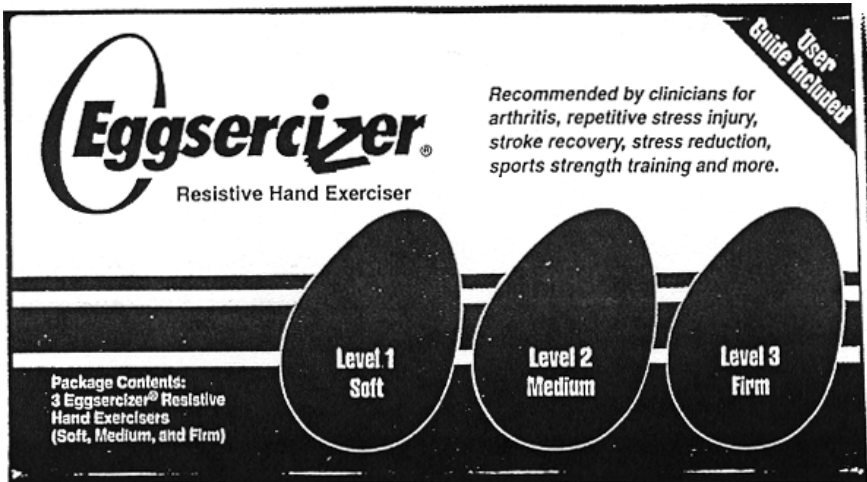
Weights and Measures

UPC Code	Description	Weight	Dimensions
52657-34472	12 Pack	6.5 lbs.	10"H x 9.93"D x 17"L

Eggstra Enterprises, Inc
P. O. Box 36563
Birmingham, AL 35236

(800) 858-EGGS (3447)

Exhibit 8. Hygenics packaging.



distributor, to promote and distribute the Eggsercizer in the medical field. Hygenics was located in Ohio, close to the manufacturing plant which produced the product, and they received most orders direct from the facility. The usual product sold by Hygenics was a three-pack. This was a box which held one each of the three versions of the standard Eggsercizer. This arrangement allowed a physician or therapist to prescribe a build regimen of exercise starting with the red or softer egg and progressing to the purple egg. (See Exhibit 8 for a picture of the Hygenic three-pack.)

Another major market was the exercise and fitness market. GNC was one customer which served the fitness market. GNC ordered 18,000 eggs in 1993 (5 percent of sales). Davis also focused on sporting goods stores. The Eggsercizer had been accepted by 25 out of the top 100 sporting goods stores. Davis' goal was to be in 40 stores by the end of the year.

The Eggsercizer was also promoted as a stress reduction product. Davis had been able to get his egg into President Bush's hands during the Persian Gulf War. He reportedly used it for stress reduction. Other celebrities had also supported this use. On the whole, however, Davis admitted that this market remained untapped.

Another major market was the gift or novelty market. Brookstone’s accounted for the lion’s share of this market segment (90,000 eggs in 1992 and 165,000 ordered in 1993).

The final major market was that of the premium and ad specialty industry. Eggstra paid printed company logos or slogans on the Eggsercizer, and this served to promote the client’s product, or company awareness. The eggs could also be scented.

Davis thought that one problem with the marketing data he had was that he did not know his sales to the various segments. While Brookstone accounted for a large proportion of his sales, he could not determine if those sales were made for exercise, fitness, or therapy purposes or if they were bought purely as a novelty.

Davis continued to attend several trade shows a year, including sporting goods and gift shows. Many contacts were made at the shows, and the company experienced a surge in sales after shows. (See Exhibit 9 for a listing of sales). Most retailers bought sporting and exercise related products in February for the spring market and bought again for August in the Christmas season.

As a result of the trade shows, Mark received many orders from small retailers. These businesses often purchased only one or two dozen eggs a year.

The Eggsercizer was also sold to individuals directly, although this was not a significant portion of sales. If a sales representative made a sale to a retailer, the commission paid usually fell in 15–20 percent range.

The international market for the Eggsercizer was growing. The product had been sold in 24 countries. There were problems with this market, however. Due to the country specific import taxes, shipping, and other add-on expenses of dealing with a foreign intermediary,

Exhibit 9. Major competitive product information.

PRODUCT	COMPANY	LOCATION	1993 SALES(\$1,000)	PRICE
SORBOTHANE BALL	SPECTRUM SPORTS	OHIO	385.0	\$ 6.99
GRIP MASTER	INTER’L METAL COMPONENTS	NEW YORK	1,350.0	\$10.99
EXERFLEX(SILICON PUTTY)	BOLLINGER INDUSTRIES	TEXAS	500.0	\$ 5.87
FLEX-O-GRIP	EVERLAST FITNESS	MISSOURI	1,200.0	\$ 4.99

gross margins averaged only 8 percent. With this low return, Davis decided not to focus on international sales.

In 1993, Eggstra spent just over \$50,000 on marketing efforts. It had not been determined what amounts had been budgeted for various market segments. One specific support system that had been installed on the company's computers was a store identification program. When a customer called in, an Eggstra employee could use the system to locate the retail outlet selling the Eggsercizer which was nearest to the customer's location. This had been a good marketing tool as Davis had been able to tell retailers that he would not undermine their business with direct sales.

Mark Davis used what he had termed a guerrilla or shotgun approach to marketing. Any opportunity for sales was pursued. In addition, Mark had used such media as the Home Shopping Network and QVC. One question that Davis was facing was projecting the life of the product. Originally, he thought that life cycle sales would be 3.5 million eggs. However, at least one marketing company had projected sales of 20 million during the product's life.

The Competition

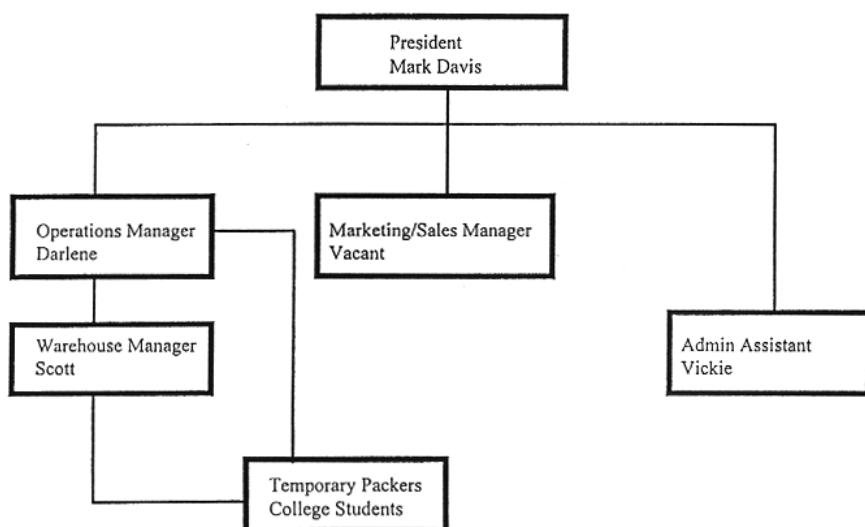
There were over 100 different hand exercisers on the market. The initial patent search uncovered a hand exerciser patented in 1926. Putties and mechanical spring-loaded devices were the primary competitive products faced by the Eggsercizer. Spring-loaded devices often failed to exercise the spectrum of muscles which the Eggsercizer exercised. Also, these devices were potentially unsafe due to their moving components.

During the 1993 Christmas season, the Eggsercizer was accepted by one store of a major mass marketing chain. It outsold its two major competitors by a 4 to 1 margin during that period. (See Exhibit 9 for a description of major competitors' products)

Company Organization

Mark Davis was the majority owner and President of Eggstra Enterprises, Inc. He assumed most marketing duties for the company.

Exhibit 10. Organizational structure.



(See Exhibit 10 for an organizational chart) The operations manager had been with Eggstra for the past four years. The warehouse manager ensured that all products were received, processed, checked for quality, packaged, and distributed efficiently and on time. Part-time packaging workers were contracted when large orders were to be processed or a sufficient number of eggs needed to be packaged.

Operations

The cost of the Sorbothane material was high. Individual eggs cost Eggstra between \$1.18 and \$1.36 depending on volume. (See Exhibit 11 for discount schedules) The product was manufactured using a liquid pour process. The cost of each production mold was \$1,500. Twenty molds were used in the production process.

While the Sorbothane material had proven very practical from a design and performance standpoint, Davis felt that the unit cost was too high to effectively enter the discount or mass market arena. Consequently, he had started testing alternative materials.

Exhibit 11. Quantity discount schedule.

ORDER SIZE	UNIT COST
2,500 < Q < 10,000	\$1.36
10,000 < Q < 20,000	\$1.30
20,000 < Q < 50,000	\$1.25
50,000 OR MORE	\$1.18

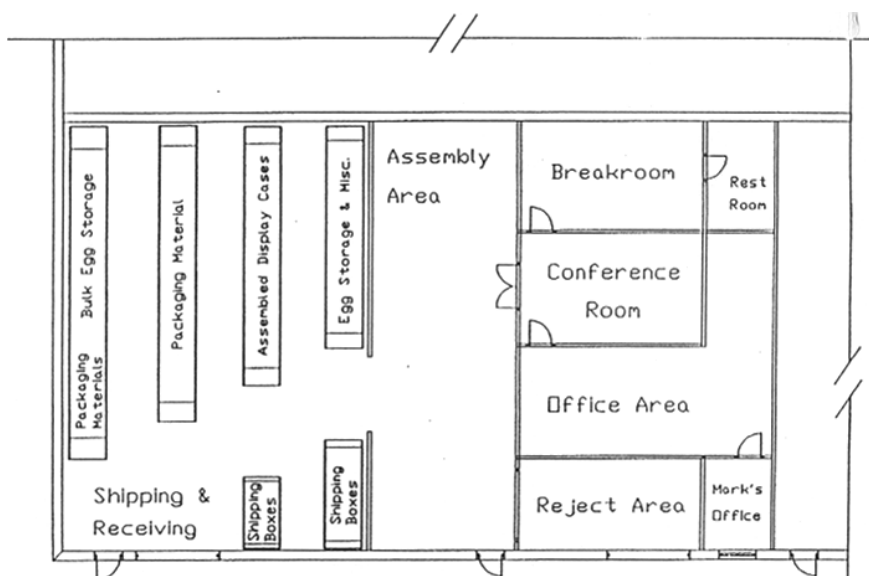
Mark had wondered at times if it would not be worthwhile to produce the Eggsercizer in-house. He knew that if he entered the mass market and sold 1 million eggs, that would mean 4,000 units would have to be assembled on average per day. He also knew that demand had not been spread out evenly over the year.

There was no formal method of determining when to reorder inventory. The decision had been driven by orders received. Generally, large orders like those from Brookstone were spread over several weeks. Due to the short (2–3 weeks) lead time for receiving products from the Ohio manufacturer, the first part of the order could be met from stock and the remainder from products ordered from Ohio to help meet the customer's future requirements. The payment terms were usually net 90 days.

When an order was received by FAX or phone, that order was placed in a "to be filled" file. The warehouse manager would pull these orders from the file and package the order according to the customer specifications. He would also prepare an invoice and packing slip. Then later this packing slip was attached to the order when it was sent out via UPS or RPS. The invoice was sent out concurrently. First time orders were usually sent COD by UPS. The customer paid UPS, who then reimbursed Eggstra. This helped minimize bad debt expense which was 0.5 percent of all expenses. The only major non-paying customer had been Home Shopping Network, which owed the company \$24,000, an amount that had been turned over to a collection agency. Payment terms for prior customers were net 30 days. All international orders were prepaid.

Inventory arrived by contracted trucking at the company's facility in Alabaster, Alabama. The facility had 5,000 sq. ft. of space and was divided into an office area and an operation/warehouse area. The

Exhibit 12. Operations layout.



office area was air conditioned while the operations area was not. (See Exhibit 12 for a floor layout.) The customary packaging at reception was 50 to a box. The boxes of eggs were received and the contents checked and counted. Some products were then packaged in final shipment boxes. The remainder was stocked in its original shipping box on multi-level shelving. The quality of eggs in each incoming box was not determined.

The Eggsercizers were processed in three ways: (1) Shipped directly in bulk without further packaging; (2) repacked in individual boxes without a clear plastic clam shell; and (3) packaged in a clear plastic clam shell with a display tray and reboxed.

If an order for Eggsercizers was received and there were no prepackaged ready-to-go boxes of product, boxes containing the unpackaged eggs were opened. Part-time packagers began processing the order by first inspecting each egg from a box. If an egg showed a defect, it was placed in a reject box. Otherwise, the egg was inserted between the two sides of a clear plastic clam shell or “clam”. The shell

also held a display card. (See Exhibit 2 for an example of the display card.) The packaged eggs were enclosed 12 to a box with a display stand before shipment. (See Exhibits 13 and 14 for the logic of order processing and filling.) The same procedure was used to process newly arrived products into prepackaged boxes.

Eggs could be rejected for several reasons. One was that the egg had porosity — small holes present on the surface of the product. These grew with use and thus could not be shipped without harming the image of quality that the company wanted to maintain. The softer versions of the product (red eggs) also were subject to compression, which sometimes left a flat spot on the surface. When the eggs stored on the storage shelves and were subject to higher temperature during the summer months, this problem arose. Reject rates were approximately 5 percent. Some of these were what Davis called “bad rejects”. They were so far gone that they could not be used for any purpose. The manufacturer had agreed to give Eggstra credit for these eggs. The amount credited was included in the next shipment of products to the company. The “good” rejects were used as sample, promotional units, or giveaways for charity functions.

There were no other major quality defects in the product or in the distribution system. Returns of bad products by customers were minimal. Davis knew that the quality inspection step in packaging was costing him money. He wondered just how much productivity could be improved if it could be eliminated.

No formal inventory control or management practices existed. Purchased quantities were driven by quantity discounts. The resulting inventory might be high depending on when the last order was received. At the end of 1993, the lead time for clam shell packaging materials grew from 4 to 6 weeks to 14 weeks. This caused some anxiety on Davis’ part, and he ordered a year’s supply of materials as a buffer against interrupted supply. (See Exhibit 15 for a listing of inventory and stocking levels.) Davis knew that inventory turnover was a key measure of operating efficiency. He wondered how he might improve his turnover and retain the high levels of customer service he was providing.

Exhibit 13. Order processing.

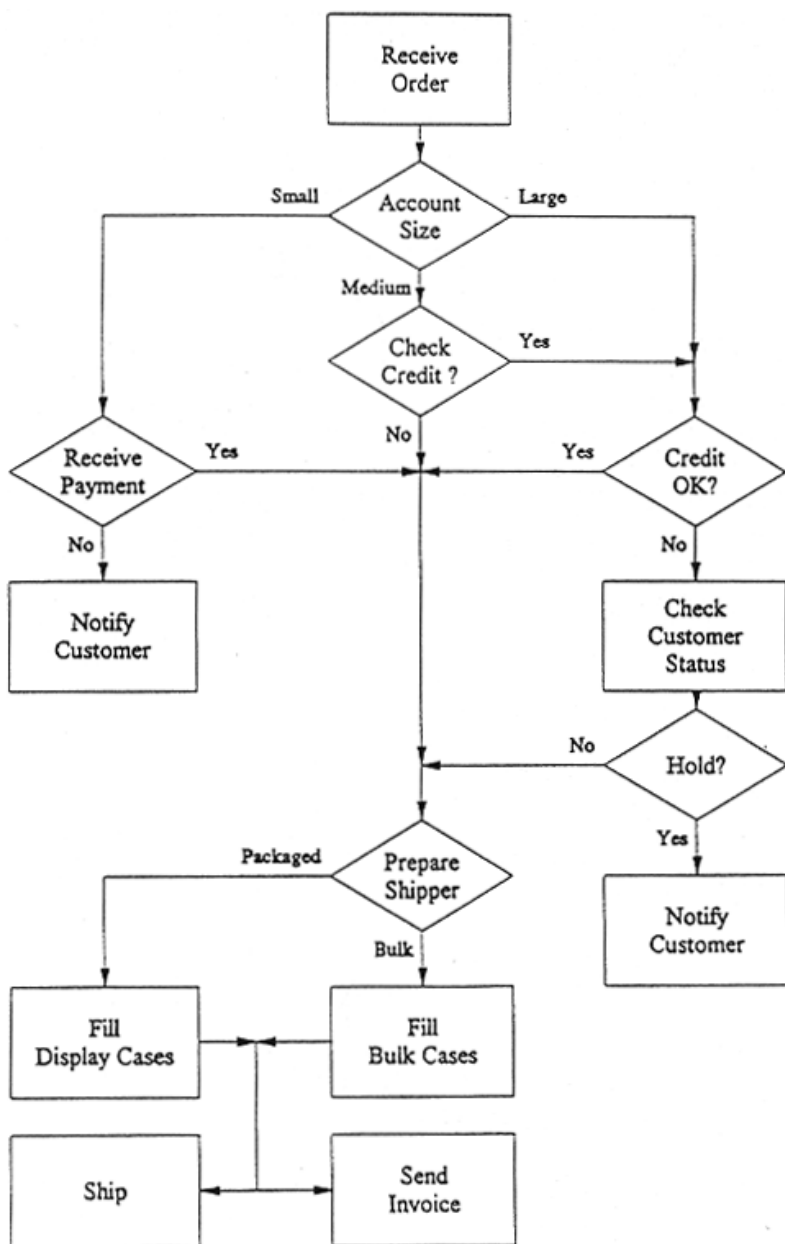
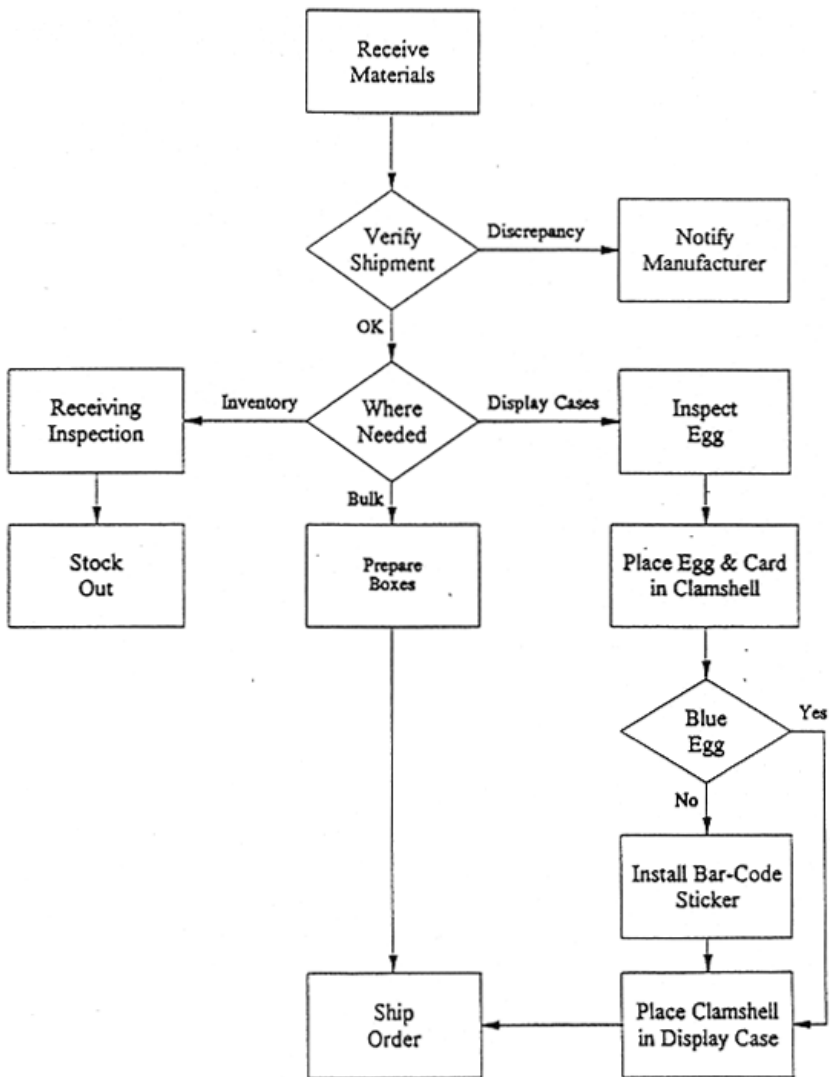


Exhibit 14. Materials processing.



The minimum order amount for eggs was 2,500 — regardless of the durometer reading. The price up to 10,000 units was \$1.18. The price breaks that occurred were as follows: \$0.06 price break when ordering 10,000 or more eggs; another \$0.05 reduction in price

when ordering 20,000 eggs; and another \$0.07 price reduction if the order was increased to 50,000 eggs. The total price break when ordering 50,000 eggs instead of 2,500 was 18 cents per unit.

Shell clams cost Eggstra \$0.18 per unit. Another variable cost was for packaging labor. Packagers were paid six cents per unit to package products. (See Exhibit 16 for a cost breakdown of the standard sized Eggsercizer)

In addition, the manufacturer of the eggs allowed Eggstra net 120 days for payment and the accounts receivables for Eggstra was net 60 days and net 45 days. This situation allowed Eggstra to use the accounts receivable to finance the accounts payable for the eggs. Davis wondered if his policy of ordering 50,000 eggs at one go was the most economical thing to do. He also wondered what his reorder point should be. Should Eggstra order enough to supply the amount that was needed to be shipped and how much ending inventory, i.e., safety stock, did Eggstra need to have available?

The Mass Market Question

The most pressing decision that Davis faced was whether or not he should enter the mass market business. Davis knew that K-Mart and Wal-Mart combined had 51,000 stores. He also knew that a significant price reduction on his sales price would be necessary in order to allow those stores a 40 percent mark-up and still sell the Eggsercizer for under \$5.00. From the discussion with mass market buying agents and managers, that was the price the product would have to sell for when offered alongside its competition. Davis made a tentative cost analysis of a knock-off egg designed just for this market which showed a possible \$1.30 per unit margin. (See Exhibit 17 for an example of this calculation.)

To complicate the decision, an additional expenditure of \$180,000 in equipment would have to be incurred in order to increase production capacity to the levels projected. Davis had projected that 12 cases per store would be sold annually. For Wal-Mart’s 2,300 stores alone, that would mean over 330,000 units of production.

Of course, additional packaging design, production, and procurement would be necessary to enter the mass market arena. Davis also knew that his current human resources infrastructure would not support the added burden of managing this extra business segment. He simply did not know what changes would be necessitated.

The Decision

Davis identified several options that he had. First of all, he could make plans to enter the mass market. He knew this would mandate many changes for his organization, and he would increase his risk of failure. He could even lose money on this end of the business. He also ran the high risk of losing Brookstone as a customer, since they had threatened to drop the Eggsercizer if it appeared at Wal-Mart or K-Mart. Davis wondered what the net result might be on the bottom-line.

Davis also wondered what changes in organization might be justified. Did he need to replace the marketing manager with another marketing officer? Or were his greatest needs in financial or operations management? What specific operating changes were needed? Could he bring manufacturing in-house or should he outsource packaging and distribution? How could he manage the inventory and quality problems?

While the company was funding operations with its current cash flow, Davis knew that for the company to grow additional capital would be needed. But how much? And when? Should he sell stock? For how much and at what price? Or should he actively seek debt financing? He even wondered if he might sell the company. HealthSouth Rehabilitation Company had been interested in buying the company. He wondered what would be a good price and return for himself and his investors, many of whom he knew personally.

Davis admitted that these decisions were affected by his own personal goals which were “to make money; to fund new inventions with a portion of this money; and to retire by the time I am 45.”

Exhibit 15. Inventory types.

Inventory Sheet April 4, 1994			
5/31/94			
Completed Inventory	Unit Costs	Qty	Value
12-pack with Display	\$20.280	508	\$10,302.24
12-pack without Display	\$18.360	692	\$12,705.12
12-pack Clam w/Sample Egg	\$21.420		\$0.00
Clam Shells - Singles	\$1.420	250	\$355.00
Prescription Packs	\$5.150	0	\$0.00
Brookstone Box- Single	\$1.405	6800	\$9,554.00
12-pack with Display (Red)	\$20.280	25	\$507.00
12-pack Progressive w/display	\$20.280	25	\$507.00
12-pack Pro	\$36.240	136	\$4,928.64
30 Pack	\$49.500	11	\$544.50
Total			\$39,403.50
Raw Goods - Inventory			
Red Eggs	\$1.360	250	\$340.00
Blue Eggs	\$1.140	2460	\$2,804.40
Purple Eggs	\$1.360	4950	\$6,732.00
Red ProEgg	\$2.740	7290	\$19,974.60
Blue ProEgg	\$2.740	385	\$1,054.90
ProEgg Clam	\$0.120		\$0.00
ProEgg Insert	\$0.100		\$0.00
ProEgg Baggle	\$0.043		\$0.00
Pro Displays	\$2.047		\$0.00
Misc - Red Eggs	\$1.140		\$0.00
Misc - Blue Eggs	\$1.140		\$0.00
Misc - Purple Eggs	\$1.140		\$0.00
Misc - Pro	\$2.740		\$0.00
Scented	\$1.360	3320	\$4,515.20
12-pack Display Headers	\$0.960	6220	\$5,971.20
12-pack Display Bottoms	\$0.960	2580	\$2,476.80
12-pack Mailers/Shippers	\$0.480	3910	\$1,876.80
Clam Shells	\$0.125	57400	\$7,175.00
Clam Inserts w/Cutouts	\$0.040	93740	\$3,749.60
Clam Inserts w/o/Cutouts	\$0.040	13070	\$522.80
Pro Displays	\$2.047	4900	\$10,030.30
Pro Shippers	\$0.393	5225	\$2,053.43
Pro Clam Shells	\$0.120	32625	\$3,915.00
Pro Inserts		28000	\$0.00
Poly Bags	\$0.000	500	\$0.00
Brookstone Boxes	\$0.100	4000	\$400.00

(Continued)

Exhibit 15. (Continued).

Brookstone Insert Cards	\$0.035	26300	\$920.50
30 - Pack Display Tops	\$1.390	274	\$380.86
30 - Pack Display Bottoms	\$1.390	281	\$390.59
30 - Pack Display Headers	\$2.030	600	\$1,218.00
Precipitation 3-Pack Box	\$0.550	1000	\$550.00
Precipitation Box Labels	\$1.500	2500	\$3,750.00
Precipitation Handbook	\$0.250	5775	\$1,443.75
Blue Dot Stickersw/o/Print	\$0.001	2000	\$2.00
Blue Stickers	\$0.001	20000	\$20.00
Red/soft stickers	\$0.001	11000	\$11.00
Purple Stickers	\$0.001	7000	\$7.00
SKUs		3700	\$0.00
Box 1	\$2.010	84	\$168.84
Box 2	\$1.530	1	\$1.53
Box 3	\$1.050	38	\$39.90
Box 4	\$0.490	611	\$299.39
Box 5	\$0.400	375	\$150.00
Pro Shippers	\$0.393	171	\$67.20
ACCO insert	\$1.640	2450	\$4,018.00
ACCO Box	\$0.521	5061	\$2,636.78
Total-Raw Goods			\$89,667.37
Total Inventory			\$129,070.87

Exhibit 16. Cost analysis: Original Eggsercizer.

WHOLESALE PRICE*	\$ 4.75
COGS	
MATERIAL COST**	\$1.18
LABOR	0.06
IN-BOUND SHIPPING	0.03
PACKAGING	0.22
TRAY COST ***	<u>0.26</u>
TOTAL	\$1.49
CONTRIBUTION MARGIN	\$2.56
ESTIMATED PER UNIT GENERAL AND ADMIN****	\$ 0.46
ESTIMATED COMMISSIONS AND ROYALTIES	\$ 0.52
OUTBOUND SHIPPING	\$0.35
ESTIMATED PER UNIT PROFIT	<u>\$ 1.23</u>

- * - with prepaid shipping; twelve units to a box; one \$3.10 display tray per box
- ** - purchase quantity = 50,000 units per order
- *** - \$3.10/12 = \$0.26 per egg
- **** - historically 10% of sales

Exhibit 17. Cost analysis: Eggsergrip.

WHOLESALE PRICE	\$3.00
COGS	
MATERIAL COST	\$1.00
IN-BOUND SHIPPING	0.00
PACKAGING	
TOTAL	<u>\$1.00</u>
CONTRIBUTION MARGIN	\$2.00
ESTIMATED PER UNIT GENERAL AND ADMIN	\$ 0.20
ESTIMATED COMMISSIONS AND ROYALTIES	\$ 0.50
ESTIMATED PER UNIT PROFIT	<u>\$ 1.30</u>

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Decision Support For Stage–Gate Processes¹

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The stage–gate process was introduced by Cooper (1990), and it became popular very quickly. The website for Product Development Institute claims that 68 percent of the leading US developers use stage–gate process. A more recent account of the process can be found in Cooper (2001). The list of criteria that companies use in stage–gate processes can be found in Hart *et al.* (2003). The implementation of stage–gate processes followed in several large corporations is described in O'Connor (1994).

Stage–gates are decision points where an analysis of the profitability of a new product development is conducted with all the information available at that point. Based on the analysis, a Go/Kill decision

¹ This case was prepared by Professor Jayavel Sounderpandian of the Department of Business at the University of Wisconsin-Parkside for instructional purposes only. After the death of Professor Sounderpandian it was modified by Professor Tom Bramorski, University of Wisconsin-Whitewater, to conform to the editorial requirements of this publication. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the Publisher or be reproduced in any way.

is made. Since new product development projects include plans for a long term, and involve huge investments, mistakes in the Go/Kill decision can be quite costly. A type I mistake of killing a profitable project ends in a loss of all the investment up to that point, and loss of future profits that could have been earned from the new product. There can also be indirect losses such as lowered employee morale and loss of market share. A type II mistake of letting a non-profitable project continue will result in the loss of large amounts invested. There can be intangible losses such as lowered image and lowered employee morale (Alexandre *et al.*, 2003). Needless to say, the Go/Kill decision has to be made very carefully, minimizing the probability of both types of mistakes. A good decision needs good decision support in the form of detailed and accurate data input, precise analyses and proper presentation of results to the decision makers.

Much software is commercially available for managing new product development projects (see Rangaswamy and Lilien, 1997). This paper shows how the Decision Tree (DT) technique and the software that can handle DTs can be used to conduct an accurate analysis at each stage including all the data available up to that point. The theory behind DT is simple, and readers can find the basics of DTs in Raiffa (1968). A DT can become quite large if the possibilities at each stage are many. When a DT becomes large, it is usually possible to use Influence Diagrams (InDia) as a short-hand. The use of InDia will be explained in this paper. The technical details of InDia can be found in Shachter (1986).

As an alternative to DTs, some researchers have used the Real Options method (Hackett and Dilts, 2004), or a method that combines Net Present Value (NPV), DT and Real Option methods (Boer, 2003). However, if a DT is completely specified, it will include the Real Options and NPV considerations automatically. Consequently, this paper deals with only the DT method.

Any new product development project is bound to be fraught with risks. Among others, there will be technical risks in production, retaliation risks from competitors, uncertainty risks in demand for the product and financial risks from the economy. Some form of risk adjustment of the analyses is absolutely necessary. Strategic level risk

adjustments are mentioned in Davis (2002), where NPV is adjusted for risk. Any risk adjustment is bound to be subjective, because different decision makers have different attitudes toward risk. DTs can analyze the risks according to the risk attitude of the decision maker, which is to say that it can find the optimal decision according to how much risk the decision maker wants to take. The formal normative theory behind making risky decisions is vast and a standard reference for it is Keeney and Raiffa (1976). There are also alternative theories, some of which can be found in French (1986). The leading theory is the Expected Utility (EU) theory, which this paper will use in dealing with DTs.

The PrecisionTree (PTree) software from Palisade Corporation was used to conduct all analyses and draw all the figures in this paper. Demo versions of the software can be downloaded from Palisade.com website.

The Basic Decision Tree

For demonstration we shall use a relatively simple case of a new product development project. Consider a stage-gate process comprising three stages. Each stage has a gate where a Go/Kill decision is made. When a Go decision is made, some progress is made in the project with an uncertain amount of technological success. For simplicity, we assume that the technological outcome can be one of two things, namely, Favorable and Unfavorable. The probabilities of these outcomes at the first stage are estimated to be: 0.8 Favorable and 0.2 for Unfavorable (see Fig. 1). However, these probabilities are not known for sure; they are only estimates. The implications of uncertainty in these probabilities will be analyzed later.

Cash flows along each branch of the DT are shown in Fig. 1 by the side of the branch. All cash flows are assumed to have been discounted at a proper rate (to account for time value of money) and expressed in present values. The task of collecting data and making the Go/Kill decision costs \$10,000. At each stage, a favorable technological outcome results in an expense of \$100,000 whereas an unfavorable technological health results in an expense of \$150,000.

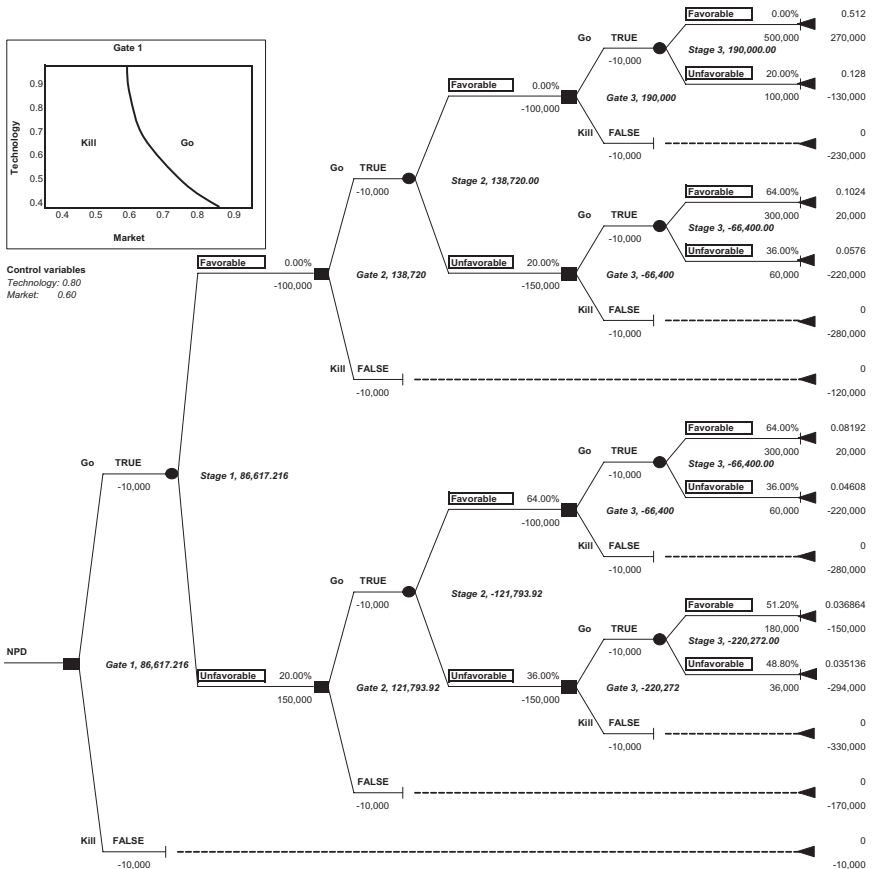


Fig. 1. Cash flow calculations for a three-stage stage-gate process.

When all technological outcomes are favorable, the new product will fetch revenue of \$500,000. But every instance of unfavorable technological outcome will reduce the market and hence this revenue by a factor of 0.6 (shown in cell C22 of the spreadsheet in Fig. 1). This factor is also only an estimate and its uncertainty will be analyzed later.

The spreadsheet is setup in such a way that when a control variable in cell C21 (Technology) or in cell C22 (Market) is changed, the

probabilities and revenues along the branches of the DT are automatically recalculated.

At current values for the control variables (0.8 probability of technological success at each state and a Market deterioration factor of 0.6), the optimal decision at Gate 1 is Go. At Gate 2, the optimal decision is Go if Stage 1 has favorable technological outcome and Kill if Stage 1 has unfavorable technological outcome. At Gate 3, the decision is Go in all cases.

Sensitivity Analysis

As mentioned earlier the probability of technological success (in cell C21), and the market deterioration factor (in cell C22) are only estimates. To handle the uncertainty in these estimates, we do a two-way sensitivity analysis varying both values from 0 to 1. The PTree software does this through a simple user interface. The result of the sensitivity analysis is shown at the top left of the spreadsheet in Fig. 1. The red line delineates the Go decision and Kill decision at Gate 1. It shows that the decision is more sensitive to technological success probability and less sensitive to market deterioration factor. If the technological success probability is less than about 0.64 the decision at Gate 1 will be Kill. If the market deterioration factor is low, it appears that it can be compensated by a suitable increase in technological success probability.

Sensitivity analysis of this kind can be very helpful to stage-gate decision makers. For instance, in our example if the managers are sure that technological success probability is at least 0.8 and the market deterioration factor is at least 0.55, they can be sure that the best decision is Go.

Influence Diagrams

A criticism of DTs is that the number of nodes can explode. It is indeed common to see cases where the number of nodes runs into millions. It would be futile to draw the full DTs. Fortunately, an alternative exists. The alternative is to use an Influence Diagram or

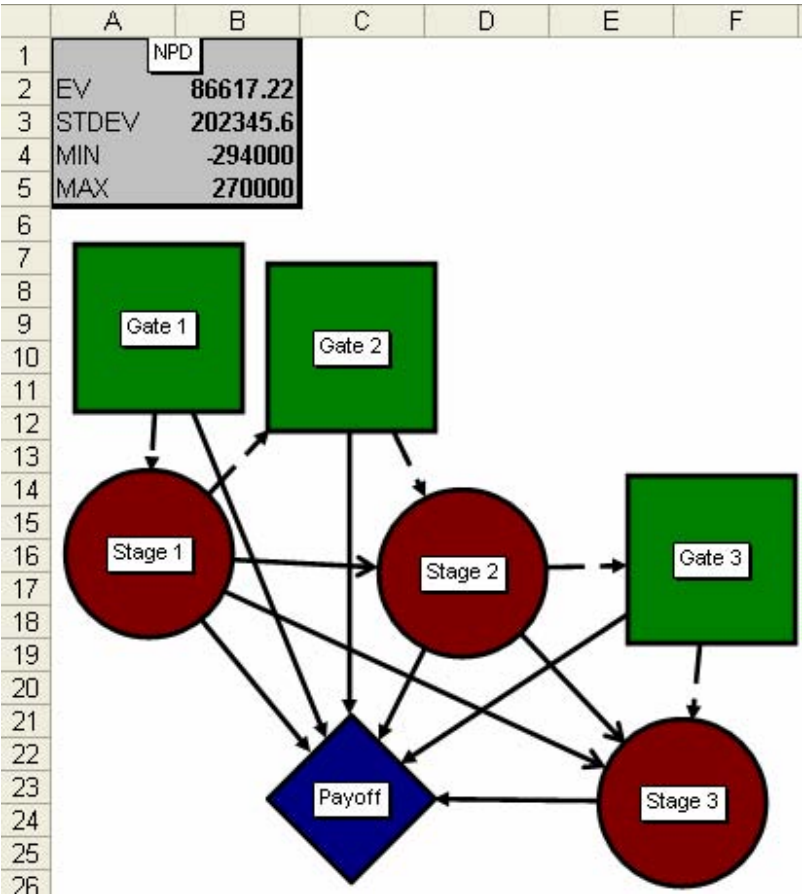


Fig. 2. InDia for the same problem.

InDia. Technical details of constructing an InDia using PTree software can be found in Clemen and Reilly (2001). Theoretical details of InDia can be found in Schachter (1986). Figure 2 shows the InDia for the basic problem modeled in the DT in Fig. 1.

Value of Information and Stage Definition

An additional advantage of InDias (or DTs) is that one can find the expected value of perfect information (EVPI) about an uncertainty.

For example, while making the Go/Kill decision at Gate 1, if we were clairvoyant and knew what the technological outcome in Stage 1 would be then we will definitely be in a better position to make the right decision at Gate 1. With clairvoyance we will increase the expected value (EV) at the start node. The difference in the EV with and without information is known as the EV of that information. If the information leaves no uncertainty, it is called perfect information. It is clear then that the EVPI of an uncertainty is how much EV we are losing by not being clairvoyant. Or, to put it another way, the EVPI of an uncertainty is a measure of the risk posed by that uncertainty. Since no information can be perfect, EVPI is only a theoretical concept. But it has practical significance, because it is a good measure of the risk caused by an uncertainty.

Figure 3 shows part of the DT when perfect information, or clairvoyance, about the Stage 1 outcome is assumed. The sequence is clairvoyance followed by Gate 1 decision followed by Stage 1 outcome. Note that when the Clairvoyance indicates Favorable outcome, the Stage 1 outcome has only the Favorable branch, and note the similar case with Unfavorable outcome. The EV at start node in this case has increased from \$86,617 (found in Figs. 1 and 2) to \$108,976 (in Fig. 3). Thus, EVPI of the uncertainty at Stage 1 is $\$108,976 - \$86,617 = \$22,359$. If the managers think that adding a gate will cost substantially less than \$22,000 and some reliable information can be obtained half way through Stage 1, then it might be worth breaking Stage 1 into two stages.

In stage-gate processes, EVPI can play a significant role. A difficult decision in stage-gate processes is how to define the stages. The only guideline in the literature is that most projects use four to seven stages (Cooper, 1990). This may not help much to define the stages in a case at hand.

One way to solve this problem is to start with an initial solution where the stages are just intuitively defined. The EVPI of the uncertainty in each stage is then computed using InDia or DT. If the EVPI of the uncertainty in a particular stage is high, then it may be better to break that stage into two or more stages and add a gate at each new stage. If the EVPI is too low, then the stage may be merged with an adjacent stage.

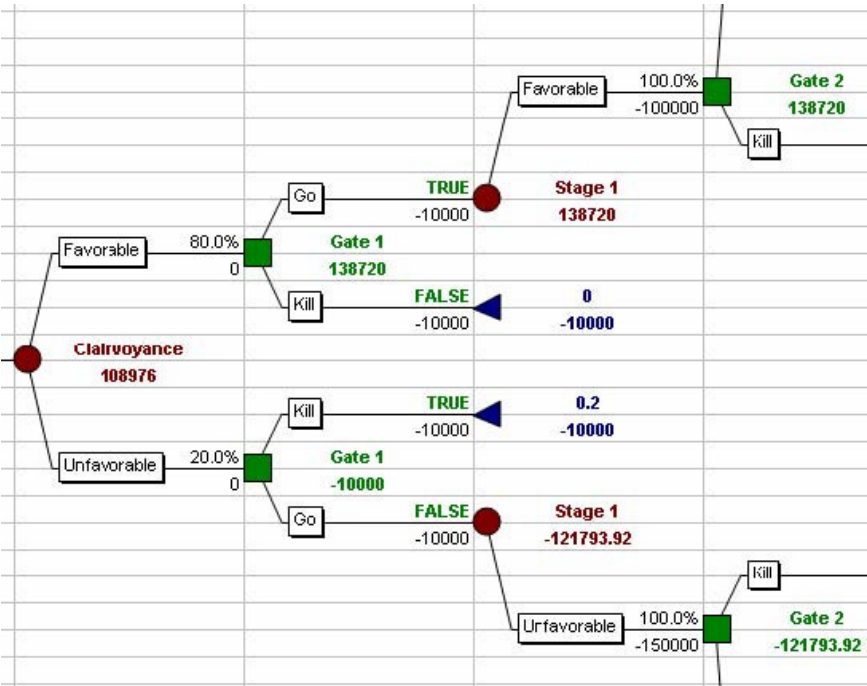


Fig. 3. Part of the DT with clairvoyance.

Simulation and Risk Analysis

When there are too many uncertainties that interact, it can be difficult to analyze the case. For example, if the revenue from a successful new product follows a normal distribution, then a simple DT or InDia cannot handle it. We need simulation. The PTree software can be combined with @Risk software, which is also from Palisade Corporation, to carry out the simulation. In our example, it is assumed that the revenue from successful product launch is normally distributed with a mean of \$500,000 and a standard deviation of \$40,000. The revenue when Stage 3 outcome is Unfavorable and all others are Favorable is assumed to be normally distributed with a mean of \$100,000 and a standard deviation of \$20,000. When the software carries out the simulation, it produces, among others, an

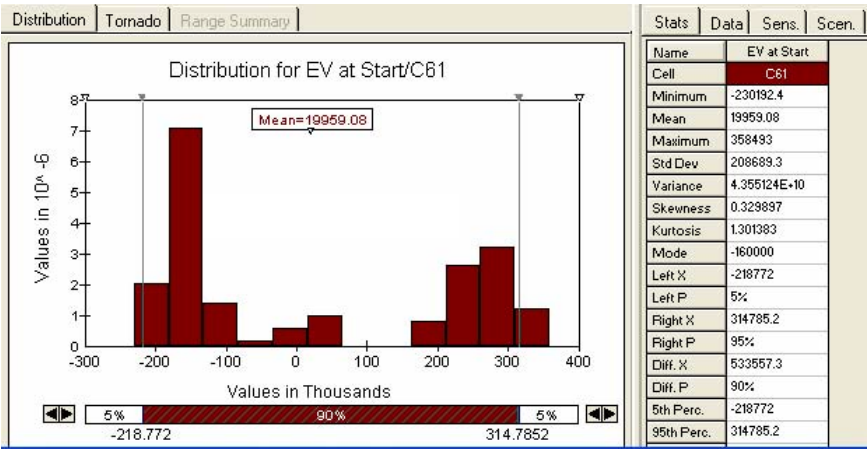


Fig. 4. Simulation output.

output chart shown in Fig. 4. The chart shows the probability distribution of EV at the start node. Notice that there are some discontinuities in the distribution. The discontinuities are due to the switching between Go and Kill at the gates. The chart also indicates that this is a risky venture because it shows possible negative EVs or losses that are substantial and very probable.

Risk Adjustment

In the DTs above, the decision criterion has been maximum expected NPV. But it is highly unlikely that a company will use expected NPV as the criterion. Rather, it will wish to maximize the risk-adjusted expected NPV. The subject of the risk adjustment is vast and there exist many theories (see French, 1986, for a discussion of various theories). The most accepted theory is the Expected Utility (EU) theory described in detail in Keeney and Raiffa (1976). According to EU theory, a decision maker (DM) must maximize the EU of the final wealth rather than the EV of the final wealth. The utility of wealth, represented by a function $u: \mathfrak{R} \rightarrow \mathfrak{R}$, can be different for different DMs. The analyst has to first assess the utility function for the given DM and use it to find the best risk-adjusted solution. Assessment of

finds the best decisions at each gate. In doing this the software picks the decisions that maximize the EU of the DM rather than the EV at the start node. When the DM is risk-averse a Go decision at a stage using the maximum EV criterion can turn into a Kill decision by maximum EU criterion. Figure 5 shows part of the DT where a utility function with $R = \$400,000$ has been used. The figures at the nodes are risk-adjusted dollars or certainty equivalents. The risk-adjusted EV at the start node is now only \$33,444 rather than \$86,617.

Conclusion

This paper has described how DTs can be used to conduct reliable Go/Kill decisions in stage-gate processes. It has shown how optimal decisions can be made at the various stages of a new product development project paying attention to all available data and the risks involved. The risk adjustment can be tailored to the risk attitudes of the decision makers.

When a DT becomes too large to work with, it is usually possible to work with a more compact InDia instead. Both DTs and InDias can be used to conduct risk analyses and compute EVPI of the uncertainties at any stage. Such EVPI can be used to arrive at optimal stage definitions.

The analyses presented here have taken into account only the quantitative aspects of new product development. There can very well be qualitative aspects to the decision, many of which are covered in Cooper (2001) and Cooper *et al.* (2002). Recently, Bremser and Barsky (2004) applied the balanced scorecard approach and the stage-gate process approach to R&D evaluation. This shows that stage-gate processes can be applied at both tactical and strategic levels.

Summary

The following problems and issues need to be considered in the case discussion:

- Why is it necessary to perform a feasibility study of new technologies at the strategic level?

- What are the risks inherent in new technology adoption?
- What are the quantitative tools and techniques that can be applied to evaluate feasibility of new technologies?
- How can decision support software assist in improving decisions regarding new technology adoption?

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Topic Area 4

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Getting a Product from the Laboratory to the Market

Consumer and industrial products require a great deal of testing before they can be introduced into the market. Results of various tests are used not only to assess the actual performance of each product, but also to determine what potential each product may have in the market. The two types of tests typically performed on a series of prototypes are technical tests and market tests. Sometimes the final product being prepared for commercialization is subjected to additional technical and market testing to fine tune it before market introduction. Technical product testing is used to determine how well the product will perform under actual use conditions, how safe the product might be in the hands of real consumers or users, and what most likely will be the expected life of the product? Market testing is designed to assess potential market acceptance of the product.

Governmental legislation, combined with various consumer movements, now requires greater and more comprehensive testing procedures, and also expects that objective third-party institutions will test potential products. A typical firm will conduct in-house testing of prototypes according to mandated national or international standards, industry accepted standards, or evolving standards for a new generation of products. In-house testing often exceeds the standards set by the government or industry; however, the market tends to view the in-house testing process as biased and self-serving. In most cases, in-house product testing is preliminary and is inevitably followed by tests conducted by governmental, private, or industry-related testing laboratories. Most of these laboratories have developed procedures for uniformly acceptable testing designed to meet both governmental and industry standards.

The results of third-party testing provide an objective assessment of a product and may become part of overall documentation for the entire development process in the case of future performance, safety problems, or legal challenges. Depending on the nature of the industry, independent laboratory testing may also be a critical and integral part of the product development and design process for the new product; as the product is developed, independent tests are conducted to identify potential strengths or weaknesses in the product. Thus, weaknesses in design flaws may be easily identified and corrected during the development process.

In addition to governmental or private laboratories specializing in testing products or product prototypes, university-based research centers also perform independent tests for a broad variety of firms. Many high technology firms find that university-tested prototypes frequently offer more theoretical options for improvements in their prototypes and, from time to time, suggestions for additional applications. This is primarily because universities tend to have broader overall research and educational interests than their governmental or private counterparts.

Industries such as biotechnology, electronics, computer, or medical equipment, among others, maintain ongoing research and testing cooperation with university-based research laboratories to test their prototypes and market-ready products on an ongoing basis. Legal agreements are generally drafted between individual firms and university-based laboratories regarding the eventual discoveries or improvements made during the testing process. These agreements routinely provide for some sort of partnership in, or sharing of, the revenue that may come about as a result of their cooperation.

Technical testing today may be a relatively complex, and even high technology, activity. Potential products are subjected to technical tests designed to determine how well the product will perform functionally. However, since most products today are designed for markets with significant differences in environmental conditions, educational levels, economic conditions, or ecological conditions, products have to be tested for performance under conditions that realistically reflect how the product will be used in a given market. Some products also

need to be tested for their effective life under extreme environmental conditions to determine what practical economic value the products might have, given the needs of their consumers or users.

Testing specifications for relatively conventional products are, as a rule, available. Governmental agencies, industry association, and consulting firms publish specifications for various performance, safety, and life expectancy tests along with instructions for how these tests should be carried out. Individual firms may also make their technical testing specifications and procedures available to the public. This is particularly true in cases where their specifications exceed all other known technical testing specifications in order to show that, from a competitive point of view, their testing standards are high. These firms will most likely use the results of their technical tests for promotional purposes.

Because of consumers' and users' tendencies to exploit products in ways for which the products have not been designed, additional tests must be performed to anticipate how consumers or users might misuse the products. Many consumer lawsuits directly result from misuse or misapplication of a product. Firms must be able to find out, or in some way predict, how their products may be misused through a series of nondestructive and destructive tests. A number of private laboratories specialize in both types of testing procedures.

Technical product testing is also becoming more common internationally. Different countries have various performance and safety requirements and insist that products be tested before they are imported into their markets. Similar product testing requirements may apply to various geographic areas, international trade unions, or market areas. In some cases different product safety requirements are well justified, while in others internal testing of imported products is used as a means of collecting additional revenue from tariffs or import duties or other barriers to international trade.

Market testing of prototypes can be a highly complex process depending on the type of products being tested and their purpose. Market testing may be used to finalize the selection of product attributes, and make them more acceptable to the potential target market. For example, taste, texture, color preference, or the physical shape

tests of proposed products may be used to finalize these attributes to increase market acceptance of the proposed products. Market tests focusing on the product's position in the market in comparison to competing products is also conducted by marketing researchers. The main objective of market testing a prototype using potential consumers or users as participants is to develop a reliable understanding of how the eventual product will perform in the target market for which it was designed.

The firm using internal marketing research specialists can conduct its own market testing of products being prepared for the market or it can contract for these services with a conventional marketing research firm. The firm, however, frequently does general market testing. Outside marketing research specialists are typically engaged when specific questions need to be answered or the research method that should be used is too advanced or costly for the firm. In some cases marketing research consultants are asked to oversee the design and implementation of market testing of prototypes that are technologically new and the firm needs additional marketing research expertise to test them such that outside consultants can supply.

A prototype can be tested in the market on two different levels. First, tests can be conducted that relate directly to the product itself, i.e., the product attributes can be finalized from input of key consumers or users. Second, a broader series of tests can be designed to clarify the potential position for the product in the market; these market tests focus on the product's relative place in the overall market and its competitive posture. Information generated from the tests related directly to the product can be used to decide which prototype is selected as the final product for commercialization. Results of the second series of tests are typically used as input into the formulation of an overall marketing strategy for the selected product.

Most large consumer product firms tend to develop proprietary marketing research approaches and use them routinely to test their prototypes or products that have been designated for market introduction. Such firms typically consider the information they collected from their testing procedures before the product was fully developed as useful but dated. Therefore, they proceed to develop additional

information about the prototype and the market again at the end of the development process. This information is used to formulate marketing strategy for the selected product. In order to develop an effective marketing strategy for a new product, marketing managers need updated information concerning the target market and the product's potential market position. Many proprietary marketing research models automatically sequence and time the necessary market tests and information gathering procedures.

It is important to realize that there are substantial differences in testing consumer product prototypes as opposed to industrial or business-to-business product prototypes. Although consumer products can be subjected to a variety of tests that include potential consumers or users, business-to-business prototypes frequently require more advanced testing without input from actual customers or users. These differences are primarily accounted for by the availability of standard industrial product specifications. For example, ball bearings, lubricants, or chemicals are produced subject to such specifications.

Industrial product prototypes that are not subject to known specifications may require creative testing procedures. Depending on the nature of the prototype, possible tests may have to be discussed with a group of industry experts or product specialists who evaluate the prototype as part of a focused discussion. Other prototypes may have to be evaluated for their potential performance or multi-market applications by individual experts. In some cases a prototype may have to be put into actual service to determine how well the eventual product will serve its purpose. In these situations, a firm may closely cooperate with existing and potential customers and frequently make new prototypes available for actual use.

Some industries also develop computer-based test marketing programs designed to introduce new products in geographically limited market areas to determine how the product may potentially perform. These limited market tests are particularly effective when testing relatively high volume, low price products. For example, a computer-based program can easily monitor the market introduction of convenience goods in a specific geographic area. However, firms marketing high priced, limited volume products tend to use computer-based test

marketing programs to specifically target potential consumers during market testing. This approach is often supplemented with a highly targeted advertising campaign in order to discover the potential demand for their products.

Technical and market testing become even more complex when the prototypes are based on new technology or incorporate market innovations. As a rule, existing governmental or industry standards do not include testing prerequisites for new technology or market innovations. New standards and testing procedures must be introduced as prototypes to approach commercialization. Because technology imbedded in products tends to change rather quickly, it is sometimes difficult to keep up with changes and, at the same time, develop meaningful testing standards. In these situations, firms must cooperate closely with governmental agencies and their industry associations in developing uniform standards for both technical and market testing. However, some international markets are sufficiently unregulated so that products with significantly new technology can be introduced without any prior testing or governmental approvals. Arbitrarily introducing new high technology products in such environments may create major problems for individual firms in other international markets due to pirating and counterfeiting.

Some markets have a substantially higher propensity to accept new technology and market innovations. In these markets governments may rely on test results provided by individual firms introducing their products to the local market. Introduction of industrial products in many international markets is not controlled by governmental agencies at all; any type of equipment may be activated for virtually any purpose or industrial application regardless of the technology being introduced. Although firms tend to differentiate their product offerings based on the needs of the markets, sometimes a product with a high level of new technology is introduced and marketed uniformly around the globe. Such products need to be tested in those markets that demand it. From this perspective, markets that do not have any testing standards for industrial products also benefit from the standards developed for other markets. For example, some technologically leading markets may require testing of all industrial products.

Markets with lower levels of technology deployment may simply rely on the more advanced markets to test the products first.

Governmental product standards for consumer products may also create interesting challenges for individual firms. While products are tested for quality and safety in some markets, quality and safety may not be defined the same way in other markets. Quality may be defined on the basis of the naturally occurring chemical content in some markets, while quality in other markets may be defined on the basis of the synthetic chemical content. The concept of safety may also have different interpretations. In some markets, the concept of safety, i.e., how safe the product is, is defined in the context of the clearly defined design function — can the product be used in a safe manner for the purpose for which it was intended? This definition may not be sufficient for other markets where higher governmental standards exist. In these markets, the concept of safety may also relate to potential auxiliary uses and misuses to which consumers or users may subject the product.

Governmental regulations, new technology, and market innovations may not necessarily be considered at the same time. In high technology products, the concepts of quality and safety frequently take a long time to assess. Damage by a new technology may be inflicted on users of a newly introduced product. When the market realizes the situation, only then does it demand an appropriate government remedy. Some large global firms tend to communicate with individual governments about potential introduction of the new technology on which their products are based and cooperate with germane governmental agencies on developing appropriate standards and technical and market testing procedures.

Another important factor in the technical and market testing process is the increasing number of supply chains and industrial networks that are responsible for increased activities in custom development of business-to-business products. Many of these products are custom developed or custom designed to specifications passed through the supply chain or network. In these situations, testing of the individual parts or components is done in cooperation with the firm that produced the parts or components and the firm that placed

the order. In other words, the firm that produces the final product supervises the production of the necessary parts or components. The entire technical and market testing process may become primarily the responsibility of the products' final producer.

When prototypes that include new technology are market tested, one question frequently asked is how much of the new technology needs to be disclosed to potential consumers or users? An increasing number of products are modified or enhanced with technological improvements ranging from major biological innovations to the latest electronic upgrades. Although a product may physically look the same, the imbedded technology is dramatically different from the previous version. Consumers typically expect gradual continuity in product appearance and technological content. If products are substantially different from one model to the next, consumers may be skeptical about the new technological makeup of the product and be reluctant to buy it.

Before any new technology or major marker innovation is introduced to consumers or users, it needs to be fully tested on its own merits, i.e., consumers need to be aware of the technological changes built into the new version of the product. Marketing research specialists need to closely cooperate with the scientists, design engineers, and the technical product development specialists in communicating the new technological features of the product to potential consumers or users. The marketing research specialists also need to study responses to new technology or major innovations built into new products and make certain that they are consistent with the consumers' or users' expectations.

Before marketing managers are ready to select the final prototype for an optimal target market, they must have complete results from both the technical tests and the market tests. The eventual product must meet the quality and safety requirements expected by potential consumers or users and must satisfy the perceptions and preferences that potential consumers or users formulated as part of their buying behavior expectations for that product. Marketing managers must have all this information and they must be able to use it in formulating a comprehensive marketing strategy necessary to properly introduce the new product in the market.

Biosolutions Incorporated: A Company in Search of Financing¹

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As Alex Roy stepped out of his office into the bitterly cold winter Wisconsin evening, he paused and took a deep look at his small research facility situated on the outskirts of the city of Madison. As he waited for his car engine to get warmed up, he made a silent promise to convert his small, hardly profitable research lab into a big company someday. Alex's recent ambition was inspired by the phenomenal research progress made by his team in the last quarter, leading to the discovery of highly effective environmental-friendly natural fertilizers/biocontrol agents. These products, if marketed wisely had the potential of capturing 70–90 percent of the local and national fungicide and plant growth products market.

Company Background

Biosolutions Incorporated (BSI) was a small research firm started in the late 1980s by Alex and his former colleague Brian Johnson. Both plant biologists, by training, Alex and Brian headed the plant fungicide and plant pesticide divisions of *Plant Genesis*, a multinational firm headquartered in Wisconsin. After 15 years of highly prolific careers culminating in positions of VP-Operations of their respective divisions, both Alex and Brian felt it was time to move on. In their current positions, they both felt a steady, yet progressive detachment from the excitement of bench research and a longing for a career geared more toward innovations and inventions; in other words, real research and development work at the bench level. Alex and Brian often pondered on their mutual growing change in career interests in numerous hallway conversations and coffee breaks until 1987. That fall, both of them decided to resign from their respective positions and used about a third of their personal investments to fund BSI.

Thus, BSI was born in the late 1980s initially with a staff of six consisting of Alex, Brian, two human resources personnel, two lab technicians and a post-doctoral worker. In the initial years of BSI's development, both Alex and Brian wore multiple hats. While Alex was the CEO and Brian the CFO, each of them also worked several hours in the lab formulating new strategies for research while simultaneously calling upon old contacts for seeking contracted work for the firm. BSI's main line of business was providing research solutions to

smaller firms lacking appropriate R&D facilities. Most of the operating costs for BSI were covered through these small contract jobs and any leftover finances were utilized in a modest amount of research work supervised by Alex and Brian. They envisioned that it would support their R&D team in a way that would someday take their small firm to bigger and higher levels. Today, in light of their breakthrough research in natural fertilizers involving PGPSB (plant growth promoting soil bacteria), such a possibility was not far away.

The Opportunity

Realizing the potential of their invention and benefits offered by their products, Alex and Brian began to brainstorm ways in which they could raise capital to expand their operations. Their dreams were based on the recent success of similar companies in the plant nutrition field that had succeeded in raising millions of dollars over the last couple of years.

In June 1996, Alex and Brian, with due diligence, approached the venture capital firm of Caulfield and Byers to secure funding for their research labs. After concluding that they had one of the best fertilizer derivatives in the market, Alex and Brian finally decided to build a business plan in order to sell their idea and product concept to Caulfield and Byer in return for an equity stake in the company. They decided to seek \$3 million in funding in exchange for a 30 percent equity stake in the company. The proceeds of the equity sale would be used to finance the growth of the firm through investment in marketing and working capital needed to ramp up production levels.

Between Alex and Brian, they felt they had a sound management team and the chemical formulations to become a major player in the specialized niche that BSI serves. In conversations with Wachovia Bank, who they had approached for equity funding, Brian introduced the capabilities of BSI as follows: “We have developed new technology and processes that are in demand by other chemical manufacturers as well as by major distributors who do not have the ability to produce our specialty products. We see our mission as not only that of custom manufacturer, but as a trade supplier where we can reach the end-user market with products we consider to be proprietary.”

BSI was currently concentrating on small lot manufacturing and custom orders. In the first quarter of 1996, BSI was approached by Piedmont Technologies, LLC to become a subcontractor for a \$23 million order they had from Bionutritional Inc., a large multinational conglomerate which offered a mirror contract to produce PGPSB pellets. In order to expand facilities to meet the requirements, BSI was successful in obtaining a \$280,000 loan through Wachovia Bank. The loan process took 12 months and BSI was only able to accommodate a small part of the order during that period through financial support from the principals. Bionutritional Inc. had to have a backup producer during this period. Unfortunately that producer failed to meet the quality standards, and Bionutritional Inc. defaulted on the contract. This also ended the BSI contract.

Since then BSI stuck to its original plan which has continued to the present time. Experience with Bionutritional Inc. brought BSI to realize that the market for pellets far exceeded \$100 million. Furthermore, BSI realized in 1996 that they would be the only domestic source of this product. With no marketing program other than word-of-mouth, BSI had achieved \$188,000 sales in 1993, \$241,000 in 1994, and \$269,000 in 1995. "We are convinced that this is a lucrative market and that, with adequate equipment and marketing, we can capture a significant part of it," said Alex Roy in one of his presentations to the VC community.

The Product

BSI was a niche player in the specialty and industrial chemical business, focusing on value-added products, which are not widely or readily available. BSI seemed to have perfected unique manufacturing processes resulting in lower manufacturing costs and high profitability for these specialized chemicals. They also had established a network of strategic alliances with distribution companies lacking a similar capability to ascend from laboratory to commercial scale and manufacture products in accordance with quality specifications.

In addition to being a specialty chemical formulator, lab analysis agency, and a contract R&D organization, BSI was considering selling

its newfound technology in the form of a product. The product commonly referred to as the “PGPSB pellet”, would be in pellet forms and sold to companies making fertilizers, insecticides, pesticides, and fungicides. Further research into the composition of the product also seemed to indicate that it might be useful for the manufacturer of plant food supplements. BSI also had plans to produce five other specialty chemical pellets for various applications. It was clear that this immense prospect had created excitement about the overall opportunity.

The Science

PGPSB (Plant Growth Promoting Soil Bacteria)

Some soil bacteria can be used as plant growth promoting agents (natural fertilizers) or as biocontrol agents for fungal diseases and insect damage. The research conducted at BSI was targeted toward evaluating the potential to develop and manufacture bacterial-inocula (natural fertilizers, pesticides and fungicides) for commercial applications in both field and greenhouse environments using PGPSB isolated in the BSI laboratory from soils collected from various farmlands in Wisconsin. The expectation was that commercial manufacture of the agents will allow farmers to replace chemically synthesized organic fertilizers (expensive and polluters) with the currently used natural fertilizers and biocontrol agents (both more cost-effective). In turn, these measures will encourage agricultural practice in a manner friendly to our environment.

PGPSB are free-living soil bacteria that promote growth of plants by one or more of several mechanisms: (i) by suppressing phytopathogenic microorganisms; (ii) by producing siderophores which can solubilize and sequester iron from the soil and provide it to the plant; and (iii) by providing fixed nitrogen and inducing synthesis of plant hormones. In Canadian research facilities, it has been demonstrated that *Pseudomonas putida* (PGPSB) contains 1-aminoacyclopropane-1-carboxylic acid (ACC) deaminase activity that might be involved, to some extent, in the promotion of plant growth by this PGPSB. The model as depicted in Fig. 1 is proposed to account for the promotion of root elongation by PGPSB.

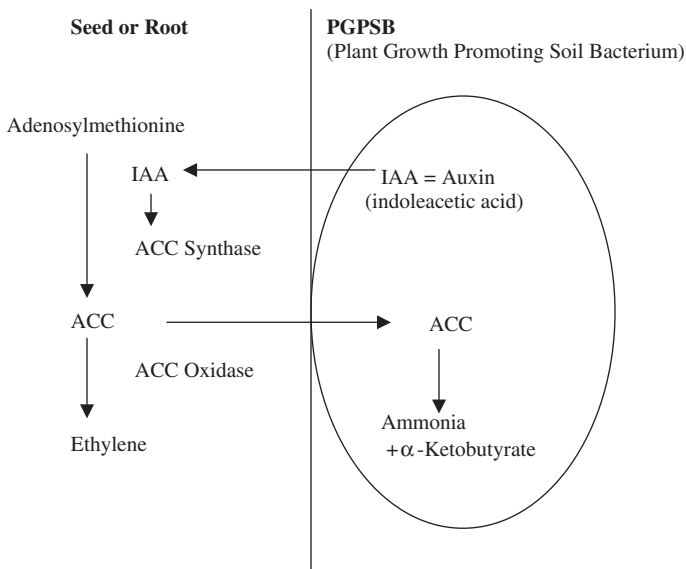


Fig. 1. A model of PGPSB stimulation of plant growth (adapted from Glick *et al.*, 1994, Hall *et al.*, 1996 and Ghosh *et al.*, 2003).

Following the binding of the bacterium (PGPSB) to either the seed coat or root of a developing plant, the bacterial enzyme ACC deaminase sequesters ACC from the plant and then hydrolyzes ACC, the immediate precursor of the phytohormone ethylene into ammonia. The level of ethylene within the plant is lowered and the promotion of plant growth is enhanced. The arrows indicate a chemical or physical step in the mechanism; ACC = 1-Aminocyclopropane-1-carboxylate.

The model envisions the binding of the bacterium to either the seed coat or the root of a developing plant, the bacterial enzyme ACC deaminase is sequestered and then the hydrolyzed ACC leaches out from the plant to afford ammonia and α -ketobutyrate. Consequently, this would lower the level of ACC and also the level of ethylene (a plant hormone that inhibits plant growth and causes aging) because ACC is the immediate precursor of ethylene in plants. Paradoxically, in bacteria, a pathway that does not include ACC probably synthesizes ethylene. In addition, the seedlings can utilize ammonia produced from the hydrolysis of ACC.

The leakage of ACC from the plant could occur as a consequence of either seed imbibition or root exudation. In many plants, around 10–25 percent of the net fixed carbon is transferred to the roots and

is subsequently lost from the plant, usually as a root exudate rich in sugars, organic acids, amino acids and other small organic molecules, such as ACC. The ready availability of these nutrients is the main reason why microbial numbers are significantly increased around the root of plants compared to the microbial population in the soil as a whole. The presumed result of the hydrolysis of ACC is that the level within the plant is lowered as a consequence of the increased exudation gradient of ACC.

Consistent with this model (Fig. 1), it was observed that: (i) mutants of *P. putida* GR12-2 that lacked ACC deaminase activity no longer promoted root elongation; (ii) all soil bacteria that were isolated on the basis of their ability to utilize ACC as a sole source of available nitrogen significantly stimulated canola root elongation under gnotobiotic conditions (see Table 3 later in discussion); and (iii) a mutant of *P. putida* that overproduced IAA, a compound known to stimulate the activity of ACC synthase in plants and hence of the amount of endogenous ACC, significantly inhibited canola root elongation. The explanation for the inhibitory effect on root growth of the IAA overproducing mutant of *P. putida* is that the increased level of IAA secreted by the mutant bacterium is taken up by the plant and therein, interacts with ACC synthase, stimulating the synthesis of excess ACC which is in turn converted to ethylene.

For a number of different plants, ethylene stimulates germination and breaks the dormancy of the seeds, but if the level of ethylene following germination is too high, root elongation is inhibited. Some of the newly synthesized IAA (indole acetic acid) is taken up by the plant and, in conjunction with the endogenous plant IAA, can either stimulate plant cell proliferation and/or elongation. Alternatively, IAA can stimulate the activity of ACC synthase to convert S-adenosylmethionine (SAM) to ACC. SAM is utilized in other cellular reactions such as methylation and polyamine synthesis so that the diversion of a small amount of convert SAM into ACC does not deplete the steady-state level of convert SAM. A significant portion of the ACC may be exuded from plant roots or seeds (along with other small molecules normally present in seed or root exudates), taken up by the bacterium and hydrolyzed by the ACC deaminase to ammonia and α -ketobutyrate (Fig. 1). Thus, when PGPSB that contain the enzyme

ACC deaminase are bound to the seed coat of a developing seedling, they may act as a mechanism for insuring that the ethylene level does not become elevated to the point where root growth is impaired. This PGPSB-facilitated stimulation of root elongation could enhance the survival of some seedlings, especially during the first few days after the seeds are planted. The model presented in Fig. 1 predicts that any bacterium that contains the enzyme ACC deaminase and can bind to plant seeds or roots in the soil should also be able to promote root elongation. Recently, it was observed that when canola seeds were treated with *E. coli* cells expressing a cloned ACC deaminase gene, root elongation was promoted significantly. This demonstrates that the ability to promote root elongation was a direct consequence of the presence of ACC deaminase.

It is well documented that plants respond to a variety of different stresses by synthesizing “stress” ethylene. In turn, the ethylene can trigger a stress/senescence response in the plant that may lead to physiological changes in those cells that are at, or near, the site of the stress. Since ACC deaminase, when present in a PGPSB, appears to lower the level of ethylene in a plant, it is of interest to examine whether a PGPSB can ameliorate some of the different kinds of environmental stress effects. In addition to the growth promotion activity, PGPSB are well known for their ability to produce antibiotics. Environmental-friendly microbial fertilizers could be a better choice over chemically synthesized fertilizers in reducing plant diseases and pesticide pollution, and stimulating growth of plants. Indeed, interest in exploration of the PGPSB strains for commercial applications to agricultural productivity is just beginning to develop worldwide.

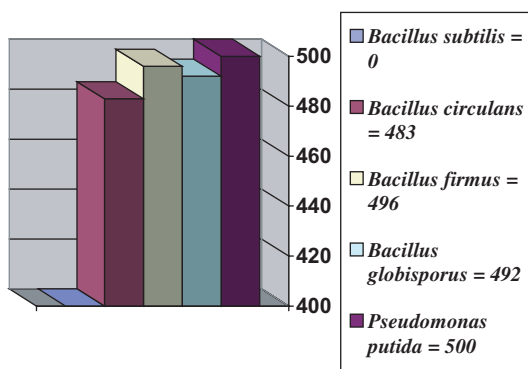
Research involving PGPSB at BSI

The research on PGPSB at BSI involved three novel species of plant growth-promoting soil bacteria (PGPSB) which were isolated from soil samples collected from tomato, corn, alfalfa, and soybean fields in Wisconsin (Table 1). These bacteria were selected solely on their ability to utilize the compound ACC as a sole nitrogen source. BSI researchers

Table 1. Isolates from soil samples obtained in southeastern Wisconsin and the Rhizosphere with which they are associated.

Novel strains of PGPSB	Plant association
<i>Bacillus circulans</i>	Alfalfa and Soybean
<i>Bacillus firmus</i>	Alfalfa and Tomato
<i>Bacillus globisporus</i>	Corn and Soybean
<i>Pseudomonas putida</i>	Alfalfa, Soybean, and Tomato

Table 2. ACC Deaminase activity in novel PGPSB (Nanomoles per milligram of protein per hour).

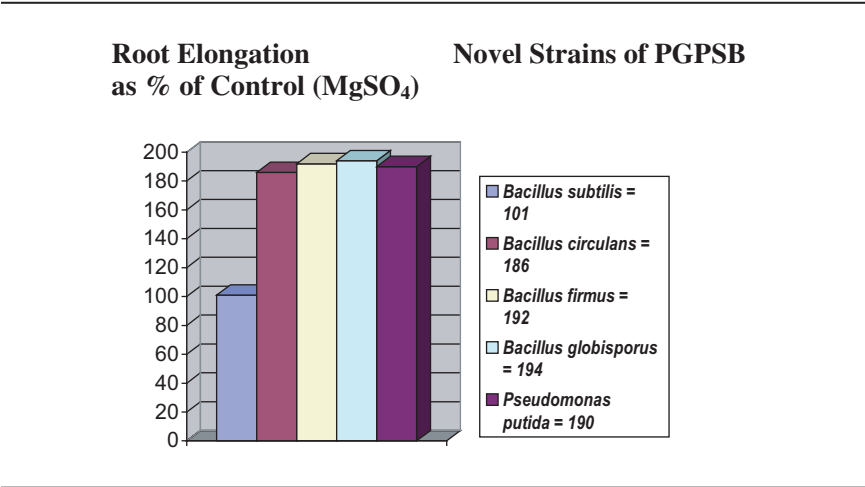


ACC deaminase activity was quantified by monitoring the amount of α -ketobutyrate that was generated by the deamination of ACC as measured following derivitization of α -ketobutyrate with 2,4-dinitrophenylhydrazine as described by Honna and Shimomura (1978). The absorbance of the resulting solution was determined at 540 nm using a Beckman DU-640 spectrophotometer. *Bacillus subtilis* was used as the control as it did not exhibit signs of growth on the ACC media. *Bacillus subtilis* was used as control with no ACC deaminase activity.

identified four strains of PGPSB to a species level with the help of Sylose Laboratory, Inc., Madison, Wisconsin: *Bacillus circulans*, *Bacillus firmus*, *Bacillus globisporus*, and *Pseudomonas putida* (Table 1).

All of these PGPSB strains produced similar levels of indole acetic acid (data not shown), exhibited similar levels of ACC deaminase activity (Table 2), and were able to promote root growth in canola seedlings (Table 3).

Table 3. Promotion of root elongation under laboratory conditions.



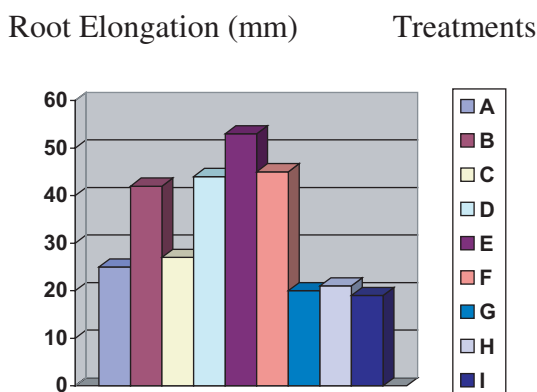
Sterilized seeds of canola were treated with 0.1M MgSO₄, or a strain of novel PGPSB suspended in 0.1M MgSO₄. The plants were grown under a 12-hour light/dark cycle. Temperature was maintained at 22°C. All measurements were taken on the sixth day of post-germination. Each data point represents 50–60 seedlings.

To support the hypothesis on PGPSB stimulation of plant root elongation (Fig. 1), BSI scientists also examined the effects of PGPSB strains as well as a chemical inhibitor (L- α -(aminoethoxyvinyl)-glycine = AVG) of ethylene production and a chemical generator of ethylene, on root elongation (Table 4). The root length increased when seeds were treated with PGPSB and/or the inhibitor of ethylene, AVG in comparison with a MgSO₄ control treatment, while the ethephon (2-chloroethyl) phosphoric acid (ethylene generator) treatment inhibited root elongation (Table 4). These observations are consistent with the model (Fig. 1) in which promotion of root growth by PGPSB is a consequence of inhibition of ethylene production within the developing seedling.

Fungicidal and pesticidal activities

The effectiveness of PGPSB as a biofungicide and as a biopesticide is yet to be confirmed. Briefly, all strains of PGPSB are being tested

Table 4. Canola root elongation under gnotobiotic conditions.



Sterilized seeds of canola were treated with (A) MgSO_4 , (B) *Bacillus globisporus*, (C) *Bacillus subtilis*, (D) AVG, (E) *Bacillus globisporus* + AVG, (F) *Bacillus subtilis* + AVG, (G) Ethophon, (H) *Bacillus globisporus* + Ethophon and (I) *Bacillus subtilis* + Ethophon. PGPSB strains were suspended in 0.1M MgSO_4 . The plants were grown under a 12h light/dark cycle. Temperature was maintained at 22°C. All measurements were taken on the sixth day of post-germination. A similar set of results was obtained with the other three PGPSBs. Each data point represents 50–60 seedlings.

in the petri dish for their antifungal activity against *Fusarium* and *Pythium* on Potato Dextrose Agar (Difco) as described by standard literature procedures. The tests are performed by planting seeds (canola, tomato, corn, soybean, and alfalfa) coated with PGPSB in the soils infested with fungi, and then the seedlings are grown under a 16-hour light/dark cycle with temperatures of 18°C for *Pythium* and 25°C for *Fusarium*. Percentage of emergence, shoot length, root length, and dry weights of the crops are recorded both under the control (absence of fungi) and treated (presence of fungi) conditions, and then the data are compared to measure the effectiveness of PGPSB as fungicide. A similar type of experiment is carried out to test the pesticidal activity of PGPSB using corn rootworms (*Diabrotica virgifera* and *Diabrotica barberi*) as a model system.

Protective effect of PGPSB

It has already been established that plants respond to a variety of different stresses by synthesizing “stress” ethylene. In turn, the ethylene can trigger a stress-senescence response in the plant that may lead to physiological changes in those cells that are at or near the site of the stress. At the same time, association of a PGPSB that contains ACC deaminase with the roots of plants, can lower the concentration of ACC and hence ethylene, which is normally produced during seed germination in the plant. A consequence of lowering the ethylene level within the plant may be a decreased extent of ethylene inhibition of root elongation. In their study, the BSI team monitored the ability of PGPSB to protect seedlings against temperature and drought in growth chambers by assessing root elongation of the treated crops under stress. Both drought and temperature stresses resulted in the synthesis of significant amounts of stress ethylene. For a PGPSB to be effective in cold climates such as Wisconsin, it must be able to survive long cold winters and then grow at cool temperatures in the spring. The PGPSB, *Bacillus globisporus* retained its ability to stimulate root and shoot growth of canola seedlings under day/night temperatures of 25°/5°C (Table 5).

Table 5. Root (a) and shoot (b) growth of canola seedlings protected by PGPSB, *Bacillus globisporus*.

	Root growth			Shoot growth		
	L	FW	DW	L	FW	DW
MgSO ₄	45	6.5	0.52	32.5	12.5	0.55
<i>Bacillus subtilis</i> (Control)	46	6.5	0.51	32.7	12.6	0.58
<i>Bacillus globisporus</i> (PGPSB)	67	7.8	0.86	37.2	14.2	0.68

Root and shoot lengths (*L* in mm), root (Mg. Root $r - 1$), and shoot (mg. Shoot $- 1$) fresh weights, and root and shoot dry weights of canola seedlings following the addition of MgSO₄ (control), *Bacillus subtilis* (no ACC deaminase = control) or *Bacillus globisporus* (PGPSB) to the soil with a daytime temperature of 25°C and a nighttime temperature of 5°C were measured after 10 days of growth. Sterilized seeds of canola were planted in 15-cm pots. Each data point represents 50–60 seedlings.

Economic Impacts of Employing PGPSB Based Fertilizers in Wisconsin

The proposed research has a tremendous potential to lead to the development of a new inoculation technology (production of natural fertilizers/fungicides). In 1992, 43 million tons of fertilizers were used in the US, according to The National Fertilizer and Environmental Research Center. The Wisconsin Statistical Reporting Service stated that in 1993, Wisconsin used a total of 1,143,908 tons of nitrogen and organic fertilizers in bulk, liquid, and bag forms. In 1994, corn producers of US used nitrogen fertilizers on 97 percent of the acres planted, with an average of 157.5 lbs per acre (7,856 million lbs applied nationally). The production of nitrogen fertilizers in the US costs billions of dollars annually, uses more than 30 million barrels of oil, and produces more than 15 million tons of carbon dioxide as well as nitrate and nitrous oxides which pollute the atmosphere and ground water. In 1995, corn and potato farmers of Wisconsin alone applied 1,044,100 lbs of insecticides and 1,000,000 lbs of fungicides. The residual effect of these chemicals on our environment is very detrimental. Thus, replacement of chemically produced organic fertilizers with PGPSB has a great potential in the future of the global economy as well as in protecting the environment. However, the economic and environmental impact of applied research will only be forthcoming if the results are used by its intended group(s) in the society. The key would be in ensuring that farmers can be persuaded to choose natural fertilizers (PGPSB) over organic fertilizers (pollution creators), and use of biocontrols (PGPSB) over chemical control measures (e.g., organic arsenic fungicides).

Recently it has been shown that PGPSB can affect plant growth either directly or indirectly. The direct effects of PGPSB include providing the host plant with: (i) fixed nitrogen, (ii) iron and phosphorus solubilized from the soil and (iii) phytohormones, such as auxins, gibberellins and cytokinins produced by the bacterium, (iv) lower the level of stress ethylene induced by heavy metals such as nickel, and (v) colonize roots to deliver biological fungicides and pesticides to the plant. The indirect promotion of plant growth occurs when

PGPSB reduce or prevent the deleterious effects of one or more phytopathogenic organisms. Phytopathogens can reduce crop yields from 25–100 percent, which is an enormous potential loss of productivity. The loss is currently dealt with by the use of chemical agents, although soil fumigation, steam-treatment, and solarization of soils have also been employed. Many of the chemicals that are used to control fungal and bacterial diseases of plants are hazardous to animals and humans, and persist and accumulate in natural ecosystems. It is therefore desirable to replace these chemical agents with biological approaches that are friendlier to the environment. In addition to these benefits outlined above, the propagation and use of these natural fertilizers will provide an evaluation of PGPSB as a way to improve the growth and development of crop plants, to overcome the loss of crop yield under environmental stresses, and to be used as a field and/or greenhouse inoculant (natural fertilizer and fungicides/pesticides).

Packaging and Pricing

Brian Johnson set off with a clear assignment to resolutely provide all the answers to tough questions that might be posed during the funding campaign. In the informal marketing strategy employed by BSI, a pilot study of these natural fertilizers on several plants was done. They were initially selected for bacilli, tested for antibiosis activity, and then for PGPSB effects. In sterile soil a 50 percent increase in yield was obtained and in non-sterile soil an approximate 15 percent increase was seen. The marketing strategy employed packaging and sale of these fertilizers as microbial pellets rather than the powder form. The reason being that pellets are known to display a longer shelf life (~2 years) than any other form. However a slight disadvantage was that the cost of production of pellets was more than that of the powder form. It was estimated that the pellet form would cost about US\$1.40 to treat one hectare, as opposed to the powder form which would cost US\$1.20, but would have a much shorter shelf life and would also be a nuisance in handling and packaging. However, in any case the natural fertilizers were more expensive than any synthetic fertilizer in use today. For example, the cost of the most popular brand known as

Xylon-A, is US\$1.05 to treat one hectare. However, the big question was that would the more expensive, yet environmental-friendly natural fertilizers be accepted by the market? Would the benefits of such a fertilizer outweigh the high cost of such a product? Most importantly, would BSI staff be able to convince venture capitalist funding agencies about this?

Market Analysis

BSI considered itself to be a highly technical niche player with a specialized product line that was in great demand. Although serving mostly to specific company requests to perform research, once they were able to commercialize the product on a mass scale, their target markets would be the distributors who had established relationships with specialty product firms, and hardware product outlets. BSI would then essentially be considered as the manufacturing arm for these distributors and could provide development services, as well as products for them.

BSI's market was divided into two segments:

Industrial products: In this segment their customers included Bionutritional Inc., Coleman Chemicals, and Chemolite.

Consumer garden products: Handled primarily through distributors.

Bionutritional Inc. was a marketing and chemical broker company. BSI provided product and process development and manufacturing services, and was the agent for PGPSB pellets. BSI felt the potential with Bionutritional Inc. alone was more than \$2 million in sales per year. Coleman Chemical was a chemical broker. BSI processed ion exchange resins and purified specialty chemical fertilizers for them. BSI felt that they could anticipate \$500,000–\$1,000,000 in sales to them per year. Their own sales exceed \$20 million per year. Chemolite Corporation was a manufacturer and distributor of ion exchange resins, and BSI provided both custom and generic manufacturing processes for them. Custom and generic manufacturers are two types of distributors that BSI served. A custom manufacturer provided the materials for BSI to use the formula and processes.

A generic manufacturer provided their own biomaterials and formulation for BSI to mix the product.

BSI felt that the consumer garden market could potentially be their biggest market for PGPSB limited only by their ability to produce. During the trials and marketing analyses conducted by BSI, they had aroused the interest of numerous distributors who were begging for the product and, in fact, this resulted in existing back orders. Hence, Brian thought it was only logical that they should devote most of their time meeting this demand. Clearly the potential in this market is the basis for our growth, felt Brian.

In the Industrial Products segment, BSI was selling both through distributors as well as directly to manufacturers. This was an untapped market and had been sustained by their reputation and ability to meet formulation criteria. Brian also felt that with a focused marketing effort in this segment BSI could produce sales that could quite possibly bring this segment to an equal level with the consumer market. Table 6 highlights the number of potential customers that BSI would be able to target with their products and technology.

Industry Analysis

The chemical industry is characterized by a wide variety of companies ranging in size from large companies such as DuPont and Monsanto to smaller specialty firms such as BSI. Generally, the companies are

Table 6. BSI market analysis.

Potential customers	Market analysis						CAGR* (%)
	Growth	1997	1998	1999	2000	2001	
Commercial	10%	75,000	52,500	57,750	63,525	69,878	-1.75
Consumer	22%	125,000	152,500	186,050	226,981	276,917	22.00
Custom research	4%	35,000	36,400	37,856	39,370	40,945	4.00
Total	13.34%	235,000	241,400	281,656	329,876	387,740	13.34%

*CAGR = Cumulative annual growth rate.

organized by either end-use markets or by product technology. In the past decade there has been a general trend in the industry to change emphasis from chemicals to biotechnology and pharmaceuticals. The cost of product development and the need to operate factories at high levels of capacity had caused chemical companies of every size to out-source parts of the chemical and manufacturing processes. This has created opportunities for smaller companies to create and occupy niches in development and contract manufacturing. BSI wanted to seize on this opportunity in a market that was fertile with a lot of companies with less convincing business plans securing funding.

Competition

In the mainstream business, channels are critical to volume. Manufacturers and distributors with an impact in the chemical market desperately needed specialty manufacturers like BSI to meet the demand. There were many specialty manufacturers, all of whom seemed to have carved out a specific niche of expertise, and upon whom these major manufacturers depended for their products. In competition, it seemed that the line was drawn at the level of expertise and experience of the specialty manufacturer and also depended on the quality performance. Brian Johnson was convinced that they had achieved that level and would be recognized for a high standard of quality performance. Companies, who seemed to be their competition, had subcontracted production to them because they did not have the ability to achieve that level of quality.

Alex Roy highlighted in the prospectus: “We have achieved another milestone in the industry by developing certain formulations which we estimate would cost another firm \$450,000 to duplicate. The PGPSB pellet formulation and process is one of them. We have the only process in the world that can produce this supplement in pellet form. It is extremely important that we seize this opportunity and begin to exclusively market this product.”

Said Alex: “Our competitive edge is in the formulations and manufacturing processes we have developed for the production of the two products in which we specialize. As detailed above, we are in an excellent position to capture a significant part of the \$300 million PGPSB

market. We simply need to establish a marketing program and begin to promote our capability.”

Sales Forecast

BSI projected their sales forecast to assume no significant change in costs or prices, which was a reasonable assumption for the past two years. However, in order to meet the increased cost of manufacturing the product, the team felt that not only the price of the product would need to be inflated but also the opportunity to serve newer markets and target a larger customer base would be the right thing to do. “After all, that is our grand vision to move from pesticides and fungicides to more of the biotech and pharmaceutical segments”, argued Brian.

BSI sales were \$187,521 in 1994, \$241,782 in 1995, and \$269,507 in 1996. Both Alex and Brian felt that with a good marketing program and adequate manufacturing facilities they could achieve a sales goal of \$2.2 million in 1997 and over \$2.6 million in 1998. While this seemed ambitious, both of them privately hoped that BSI could rely on their distributors’ projections and based on that, they would be able to literally sell to the production capacity of their manufacturing facilities.

As much as the opportunity to secure significant funding was desirable, Alex and Brian were not sure if they would be able to convince the venture capital firm about the leap in prospects with such an aggressive plan depicted in Table 7.

Approach for Funding

Stating that the objectives of this business plan was for sales to exceed \$3 million by 2003, with a gross margin of 50 percent or more and net profits of over 16, Alex and Brian decided to approach the VC firm for a funding of \$3 million.

Alex decided to open discussions with the venture capital firm of Caulfield and Byers with the following opening statements: “Our distributors and our customers have given us an opportunity to provide

Table 7. BSI profit and loss margin.

	Pro forma profit and loss		
	1997	1998	1999
Sales	\$2,217,375	\$2,653,800	\$3,450,000
Direct cost of sales	\$975,445	\$928,830	\$1,207,500
Other	\$0	\$0	\$0
Total cost of sales	\$975,445	\$928,830	\$1,207,500
Gross margin	\$1,241,930	\$1,724,970	\$2,242,500
Gross margin %	56.01%	65.00%	65.00%
Operating expenses:			
Advertising/promotion	\$75,000	\$75,000	\$0
Travel	\$1,500	\$0	\$0
Miscellaneous	\$21,300	\$24,000	\$24,000
Payroll expense	\$229,026	\$250,000	\$310,000
Payroll burden	\$34,354	\$37,500	\$46,500
Depreciation	\$305,001	\$344,994	\$0
Leased equipment	\$11,172	\$25,000	\$25,000
Utilities	\$12,000	\$15,000	\$18,000
Insurance	\$3,545	\$5,000	\$0
Rent	\$29,400	\$30,000	\$30,000
Contract/consultants	\$7,000	\$5,000	\$5,000
Total operating expenses	\$729,298	\$811,494	\$458,500
Profit before interest and taxes	\$512,632	\$913,476	\$1,784,000
Interest expense short-term	(\$1,896)	(\$7,021)	(\$12,021)
Interest expense long-term	\$35,705	\$41,455	\$47,455
Taxes incurred	\$119,706	\$219,760	\$437,141
Extraordinary items	\$0	\$0	\$0
Net profit	\$359,117	\$659,281	\$1,311,424
Net profit/sales	16.20%	24.84%	38.01%

products beyond our present capability. We need to add equipment, increase our inventory, and establish marketing and support activities. We are seeking adequate capital to enable us to expand our operation and become a major factor in the production of chemicals in the

industrial, consumer, and biotech products in the future. Our signature product is PGPSB pellets; we manufacture both the pellet form and the powder and liquid forms if necessary in the future. We are the only company in the world capable of manufacturing this product in liquid form. Our market research shows that the demand for this product alone justifies the expansion of our facilities.”

Now, Alex and Brian also had to make the tough decisions. Firstly, they had to make sure they had answers to all questions that Caufield and Byers might pose about the future prospects of the firm. How much of the firm should they give away? Was there anything about the business plan that they had not thought of? Alex was clearly eager to conclude a deal successfully with the VC firm and begin to expand BSI operations.

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Implementing ISO 22000 Standards to Enhance Safety in Food Supply Chains¹

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Problem Overview

Each year, 76 million people in the United States fall sick due to contaminated food. Common culprits include bacteria, parasites and viruses. Symptoms range from mild to serious. Harmful bacteria are the most common cause of foodborne illness. Foods may have some bacteria on them when you buy them. Raw meat may become contaminated

¹ This case was prepared by Professors Alina Matuszak Flejszman of Quality Economics Department, Poznań Academy of Economics and Tom Bramorski of the Department of Management at the University of Wisconsin-Whitewater for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the author or be reproduced in any way.

during slaughter. Fruits and vegetables may become contaminated when they are growing or when they are processed. Contamination can also occur during food preparation if the consumer leaves food out for more than two hours at room temperature.² Clearly, ensuring food supply chain safety is an issue of critical importance for all supply chain entities including farmers, food producers, distributors, and consumers.

Several potential sources of food contamination have been identified and studied in the literature. For example, Handley³ investigated the sources of an outbreak of lead poisoning in Monterey County, California, to identify risk factors for elevated blood lead levels (≥ 10 microg/dL) among children and pregnant women. The prevalence of elevated blood lead levels was significantly higher in one of the three clinics (6 percent among screened children and 13 percent among prenatal patients). Risk factors included eating imported foods (relative risk (RR) = 3.4; 95 percent confidence interval (CI) = 1.2, 9.5) and having originated from the Zimatlan area of Oaxaca, Mexico, compared with other areas of Oaxaca (RR = 4.0; 95percent CI = 1.7, 9.5). Home-prepared dried grasshoppers (chapulines) sent from Oaxaca were found to contain significant amounts of lead. Consumption of foods imported from Oaxaca region was identified as a risk factor for elevated blood lead levels in Monterey County, California. Lead-contaminated imported chapulines were identified as a source of lead poisoning. The authors concluded that food transport between bi-national communities presents a unique risk for the safety of imported food.

Namkung⁴ examined the length of time between packing and delivery of home-delivered meals and the extent of foodborne illness risk to the elderly. Procedures to mitigate that risk were also evaluated. Researchers surveyed 95 drivers from home-delivered meal

² Source: <http://www.nlm.nih.gov/medlineplus/foodcontaminationandpoisoning.html>.

³ Handley, MA *et al.* (2007). Globalization, binational communities, and imported food risks: results of an outbreak investigation of lead poisoning in Monterey County, California. *American Journal of Public Health*, 97(5), 900–906.

⁴ Namkung, Y *et al.* (2007). Mitigating the risk of food handling in the home-delivered meal program. *Journal of the American Dietetic Association*, 107(2), 316–320.

preparation sites in six states across the United States to determine the average length of time that passed during packing, loading, leaving, and delivery. The efficiency of various risk mitigation methods were evaluated and used to adjust the actual delivery time. Total average delivery time from packing to last delivery was 1.92 hours. This study suggested that the risk associated with the actual 1.92 hours of total delivery time could be mitigated to represent approximately 1.55 hours of effective time with proper packing and holding conditions. Their research methodology proposed a single measure for evaluating the effectiveness of various handling procedures associated with distributing home-delivered meals, which can be utilized to evaluate overall risk when combined with in-house preparation and client-handling behaviors.

Health Day News⁵ recently reported that melamine was found in fish designated for human consumption. After finding its way to America's dinner tables via pork and chicken, the melamine contaminant in recalled pet food may have also been fed to farmed fish, federal health officials announced. Levels of melamine in the fish were probably far too small to affect human health, stressed officials at the US Food and Drug Administration and the US Department of Agriculture. The FDA has so far not disclosed which fish farms received the contaminated food, or how many fish, of what type, may have eaten it. It is also not clear how much of the potentially tainted fish, if any, has made it to supermarkets. "We have discovered that the wheat gluten and rice protein was mislabeled," the FDA officials said. Some of the mislabeled wheat flour was shipped first to Canada and then to the United States as fish meal used to feed commercially raised fish, Acheson said. Melamine contamination is the prime reason for the massive recall of more than 100 name brands of pet foods in the last two months, following reports of pet illnesses and deaths from liver failure. Some 2.7 million chicken and 345 hogs have also since been identified as having consumed tainted

⁵ Anonymous (2007). Farmed fish ate melamine: FDA. It's not clear how much, if any, contaminated stock made it to stores. *HealthDay*, Tuesday, May 8. http://www.nlm.nih.gov/medlineplus/news/fullstory_48965.html.

pet food as part of their feed. Most of the meat from those animals has already been sold to and eaten by Americans nationwide, health officials say. "We believe the likelihood of a human illness from melamine is unlikely." To date, FDA has only ever confirmed the deaths of 16 pets from contaminated food since the recall began in March 16. But the agency has acknowledged that pet owners have reported the deaths of about 1,950 cats and 2,200 dogs. It is not known how many of those were linked to the recalled pet food.

Finally, Crutchey⁶ studied the US agricultural infrastructure characteristics that make it extremely vulnerable to a terrorist attack by a biological weapon. Several experts have repeatedly stated that taking advantage of these vulnerabilities would not require a significant undertaking and that the nation's agricultural infrastructure remains highly vulnerable. As a result of continuing criticism, many initiatives at all levels of government and within the private sector have been undertaken to improve our ability to detect and respond to an agroterrorist attack. However, outbreaks, such as the 1999 West Nile outbreak, the 2001 anthrax attacks, the 2003 monkey pox outbreak, and the 2004 *Escherichia coli* O157:H7 outbreak, have demonstrated the need for improvements in the areas of communication, emergency response and surveillance efforts, and education for all levels of government, the agricultural community, and the private sector. The researchers recommended establishing an interdisciplinary advisory group that consists of experts from public health, human health, and animal health communities to prioritize improvement efforts in these areas. The primary objective of this group would include establishing communication, surveillance, and education benchmarks to determine current weaknesses in preparedness and activities designed to mitigate weaknesses. They also recommend broader utilization of current food and agricultural preparedness guidelines, such as those developed by the US Department of Agriculture and the US Food and Drug Administration to make the food chain more secure.

⁶ Crutchey, TM *et al.* (2007). Agroterrorism: Where are we in the ongoing war on terrorism? *Journal of Food Protection*, 70(3), 791–804.

In this case, we present the application of a HACCP⁷ system as a preventive tool used to monitor the food production process and assist in preventing food contamination. The approach presented here is a compendium of best practices implemented since 2000 by food processing businesses in Poland. It can be adopted comprehensively by multiple organizations in the food supply chain to ensure food safety.

The Components of ISO 22000

Entities operating in the food market have a legal responsibility for the safety of food in the processes of production and distribution. It is necessary for these organizations to develop and continuously improve the capability to monitor sources of potential threats to food. This focus is mandated by legislation and is administered by agencies such as Food and Drug Administration (FDA), United States Department of Agriculture (USDA), and the European Union.⁸ In Europe, for example, the foundation for addressing food hygiene and safety are provided in directive (WE) No. 852/2004 amended on 1 January 2006. The four new mandatory directives include:

1. Directive No. 852/2004 regarding general principles of food hygiene,
2. Directive No. 853/2004 regarding general principles of handling food from animals designated for human consumption,
3. Directive No. 854/2004 regarding conformance control of food from animals designated for human consumption,
4. Directive No. 882/2004 regarding conformance control of animal food and general principles of handling animals.

⁷ HACCP — Hazard Analysis and Critical Control Point.

⁸ For example, the European Food Code is based on uniform international food standards. It covers all categories of food products (unprocessed, semi-processed, and fully processed). The code has been created by the Food Code Commission of FAO/WHO and its subunits. It includes advisory directives and best practices applicable to the food industry.

These directives create a basis for food safety system based on the principles of HACCP and articulate preconditions for a comprehensive and successful implementation of a system. The documentation presents specific infrastructural requirements including buildings, transportation, equipment, water supply, waste treatment, personnel hygiene, packing and storage, processing and treatment, as well as personnel training. The legal system is somewhat flexible in that it allows exemption of certain facilities from the provisions of HACCP. In such cases, Good Hygienic Practices/Good Manufacturing Practices (GHP/GMP) can be substituted. In all cases, all practices and amendments must be appropriately documented to assure traceability.

Since it simplifies the legal environment for businesses operating in the food supply chain, the establishment of a uniform code aimed at protecting public health is clearly desirable. On the other hand, incompatible and often contradictory legacy systems in various countries make efficient operation in international markets difficult. One way to achieve uniformity of the legal code and to provide a similar level of protection to consumers is to base the HACCP system development and implementation on a common platform reducing the system complexity and improving its transparency. The sample documents encompassing some of today's leading practices include:

1. The Food Code Codes Alimentarius — FAO/WHO (The Roman Code);
2. DS 3027 E:2002 Management of Food safety based on HACCP — Requirements for food producing organizations and their suppliers (Danish standard);
3. Requirements for a HACCP based Food Safety System (Dutch standard);
4. DIN 10503:2000 — The Principles of Food Hygiene (German standard);
5. IS 343 Food Safety Management Mark (Irish standard);
6. HB 90.5 Correlation between ISO 9001:2000 and the HACCP Principles (Australian standard).

A uniform food safety system integrating the concepts of ISO 9001:2000 international quality standards with HACCP has been proposed by the ISO/TC-34 technical committee in 2001. Food industry representatives from 23 countries participated in the development of the standard that was approved on ISO 22000:2005. The food safety management system standard identifies specific requirements that must be met by any organization in the food supply chain. Since its adoption, it has been amended by the following supplementary standards from the ISO 22000 family:

1. ISO/TS 22004:2005, Food safety management systems — Guidance on the application of ISO 22000:2005. This standard contains general requirements outlining the applicability of ISO 22000:2005 with implementation guidelines for small- and medium-size enterprises in the food business. It includes specifics regarding interpretation of the standard requirements, which are based on industry best practices in food safety. Most importantly, it includes practical examples of how to meet most requirements of ISO 22000:2005. As it outlines all phases of system design, evaluation, implementation, and improvement, the standard is a useful reference for an organization having to address food safety issues.
2. ISO/TS 22003, Food safety management systems — Requirements for bodies providing audit and certification of food safety management systems. This standard contains standardized directives dealing with accreditation of organizations certifying the food safety management system to the requirements of ISO 22000. It reviews specific procedures regarding system certification and auditing processes.
3. ISO 22005, Traceability in the feed and food chain — General principles and guidance for system design and development. This standard outlines general requirements regarding traceability in a food supply chain and specifies appropriate documentation requirements regarding food product or component origin. In conjunction with the standards outlined in items (1) and (2) above, it serves as a guide to designing and implementing a robust

food chain safety system. It has been designed to assist all organizations in food supply and distribution chains as well as consumers.

The Operation of ISO 22000

The standard defines food chain as a sequence of interrelated stages and actions dealing with production, transformation, distribution, storage and handling of food products, and components covering all stages from farming to consumption. A primary objective of ISO 22000:2005 is to ensure proper identification and improvement of critical elements leading to food safety being compromised. Such critical elements can occur at any stage in the supply chain irrespective of its size or process complexity, for example, in production of animal food and materials that have direct contact with food or food components. Consequently, its provisions affect farmers and growers, makers of packaging materials, wholesalers, and retailers. Hence, it is important to create a system to effectively control food contamination hazards and to ensure close collaboration between all entities in the supply, production, and distribution chains.

The following are general TQM-based principles of the ISO 22000 standard. Organizations operating in a specific segment should further amend these principles to address their specific requirements.

1. Establishing and maintaining effective multi-channel communication, including access to information on product design, production and storage in areas affecting food safety. This also requires that an organization communicate with its suppliers and customers.
2. Developing and deploying a system of training on food safety procedures for employees at all levels.
3. Adopting a system approach to management, requiring active involvement of top management in identifying, resolving and preventing the sources of threats to food safety.
4. Utilizing the principles of HACCP in order to identify critical control points (CCPs) in processes and determine appropriate approaches to manage them.

5. Identifying and utilizing other measures to control developments not directly addressed by HACCP.

The ISO 22000 standard lists seven requirements necessary to ensure an uninterrupted flow of safe finished food products to the market. These requirements include:

1. Determining a list of threats and analyzing them to assess a probability of occurrence in the production process.
2. Identifying product- and process-specific CCPs.
3. Determining the critical values for each CCP identified in item (2) above.
4. Developing and implementing a system of data-monitoring of each CCP.
5. Determining appropriate corrective action for each hazard class.
6. Developing appropriate documentation needed to verify the status of the HACCP system. This item also requires determining the type of data to be collected from processes and the means to store the data to ensure efficient CCP management.
7. Developing a documentation and data-storage system required by HACCP.

Clearly, the ISO 22000 and the HACCP system share similar philosophies, implementation goals and means. Hence, organizations wanting to develop a food safety system will find it useful to utilize the best approaches derived from both. Exhibit 1 shows the 12 stages used in implementing the HACCP system in food businesses and their relationship to the elements of the ISO 22000 standard.

Exhibit 1 demonstrates that all steps necessary in the implementation of the HACCP system in food industry are also reflected in the ISO 22000 standard. Special consideration to the issue of securing safety of food products is expressed in Items 4 and 7. We also observe many similarities between the requirements discussed above and the stipulations of the ISO 9001:2000 standard. The general quality system requirements expressed in ISO 9001:2000 have been amended in ISO 22000 to meet the specific requirements of the food business.

Exhibit 1. The mapping of HACCP system requirements and the elements of ISO 22000.

Principle	HACCP		ISO 22000:2005	
	Step	Description	Section	Description
1. Perform the analysis of threats	1	Establish the HACCP team	7.3.2	Establish the food safety team
	2	Define product characteristics	7.3.3	Define product characteristics
			7.3.5.2	Describe process stages and control methods
	3	Define intended use	7.3.4	Define intended use
	4	Develop production process diagram	7.3.5.1	Prepare flow diagrams
	5	Verify production process diagram		
	6	Determine, evaluate and analyze potential threats	7.4	Conduct the analysis of threats
			7.4.2	Identify threats and determine their acceptable levels
			7.4.3	Evaluate threats
			7.4.4	Select and evaluate control methods
2. Identify critical control points (CCPs)	7	Identify critical control points (CCPs)	7.6.2	Identify critical control points (CCPs)
3. Determine critical limits for CCPs	8	Determine critical limits for CCPs	7.6.3	Determine critical limits for CCPs
4. Design a system for monitoring CCPs	9	Design a system for monitoring CCPs	7.6.4	Design a system for monitoring CCPs

(Continued)

Exhibit 1. (*Continued*)

Principle	HACCP		ISO 22000:2005	
	Step	Description	Section	Description
5. Define corrective actions to be taken when critical limits have been exceeded	10	Determine corrective action	7.6.5	Define actions to be taken when critical limits have been exceeded
6. Define verification procedures to confirm the HACCP system operational effectiveness	11	Establish verification procedures	7.8	Implement verification planning
7. Establish documentation system for maintenance of procedures and data including determination of their scope	12	Establish documentation requirements and data/documents-storage methods	4.2	Define documentation requirements
			7.7	Establish information and program documentation updating procedures for pilot programs and the HACCP plan

Source: ISO 22000:2005 Standard, Appendix B.

Hence, organizations wanting to develop a food safety system will find it useful to utilize the general and specific approaches described in both standards. Exhibit 2 shows important linkages between ISO 22000:2005 and ISO 9001:2000 standards.

Exhibit 2 demonstrates that the two standards consist of eight highly compatible building blocks (shown in *italics*). In many instances the requirements stated in both standards are practically identical. This similarity is apparent in the areas related to documentation

Exhibit 2. The correspondence of ISO 22000:2005 and ISO 9001:2000 procedures.

ISO 22000:2005		ISO 9001:2000	
Section	Description	Section	Description
	<i>Introduction</i>	0	<i>Introduction</i>
		01	General provisions
		02	Process orientation
		03	Linkage with ISO 9004
		04	Compatibility with other management systems
1	<i>Scope</i>	1	<i>Scope</i>
		1.1	General provisions
		1.2	Applicability
2	<i>Related standards</i>	2	<i>Related standards</i>
3	<i>Definitions and terminology</i>	3	<i>Definitions and terminology</i>
4	<i>Food safety management system</i>	4	<i>Quality management system</i>
4.1	General requirements	4.1	General requirements
4.2	Documentation requirements	4.2	Documentation requirements
4.2.1	General requirements	4.2.1	General requirements
4.2.2	Document control	4.2.3	Document control
4.2.3	Control of updates	4.2.4	Control of updates
5	<i>Management responsibility</i>	5	<i>Management responsibility</i>
5.1	Management involvement	5.1	Management involvement
5.2	Food safety policy	5.3	Quality policy
5.3	Food safety management system planning	5.4.2	Quality management system planning
5.4	Rights and responsibilities	5.5.1	Rights and responsibilities
5.5	Food safety team leader	5.5.2	Management representative
5.6	Communication	5.5	Rights, responsibilities, and communication
5.6.1	External communication	7.2.1	Determine product requirements
		7.2.3	Communication with customers

(Continued)

Exhibit 2. (*Continued*)

ISO 22000:2005		ISO 9001:2000	
Section	Description	Section	Description
5.6.2	Internal communication	5.5.3	Internal communication
		7.3.7	Management of changes in design and development
5.7	Readiness and response to breakdowns	5.2	Customer orientation
5.8	Management review	8.5.3	Preventive action
5.8.1	General requirements	5.6	Management review
5.8.2	Input to review	5.6.1	General requirements
5.8.3	Output from review	5.6.2	Input to review
		5.6.3	Output from review
6	<i>Resource management</i>	6	<i>Resource management</i>
6.1	Provision of resources	6.1	Provision of resources
6.2	Human resources	6.2	Human resources
6.2.1	General requirements	6.2.1	General requirements
6.2.2	Capabilities, attitude, and training	6.2.2	Capabilities, attitude, and training
6.3	Infrastructure	6.3	Infrastructure
6.4	Work environment	6.4	Work environment
7	<i>Planning and producing safe products</i>	7	<i>The production process</i>
7.1	General requirements	7.1	Production process planning
7.2	Pilot programs (PRPs)	6.3	Infrastructure
7.2.1		6.4	Work environment
7.2.2		7.5.1	Production and service process management
7.2.3		8.5.3	Preventive action
		7.5.5	Product safety
7.3	Preliminary actions to enable analysis of threats	7.3	Design and development
7.3.1	General requirements		
7.3.2	Food safety team		
7.3.3	Product characteristics	7.4.2	Purchase data
7.3.4	Intended use	7.2.1	Determining product requirements

(*Continued*)

Exhibit 2. (*Continued*)

ISO 22000:2005		ISO 9001:2000	
Section	Description	Section	Description
7.3.5	Flow diagrams, process stages, and control methods	7.2.1	Determining product requirements
7.4	Analysis of threats	7.3.1	Design and development planning
7.4.1	General requirements		
7.4.2	Identification of threats and determination of acceptable limits		
7.4.3	Evaluation of threats		
7.4.4	Selection and evaluation of control measures		
7.5	Establishment of pilot programs (PRPs)	7.3.2	Input to design and development
7.6	Establishment of the HACCP plan	7.3.3	Output from design and development
7.6.1	The HACCP plan	7.5.1	Production and service process management
7.6.2	Identification of critical control points (CCPs)		
7.6.3	Determine critical limits for CCPs		
7.6.4	A system for monitoring CCPs	8.2.3	Monitoring and process measurement
7.6.5	Actions to be taken when critical limits have been exceeded	8.3	Management of nonconforming products
7.7	Updating information and documents for pilot programs and the HACCP plan	4.2.3	Document control
7.8	Verification planning	7.3.5	Design and development planning verification
7.9	The traceability system	7.5.3	Identification and traceability

(Continued)

Exhibit 2. (*Continued*)

ISO 22000:2005		ISO 9001:2000	
Section	Description	Section	Description
7.10	Management of nonconformities	8.3	Management of nonconforming products
7.10.1	Corrections	8.3	Management of nonconforming products
7.10.2	Corrective action	8.5.2	Corrective action
7.10.3	Treatment of potentially hazardous materials	8.3	Management of nonconforming products
7.10.4	Recall	8.3	Management of nonconforming products
8	<i>Validation, verification, and improvement of food safety management system</i>	8	<i>Data collection, analysis, and improvement</i>
8.1	General requirements	8.1	General requirements
8.2	Validation of control measures	8.4	Data analysis
		7.3.6	Design and development validation
		7.5.2	Production process and service delivery validation
8.3	Management of data collection and monitoring	7.6	Management of data collection and monitoring equipment
8.4	Food safety system management and verification	8.2	Data collection and monitoring
8.4.1	Internal audit	8.2.2	Internal audit
8.4.2	Evaluation of outcomes	8.2.3	Process data collection and monitoring
8.4.3	Evaluation of verification action outcomes	8.4	Data analysis

(*Continued*)

Exhibit 2. (*Continued*)

ISO 22000:2005		ISO 9001:2000	
Section	Description	Section	Description
8.5	Development	8.5	Continuous improvement
8.5.1	Continuous improvement	8.5.1	Development
8.5.2	Food safety management system updating	7.3.4	Design and development review

Source: ISO 22000:2005 Standard, Appendix A.

requirements, management involvement, policies and procedures, communication, management review, resource management and system improvement.

The Benefits from Implementing HACCP

Food supply chain businesses derive multiple tangible benefits from implementing the HACCP system. In view of the ISO 22000:2005 standard, the HACCP system significantly improves overall level of food safety. It helps businesses meet diverse legal requirements related to food safety. It helps focus organizational resources on areas that are critical to efficient and safe operation of the food supply chain. This results in a higher level of consumer confidence and leads to increased market share and sales revenue.

Standardizing and improving system documentation reduces time and cost involved in documentation maintenance and also is a significant benefit from implementing the HACCP system. The system requires all employees to use standard documents available on demand in the business database system. Experience has shown that proliferation of documents often serving the same purpose is a major obstacle to achieving cost and cycle time reductions.

The system requires production personnel to become active in monitoring and controlling quality level and safety of food products. This, in turn, necessitates the development of a system of continuous employee

training to reinforce their pivotal role in organizations. Frequently the caliber and the involvement of rank and file employees are the sources of competitive advantage of a business in a competitive market. Training facilitates the alignment of employee personal goals and strategies with the organization's strategic goals defined in the quality manual of the business. For example, as noted by Góralczyk *et al.*, the alignment of goals improves food product quality in a significant and permanent way resulting in improving customer satisfaction and solidifying the brand's position in the market.⁹ Food businesses that implemented the safety system have been able to significantly reduce both the number of nonconformities in the production process (internal failure costs) and the number of product returns (external failure costs). The reductions in both costs resulted in increasing the firm's profitability. This observation applies both to measurable costs, including handling of returned or nonconforming products, and nonmeasurable costs, such as a loss of customer goodwill and deterioration of the firm's image in the market.

In order to be effective, the implementation of the food safety system must be comprehensive. One important system element that should not be disregarded is sound management and periodic calibration of measuring and control equipment. Investments in these areas result in improving resource capabilities and product quality.

Implementing HACCP according to ISO 22000 requirements to meet the preliminary conditions of HACCP, such as improving roads, also improves operation of the company infrastructure, including warehousing and logistics, better worker safety (e.g., providing protective clothing for employees). Well-maintained machines and equipment are less likely to injure operators, break down, and/or produce nonconforming products. This produces internal efficiencies and reduces operational costs. As demonstrated in Wysokińska,¹⁰ the presence of a well-designed and systematically maintained HACCP food safety

⁹ Góralczyk, M *et al.* (2006). Case studies in quality of food products determines consumption levels. *The Issues of Quality* (11), 44–46 (in Polish).

¹⁰ Wysokińska-Senkus, A (2006). Best quality management practices in milk production businesses. *The Issues of Quality*, (5), 26–28 (in Polish).

system also improves company image and creates opportunities to expand market share and charge a premium price. We note that in the food business being certified to ISO 22000 is becoming an order-qualifier rather than an order-winner. This requirement is particularly important for wholesalers and large retail chains. Therefore, having a third-party certified food safety system is quickly becoming a prerequisite for market presence.

External benefits from having a food safety system include improved relations with government agencies, such as Sanitary Inspection and the Department of Agriculture, that have been charged with the responsibility monitoring safety and quality of food products. A fact that an organization is certified to ISO 22000 improves confidence and reduces first-party government audits resulting in additional cost reductions.

Summary

The following problems and issues need to be considered in the case discussion:

- What are the similarities and differences between ISO 9001:2000 and ISO 22000:2005 standards? Why are general provisions of ISO 9001:2000 insufficient to ensure food safety?
- What are the building blocks of the HACCP food safety system?
- How effective is the HACCP food safety system based on ISO 22000 standard?
- How expensive and how time-consuming is the HACCP system development and implementation? Is it worth for a food business to incur this cost?
- Based on the information in the case design a skeleton HACCP system for a producer of orange juice. Address all applicable areas required by the standard.

SH a.s.: A Company in Search of its Market Options¹

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The transition in Central Europe has left a number of companies in a major quandary. Many of these firms had a long history of successful

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manufacturing before the previous regime nationalized them and removed their competitive effectiveness in their domestic as well as in foreign markets. With the onslaught of the Communist regime in Czechoslovakia in 1948, for example, their products, technology, and even physical resources were literally frozen in time. All manufacturing firms were forced to change their sales and marketing strategy to fit the restrictive mandates of the centralized planning system. Since their domestic market was closed to most outside sources of information, many of these firms were unable to keep up with the technological improvements emerging in foreign environments.

Although some of the manufacturing firms in Central Europe experienced major revitalization after the demise of Communism in late 1989, few firms have managed to fully recover from years of neglect and mismanagement. The waves of privatization, restoration to their original owners, and, in some cases, sales to major global corporations have not assured their future success. The recent privatization in the Central European countries was a traumatic experience for most state-owned firms. Legal, political and financial manipulations by the state, groups of individuals, or individuals challenged ownership rights and privileges. Government officials as well as the public frequently questioned management's involvement in privatization efforts. Outside interference in the privatization process, especially in Czechoslovakia, was substantial. Some firms were successfully privatized and managed to become viable players in the marketplace.

After privatization, some of these firms attempted to restructure, reorganize, and downsize with marginal results. A number of firms succeeded despite enormous odds. Ten years later, with the influx of major doses of foreign capital, some firms have become very successful growing and expanding firms in Central Europe. The notable examples are Skoda, the Czech auto manufacturer owned by Volkswagen, Tungsram, the Hungarian light bulb manufacturer owned by General Electric, and Ceské Cokoladovny, the Czech chocolate manufacturer owned by Tobler Chocolate Company.

The problem with many manufacturing firms in Central Europe, in most cases, stems from a lack of the necessary capital needed to

modernize operations, over employment, and in many cases, obsolete technology. The new management can usually cope with the day-to-day operational problems, the constraints that the new political system places on managers, and even the new types of business relationships that require new approaches to financing sales and distribution. In the short-term, many of these firms remain optimistic; however, their future is uncertain in the medium or long-term.

The need for extensive research and development efforts is extensive. Management education and training is needed at all management levels in order for them to successfully compete in the expanding global economy. An ability to collect and process information effectively needs to be developed and implemented rapidly just to keep up with the latest developments in processing and using information for decision making in Europe and the rest of the world.

SH a.s. is an excellent example of a firm with the dilemmas described above. SH a.s. has a strong will to grow and to expand its operations into foreign markets. It has strong management. Its technology is highly specialized and intended for a unique market. Yet, it is experiencing major self-identity problems combined with a serious lack of resources needed for major expansion into viable markets. Some of its domestic clients also face an uncertain future. Expansion into foreign markets requires great managerial and technical resources, improvements in quality, ISO certification, and memberships in industrial networks in Europe and North America. All three of its product lines need careful examination and technological assessment in the form of benchmarking to determine SH a.s.' market position.

The following facts are presented, in the context of the above framework, from the point of view of an outside analyst who understands: (1) the external business environment in which SH a.s. functions, (2) market changes taking place in the Czech Republic, and (3) the nature of global competition for the types of product and services SH a.s. offers. The objective is to evaluate all the facts presented and recommend what strategic course of action SH a.s. should take in the future. SH a.s.'s top management believes that the future lies in both market development and technological improvements.

Company's History

SH a.s. has a long and rich history as a company. It was established in 1925 as a subsidiary of Louis Friedman, Incorporated, located in Vienna, Austria. Louis Friedman, Incorporated, specialized in engineering and manufacturing of lubricating systems. Initially, the subsidiary that is now SH a.s., located near Brno in the Czech Republic, started out as a supplier of component parts for the parent company. Only four years later, in 1929, the subsidiary was engineering and manufacturing lubricating pumps and injectors of its own.

Ten years later, in 1939, the firm employed 120 employees and began to manufacture bearings and railroad car couplings, among other railroad related components. During the war period from 1939 to 1945, production was modified to produce a variety of hydraulic valves for military applications, including submarines.

In 1948, the company was nationalized and its engineering and manufacturing resources were refocused on railroad applications. The manufacture of heating systems for railroad cars was introduced along with other products used in railroad car manufacturing. However, the manufacture of centralized grease lubricating systems was also restarted and hydraulic technology became an integral part of the manufacturing process during this time. After 1948, the company was formally known as ZTS Juranovy Závody Brno.

Several changes took place between 1948 and 1990 when ZTS Juranovy Závody Brno operated as a state-owned company. The manufacture of the centralized grease lubricating systems was substantially expanded in 1961 and serial production of hydraulic pumps, pumping stations, hydraulic piston type motors, and hydraulic distributors was introduced in 1970.

Major capital investments were made in the physical facilities in 1976. Production facilities for manufacture of hydraulic components were substantially expanded. Internally designed hydraulic radial piston type motors were put into production. During this period, military applications were introduced, especially a line of hydraulic motors and distributors. A major expansion took place over the ten-year period from 1980 and 1990. The production of centralized grease

lubricating systems was substantially expanded. A newly introduced R&D effort resulted in the design, development and production of lubrication equipment reflecting a wide field of applications. One important innovation was a progressive distribution lubrication system. During this period, as a legal Czechoslovak monopoly, the company specialized in producing systems for heavy equipment manufacturing industries, steel making, and mining.

A new era for the firm came in 1987 when it negotiated a licensing agreement with a French firm, Poclain Hydraulics, for the manufacture of radial piston hydraulic motors and components. Under this agreement, ZTS Juranovy Závody was licensed to manufacture components for the French firm and represent it in the Czechoslovak market. In 1990, however, ZTS Juranovy Závody began to actually manufacture a radial piston hydraulic motor model G4 type S02.

A major transformation came in 1992, when ZTS Juranovy Závody was privatized under the Czechoslovak privatization program. ZTS Juranovy Závody was subdivided into two parts and each was privatized separately. One part was sold directly to Poclain Hydraulics, the French licensor for ZTS Juranovy Závody. This part contained the original agreement previously negotiated in 1987. The other part, which included the production of all kinds of lubrication equipment and technology for the commercial and military markets, was privatized by a direct sale to BSH s.r.o., a Czechoslovak firm representing a group of domestic investors. This part of the firms started its commercial activities under the SH a.s. corporate name.

The resulting activities of SH a.s. have not been very successful. A reduction in military orders combined with assumed obligations from the previous company pre-dating privatization resulted in major financial problems. By 1995, the original holding company was no longer able to carry the financial obligations and a new holding company, SH a.s., was established. Under this new ownership, SH a.s. was reorganized and its financial obligations were restructured. In 1997, the company was completely restructured, reducing its fixed and variable costs combined with a systematic restructuring of remaining debts. As part of the restructuring, a separate entity, SH a.s., was established to manufacture and market the centralized grease lubrication

systems and light hydraulic units. This entity represents about one third of the total production of SH a.s. The following two years, 1998 and 1999, were considered to be successful in terms of total output.

In June 1999, SH a.s. employed approximately 168 employees. The employees can be classified as follows: 110 employees are considered to be hourly employees, 49 represent technical management, and nine represent maintenance and housekeeping. The average employee has been on the job an average of 16.5 years with SH a.s.² The workforce is generally well educated and trained in their respective trades. The general unemployment in the area is below the national average, and consequently, the employees tend to be well compensated. Salaries are relatively stable.

Products

Three lines of products and services are currently offered: (1) heavy hydraulics, (2) light hydraulics (lubrication applications), and (3) custom fabrication of components. In 1999, heavy hydraulics accounted for approximately 34 percent of the firm's sales revenue, light hydraulics accounted for approximately 31 percent, and custom fabrication accounted for approximately 28 percent of sales revenue. The entire production mix tends to be rather complex and eclectic.

Heavy hydraulics

The market for heavy radial piston hydraulic motors has been relatively stable. The company is the sole manufacturer of these types of motors for customers in the domestic market and in Hungary, Poland and Slovakia. Most of the applications for these types of motors are in military equipment. A new line of lubrication equipment was developed over the past few years using the concept of open architecture. Customers can choose from different capacities and configurations among available equipment to design a more flexible lubrication system.

² In the historical context, SH a.s. refers to all original entities with all its previous names.

Any additional R&D effort into heavy hydraulic technology is limited by a lack of capital and competition. In the past, competitors abroad made significant advances in this field and offered lubrication equipment based on considerably more advanced technology. At the request of major clients, SH a.s. introduced some innovations, but only on a very selective basis. These innovations generally represented only new components or configurations of SH a.s. standard lubrication systems.

Light hydraulics

These are represented by a line of hydraulic pumps and distributors capable of performing up to 100–300 Bar (inch equivalents) using heavy lubricants of NLGI 3 standard. This is a highly specialized area of hydraulics and is dominated by special agreements with exclusive customers. One such customer is Alfatex s.r.o. This firm is very active in the field of light hydraulics and sales of centralized grease lubricating systems. Alfatex s.r.o. cooperates with SH a.s. on sales of light hydraulic lubrication systems.

Many of the current applications for centralized grease lubricating systems are in traditional industries including heavy equipment manufacturing, steel making, and mining. In the domestic market, these industries are represented by major firms attempting to find their positions in the market. In the context of a broader global market, most of their market share is declining because they represent older technology.

Custom fabrication of components

The custom fabrication of components seems to be a growing area. Various components are fabricated to customers' specifications. In 1997, a special effort was made to secure orders from clients that have long-term repetitive needs. Orders were solicited from clients in Austria and additional orders from abroad are being sought. Close relationships are also being explored with major domestic manufacturers that require special hydraulic equipment that may be imported

from outside suppliers. Although this is a relatively small part of total sales revenue, it is nevertheless an important part of the business that is expected to grow significantly in the near future.

Markets

SH a.s., in many of its stages, has been exposed to a number of both domestic and foreign markets over the years. Since the major restructuring in 1997, its market position has changed dramatically. The company is beginning to focus on a smaller number of clients in fewer markets. SH a.s. is beginning to offer service and maintenance in addition to sales of its heavy duty centralized grease lubrication systems. It is working closely with a selected number of major manufacturers of heavy equipment, steel mills and coal mines. Although some of these clients appear to be ideal for the types of products SH a.s. offers, the future of many of these clients is uncertain.

Environmental trends such as pollution, surplus demand for steel, and replacement of natural gas for lower quality coal is drastically reducing the economic viability and survival of these clients. Although there is a strong potential demand for heavy duty centralized grease lubrication equipment, recent technological advancements have significantly reduced SH a.s.'s competitive position. Competitors from Germany, the United States, and other Western countries have introduced equivalent computer based technology. Much of this technology is automatically integrated into the overall operating and maintenance system of equipment typically operated by a central computer.

Markets in the areas of light hydraulics applications in lubrication technology are also changing. Although traditional applications for light centralized lubrication systems can be found in water treatment plants, water filtration, breweries, and other process related industries, the technology in these industries is rapidly changing as well. Downsizing of the processes and introduction of higher levels of automation combined with centralized computer operations are replacing traditional lubrication systems.

Other markets traditionally serviced by light hydraulic lubrication technology are also experiencing major transitions. The manufacture of buses, heavy duty trucks, agricultural equipment, and various agriculture related equipment that used centralized lubrication systems are now, in many cases, foreign owned and use systems specified by their parent company or are purchasing systems manufactured abroad. This is primarily due to foreign competitive pressures.

The effort to offer custom fabrication services has been intensified since 1997. Several major clients, including a foreign client from Austria, represent a significant portion of current business. SH a.s. offers several types of fabrication services for machine tools that perform routine metal cutting operation and several types of fabrication services that involve installing various types of industrial and manufacturing operations. There appears to be a relatively even demand for these services throughout the year.

Although it appears that long-term relationships have a positive impact on SH a.s.'s market, primarily due to the installed base of its centralized grease lubrication systems before 1989 when SH a.s. still had a monopolistic position in the market, it appears that its market is not eroding. The principal underlying reason why SH a.s. is still operating in this seemingly competitive market seems to be its low prices. Most of SH a.s.'s competitors in the domestic market are foreign suppliers represented by domestic distributors. The sole domestic competitor in the domestic market is Poclain Hydraulics, Brno, a French company that originally, during privatization, purchased the other half of ZTS Juranovy Závody Brno.

There also seems to be minimal competition in the other product lines carried by SH a.s. Although foreign manufacturers are entering the Czech market with broad lines of lubrication technology, SH a.s. maintains a strong market position. Foreign suppliers do not maintain sufficient inventory levels in the domestic market and generally are interested in component sales rather than the design and installation of complete lubrication systems. These competitors are mostly German and American.

The supply of lubrication systems for the military market is still a viable option for SH a.s. It still has a significant domestic advantage in this market that will very likely continue into the future.

In summary, the market for hydraulic motors and heavy centralized grease lubrication technology in the industrial sector will very likely experience a slight decrease. A slight increase is expected in the military market for the same type of equipment. The market for custom fabrication of parts and components appears to be growing significantly.

Future Trends

Several major trends are shaping the operations of companies such as SH a.s. Some of these trends are technological while others are global. The technological trends are mainly strong computerization efforts in all of the industries that SH a.s. serves. Maintenance and operations of railroad rolling stock are being computerized, while heavy duty trucks are being redesigned to incorporate centralized computer operations. In addition, heavy manufacturing industries are revising their systems for computer operations. Business to business marketers are trying very hard to integrate their individualized equipment into computer design and operations.

Most manufacturers of components or accessories such as centralized lubrication systems need to work with manufacturers within the supply chain in order to be able to integrate their components and accessories into the final product. The major design criterion in many designs of heavy equipment is the central computer that will operate the final piece of equipment. This is a nonreversible trend. Business to business marketers need to understand this trend and innovate their product offerings accordingly.

Globalization of business to business marketing is another major issue. Business to business marketers today need to understand that they are competing not only in their own domestic market, but that they are actually part of the global environment. Business to business marketers source for supplies globally. They seek business partners that are willing to work closely with them to help them satisfy their

needs and help them create value for their final customers. The internet has stimulated the globalization trend. Many progressive business to business marketers rely on contacts made over the internet and pro-actively foster relationships that can be turned into viable business relationships in the future.

It is important to examine companies such as SH a.s. within this scenario. Many firms in Central Europe perceive themselves as competitive in a relatively stable, if not expanding, market. Yet, some broader analyses suggest that it is not the expanding or a relatively stable market that is the key indicator of their success, but the major trends around them that influence their market operations. In this case, the two major trends are technological changes in their industry and globalization of markets. How should SH a.s. respond to these two trends to ensure its competitive market position in the future?

Appendix A. Economic Transformation in the Czech Republic

At the beginning of the transition — a sweet dream

Radical economic reform began in the former Czechoslovakia in 1991 after the creation of the necessary political conditions. The reform was designed to replace an antiquated central economy planning approach with a regulated market economy. Some principal measures of the economic reform were introduced in a very short time, one or two years. The necessary legal preconditions for the development of a private sector were created and the privatization process was successfully started. Next, prices and foreign trade were liberalized almost completely. There was a substantial reduction in subsidies.

A significant success of this reform is considered to be the macro-economic stability, which is indicated by a relatively low level of inflation, by a low rate of unemployment, and by a moderate growth in external debt. The manifested willingness of the Czech people to accept the necessary decline in living standards in exchange for future

improvement is also considered to be an important success for the reform.

One of the fundamentals of a market economy is a plurality of property ownership. In the former Czechoslovakia, the private sector was nationalized completely in 1948. For this reason, sweeping privatization was set as one of the main tasks of the current economic reforms. Privatization in Czechoslovakia, now the Czech Republic, is achieved in two principal ways: (1) by restitution, when properties are returned to the former owners — Czechoslovak nationals — provided that their properties were nationalized after 1948; and (2) by privatization of state-owned properties, not privatized by restitution, where privatization is considered appropriate.

Privatization is ruled by a special law, which determines two basic forms of privatization, namely small privatization and large privatization. Small privatization was launched in 1990, before the much more complex and complicated large privatization. The aim of small privatization was to open an entrepreneurial area for small businesses, especially for craftsmen, retailers, and other services as soon as possible. Small privatization was brought about by only one method — auction. It was announced that about 5 percent of state-owned property was privatized in this way up to 1992. Large privatization applies to large state-owned industrial companies, banks, insurance companies, large hotels and other properties representing a substantial part of state property within the Czech economy. Organizational and financial restructuring is realized along with privatization. The aim is to create strong and competitive units, competing in a de-monopolized market environment.

The great privatization was launched in the former Czechoslovakia in 1991 in accordance with the so-called Transformation Law, which sets out 10 possible privatization methods (see Czechoslovak Federative Republic Law No. 92/1991), of which the most important are:

1. Public auction, where the only criterion for the decision about the future owner is the level of price offered.
2. Public competition, which differs from public auction only by using a multi-criteria decision on the future owner (the price

offered is important but also other predefined criteria must be taken into account).

3. Direct selling to a pre-determined owner, where the decision over the future owner is the responsibility of a public department.
4. Coupon privatization, with the aim of bridging a temporary gap in the provision of domestic capital. This method allows almost all Czech citizens to participate in privatization, including the less affluent. Every Czech citizen over the age of 18 has the right to compete in buying shares in a privatized company using investment coupons bought from the government at a nominal price. In spite of some difficulties, especially caused by the division of the former Czechoslovakia, the first round of the coupon privatization was completed last year. The experts' evaluation of its results is relatively positive.

The main advantage of coupon privatization compared with other methods is its rapidity and efficiency. For example, in the Czech Republic property worth 500 million Czech Crowns was privatized by this method in one year. Its main disadvantage is the fact that there is no immediate income for the state budget.

The results of privatization in the Czech Republic are impossible to evaluate by direct comparison with other countries. No other country in the world is solving the problem of privatization to this extent and at this speed. Evidence that this important part of Czechoslovak economic reform is regarded on the whole as a success, can be derived from the assessments of outstanding international economic and financial institutions. For example, one of them, the OECD (Organization for Economic Co-operation and Development) published in 1992 the following evaluation (see *Hospodářské noviny*, 17th January 1992):

“Generally Czechoslovakia has made significant progress in the creation of the conditions for the functioning of a market economy, but much has to be done in the future. The government's impact on privatisation is right. It is necessary to continue this strategy ... ”

The situation of today — facing the reality

After the collapse of the Communist regime in 1989, Czechoslovaks started to wake up from the lethargy of the political cold period of 49 years. It was a time full of hope and worries. Many people both in Czechoslovakia and other post-communist countries believed that the West would welcome millions of new members from Eastern Europe into the independent world and would be open to them with no reservations. Then, at the time of de-monopolization of the communist party, democratization of society, opening to Western influence, market liberalization, price liberalization and preparation of privatization, the economic transformation leaders headed by Mr. Václav Klaus, the Minister of Finance, estimated that the economic privatization and transformation would be achieved in quite a short period of four to five years. Before the election of 1996, Mr. Klaus announced a successful end of the economic transformation. Today, nobody believes that in the Czech Republic. The economic transformation has nearly stopped. What are the main reasons?

When compared with other post-communist countries, the Czech Republic was in a good starting position with the following conditions: a relatively efficient and debtless economy, and particularly important, a powerful team of economists and sociologists who were able to take the management of the country and economy into their hands. It was mainly due to this fact that the economic transformation started at very high speed from the very beginning. Unfortunately, we can see now that the transformation and especially the privatization started without any proper preparation such as setting rules and above all, considering the legal aspects. Thus, economic crimes, corruption in the privatization process, tunneling of companies and banks by their management, disorder in the capital market, etc., became an everyday reality. What is more, the Czech legal system provides very little protection to small investors, the tax system is very complicated and courts of commerce function badly. A dishonest debtor is in a better position than the creditor. Despite recent attempts to put things right, this discrepancy still exists to a certain extent.

The geographic location of Czechoslovakia helped local industry quickly substitute West European markets for the lost Eastern market in the initial years of transformation. As early as 1993, more than 60 percent of export went to the EU and other Western countries, which was a real success. The question is how the industrial firms that had not yet been privatized and that were often managed by the old (communist) management could achieve such outputs. The secret of their success lies in the profound devaluation of the currency at the beginning of transformation in 1991.

The devaluation represented the so-called transformation cushion, the authorship of which is attributed to Mr. Klaus. Local companies that had not been restructured yet and were still inefficient could offer their products to Western markets for unusually low prices. Compared with other post-communist countries, transport costs represent another advantage for local businesses. The main items of export are raw materials, steel, and semi-finished products. However, engineering products and other more technologically demanding goods are exported in smaller amounts.

The situation culminated at the end of 1999 when, due to the unbearable deficit of the balance of payments, an overvalued Czech crown and speculators, the currency had to be further devalued by roughly 20 percent and the system by which the Central Bank derived the exchange rate had to be radically changed. One of the basic pillars of transformation collapsed and the myth of its successful development ended.

The coupon privatization played a very contradictory role in the transformation process. There is no doubt that it will become a part of Czech history. Thanks to the coupon privatization, most citizens changed practically overnight from apathetic and demoralized interpreters or victims of Marxism–Leninism to “capitalists”. There is no other country in the world with such a high percentage of shareholders as here. And there is probably no other country where the sweet joy from the “people’s” capitalism turned to bitterness so soundly for most people in the period of wild capital accumulation that broke out after the coupon privatization ended its third wave. However, the third wave was not organized by the government and parliament, but by the market.

The ownership of firms was redistributed back from the people to investment companies and firms. Nevertheless, the management of the privatized firms mostly wanted to gain property and care little for the development of production. It was more and more obvious that there is a lack in the Czech Republic of capable businessmen with sufficient capital and strong motivation to be in a business and compete successfully.

Another negative aspect of the coupon privatization lies in the fact that even though it enabled a formal denationalization of a significant part of state-owned property in the short period of three years, it did not, on the other hand, bring the companies any new capital that was so necessary for investment, rationalization of production and increase of productivity. In order to solve the problems with obtaining capital, the Czech National Bank stopped regulating the foreign currency regime. Thus Czech commercial banks and companies did not face large obstacles and could borrow abroad, mostly in the West, under much more advantageous terms than back home. So a boom of the Czech economy began, but at the same time the deficit in the balance of payments also started to increase.

The influx of Western consumer goods changed post-socialistic shops into palaces for consumers. There was suddenly surprising purchasing power; Czech households could finally treat themselves to goods that in the past required many years of saving and the supply of which was often insufficient. It was a time of quickly increasing demand, especially for consumption goods. In 1993, GDP increased by only 0.6 percent while in 1995, it went up by an incredible 5.9 percent. Some Czech politicians started to talk about the economy as being a Central-European tiger.

Conclusion

The economical and moral damage that has been done in the past few years is quite extensive. It can be repaired only in the long-term and the hard work. The people's lost trust in the system of market economy and democracy will have to be won back. Nowadays, nobody speaks of the Czech economic miracle. Unemployment has risen

quickly from 3 percent to 6 percent, which is acceptable. And there is no reason why it should not increase even more. Local companies are under market pressure and they are starting to increase productivity in a traditional way — by saving wherever possible, investing in machinery and equipment. These rationalizing measures have brought cuts in the number of employees both in production and administration of the companies. What the Czech Republic needs now is an inflow of foreign investment, especially in regions with high unemployment. But there are no investors coming at the moment. The Czech capital market is still in shock and it will not be easy to gain the trust of foreign investors again.

Appendix B. Old vs. New Technology

As mentioned earlier, SH a.s. has technology in the following components and systems: (1) hydraulic pumps, (2) pumping stations, (3) hydraulic motors, (4) hydraulic distributors, (5) grease central lubricating systems, (6) safety and unidirectional valves, (7) heavy hydraulic technology, (8) light hydraulic technology, and (9) mobile hydraulics.

In the following sections, comparisons will be drawn between old and new technology with respect to a representative sampling of these products. Brief background information is provided for the underlying scientific principles behind each of the products.

*Hydraulic pumps*³

Pumps transform mechanical energy, typically produced by an electric motor, into hydraulic energy. Hydraulics transmit energy from a source to an output. The source/output ratio varies according to the design of the devices. A hydraulic pump generates fluid flow but not pressure. Pressure results when the pump flow encounters a resistance, such as a cylinder attached to a load (Fig. 1).

The mechanical action of the pump creates a vacuum at the inlet port, which permits atmospheric pressure to force liquid into the

³ See www.phionline.com/HpumpTut.htm

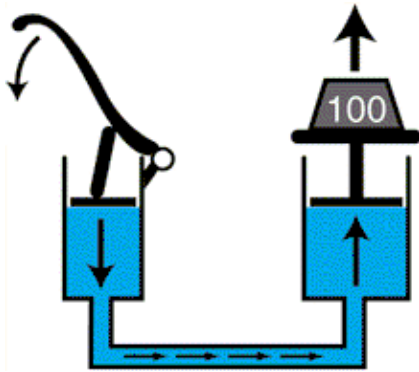


Fig. 1. The hydraulic process showing transfer of energy to lift a weight.

hydraulic system. Most pumps are of the “positive displacement” type in which there is an extremely close fit between the pumping element and the pump case. This leads to minor slippage compared to the pump output. Displacement of pumps may be fixed or variable. Variable displacement pumps permit the output to change during a pumping cycle. This is achieved by adjusting the geometry of the displacement chamber with an electrical or fluid control system. Pumps are classified by the type of element that transmits the fluid. The most common elements are gears, pistons, and vanes. By design, piston pumps, lend themselves to variable as well as fixed displacement operation. Poclain Hydraulics, a leading French company,⁴ manufactures pumps which allow controls through mechanical, hydraulic, or electronic means. Pump operation can now be integrated to efficient equipment operation via computer control.

*Piston pumps*⁵

The basic piston pump has just two valves and one stuffing box (Fig. 2). A stuffing box is the seal between the rotating and stationary parts which is typically packed with loose sealing material. It is located

⁴ See <http://www.poclain-hydraulics.com/>

⁵ Image and information drawn from www.animatedsoftware.com/pumpglos/pistpump.htm and www.phionline.com/Hpumps.htm

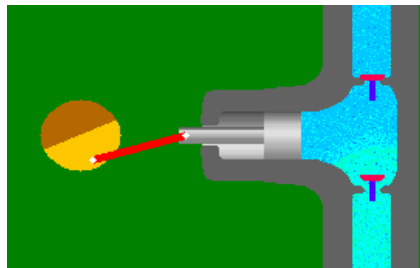


Fig. 2. Operation of a piston hydraulic pump.⁵

where the rotating shaft enters the pump. Typically the reciprocating piston is driven back and forth by a rotating mechanism. This piston pump uses suction to raise fluid into the chamber. The lower valve can be placed below the fluid level.

Piston pumps are generally quieter than either gear or vane pumps. They offer many control options, and provide pressure compensated control, where the flow (in gallons/minute or GPM) goes down to maintain pressure at a fixed level.

Pumping stations (Lubricant Handling Equipment Systems)

Industrial pumping stations have a pneumatic pump, barrel equipment, directional grease valve controls, valves, hoses, a compressed air filter and regulator. Small industrial and vehicular greasing systems can be piped with an electrically powered pump and a small reservoir.

The Swedish firm Assalub offers⁶ a lubricant handling equipment system for use in service and repair shops for vehicles, aircraft, etc. It is equipped with a computer-based recording system that will record all fluids dispensed to the various working stations and keeps a check on volumes in stock. This configuration is used both in workshops and in vehicle production plants. Older methods, used in some of the systems from SH a.s., still rely on manual bookkeeping.

⁶ Information drawn from www.assalub.se/eng/lubhan.html

Stations can be classified into either light or heavy centralized lubrication systems. These will be described in turn.

*Light centralized lubrication systems*⁷

Light and medium-heavy industry utilizes individual machines with a small number of lubrication points. Typical applications involving grease lubrication include pellet presses, gears, stone-crushers, cement kilns, screw conveyors, process filters, ship steering, industrial separators, etc.

Machines are typically lubricated through separate lubrication that may adopt several configurations. One setup would entail a simple lubricator with the number of outlets directly corresponding to the number of lubrication points in the machine. Another arrangement might be more intricate with automatic replenishment of lubricant and equipped with functional checks, control units for intermittent operation, etc. Some automatically operated systems can be controlled on a time- or load-dependent basis. Vogel AG, a German firm, manufacture systems which not only monitor the operation and interval of the electric motor but optionally may monitor fill level, pressure, cycle, and stroke number.⁸ This can all be accomplished with careful computer control. Older systems, such as that employed by SH a.s., are controlled by timers or load sensors and lack computer integration. The downtime for lubrication along with human error factors cannot be eliminated in the latter setup.

*Heavy centralized lubrication systems*⁹

Heavy process industry uses machines with many lubrication points in a small area of operation. For these applications it is cost effective to install a large central lubricating system. Despite a higher cost for a central common pump center, the cost per lubrication point is not

⁷ See www.assalub.se/eng/lilub.html and www.212.169.211.105/seiten/pro151_1.htm

⁸ See <http://www.vogel-fluidtec.de/Homepage.html.en>

⁹ Background information drawn from www.vogel-fluidtec.de/Products/Details/en/?product=1,2,1,3,2,0 and www.assalub.se/eng/hevlub.html

especially excessive. Typical applications include lubrication of paper machines, causticizing plants, cleaning plants, sawmills, various applications in steel mills, etc.

A dual-line system may include in excess of 1,000 lubrication points. Special dual-line distributors ensure optimum distribution and metering of the quantities of grease delivered by the pump to the lubrication points. The lubricant is conveyed in the correct quantity to the friction point through the use of either block or module distributors. With block distributors, the delivery volume range is pre-defined. Adjustments can be carried out within this range by varying the depth of adjustment screw. In the case of module distributors, the delivery volume can be determined by the use of a variety of modules and by varying the depth of adjustment screw. This means that subsequent modifications to the lubrication system are easy to put into effect. Newer technology from companies such as Assalub allows for these systems to be controlled by either a control center for one or more lubrication channels or an existing process computer in the production unit.

*Hydraulic motors*¹⁰

Hydraulic motors are powered by pressurized fluid and transfer rotational kinetic energy to mechanical devices. Piston hydraulic motors used in various applications are similar in general design and construction to the piston-type pumps. The difference in the operation of a hydraulic motor and a hydraulic pump is as follows. In the operation of a pump, when the drive shaft is rotated, fluid is drawn into one port and forced out the other under pressure. This procedure is reversed in a hydraulic motor. By directing fluid already under pressure into one of the ports, pressure will force the shaft to rotate. Fluid will then pass out the other port, and back to return. The rotary mechanical force provided by the motor can be used to drive a gearbox, torque tube or jackscrew.

¹⁰ Background information drawn from www.industrialtechnology.co.uk/2000/jun/linde.html

*Radial-piston hydraulic motors*¹¹

The radial-piston motor operates in reverse of a radial-piston pump. In the radial-piston pump, as the cylinder block rotates, the pistons press against the rotor and are forced in and out of the cylinders, thereby receiving fluid and pushing it out into the system. In the radial motor, fluid is forced into the cylinders and drives the pistons outward. The pistons pushing against the rotor cause the cylinder block to rotate. The operation of a radial-piston motor is briefly described.

The newer radial-piston motors, such as those produced by Poclain Hydraulics, are of high torque and low speed. Main applications for these motors include construction equipment (e.g., compactors, loaders, etc.), agriculture (e.g., sprayers, harvesters, etc.), material handling (e.g., cranes, forklift trucks), marine (e.g., winches, trawlers, etc.), and industry (e.g., wind turbines, extruders for plastic injection equipment, etc.). They utilize the latest state-of-the-art computer aided design systems to optimize product. Hydraulic testing validates components and systems design in cooperation with an integrated metallurgical laboratory that defines and checks materials and surface treatments. New products and systems are submitted to a homologation process that assures specifications and performances before they are installed with the customer. Compared to the older technology motors from competitors, Poclain has produced a product with 50 percent less weight for the same power output within the last 40 years.

*Axial-piston hydraulic motors*¹¹

The variable-stroke axial-piston pump is often used as a part of variable speed gear, such as electro-hydraulic anchor windlasses, cranes, winches, and the power-transmitting unit in electro-hydraulic steering engines. In those cases, the tilting box, a device that transfers power to a drive shaft, is arranged so that it may be tilted in either direction.

¹¹ Information drawn from www.tpub.com/fluid/ch3b.htm

Thus, it may be used to transmit bi-directional power hydraulically to pistons or rams, or it may be used to drive a hydraulic motor. In the latter use, the pump is the A-end of the variable speed gear and the hydraulic motor is the B-end. The B-end of the hydraulic unit of the hydraulic speed gear is exactly the same as the A-end of the variable-stroke pump. However, it generally does not have a variable-stroke feature. A tilting box is installed at a permanently fixed angle. Thus, the B-end becomes a fixed-stroke axial-piston motor.

One example of a dual system is an axial-piston hydraulic speed gear with the A-end and B-end as a single unit. It is used in turrets for train and elevation driving units. For electro-hydraulic winches and cranes, the A-end and B-end are in separate housings connected by hydraulic piping. Hydraulic fluid introduced under pressure to a cylinder (B-end) tries to push the piston out of the cylinder. In being pushed out, the piston, through its piston rod, will seek the point of greatest distance between the top of the cylinder and the socket ring. The resultant pressure of the piston against the socket ring will cause the cylinder barrel and the socket ring to rotate. This action occurs during the half revolution while the piston is passing the intake port of the motor, which is connected to the pressure port of the pump. After the piston of the motor has taken all the hydraulic fluid it can from the pump, the piston passes the valve plate land (which connects the A and B ends) and starts to discharge oil through the outlet ports of the motor to the suction pistons of the pump. The pump is constantly putting pressure on one side of the motor and receiving hydraulic fluid from the other side. The fluid is merely circulated from pump to motor and back again. The axial-piston motor may be operated in either direction. The direction of rotation is controlled by the direction of fluid flow to the valve plate and may be instantly reversed without damage to the motor.

In 2000, the Linde Company came up with a concept¹² that results in pumps and motors that are more compact, have a higher power density, and are cost-effective. At the heart of the new products is a design of piston and slipper pad that is the reverse of the norm.

¹² Information drawn from <http://www.lindehydraulics.co.uk/index.htm>

Whereas the ball end of the ball-and-socket joint is usually on the piston and the socket is on a slipper pad, the new units have the ball on the slipper pad and the socket on the piston end. This minor change led to striking results. One of the main advantages of this arrangement is that the swash angle (angle of the tilting box) may be increased from the normal 18° to 21° thereby increasing the swept volume. A greater swash angle allows the pistons to move further resulting in more fluid transfer. Since fluid power is directly proportional to the displacement per revolution, the power density increases. A secondary benefit of this alternative arrangement is that the piston can be hollow thus reducing the weight of the rotating components and improving lubrication.

From the outset, one of the objectives for the newly designed pumps and motors was to use common parts for both types of product. In fact, the rotating groups — as well as many other components — are common to both. Other elements of the design have also been made modular so that even models of different capacity share common parts. By this approach Linde can streamline its manufacturing and reduce its stock holding, thereby generating cost savings that can be passed on to customers. Running clearances between the dynamic components have been reduced, so there are lower frictional losses, higher volumetric efficiencies and, consequently, an improved overall mechanical efficiency. High performance, high efficiency and low noise, all from a compact, cost-effective package are benefits cited by Linde.

Hydraulic distributors

Directional control valves (or directional drawer valves) are components that function to direct the circulating oil flow in an oil-hydraulic system to the use that has been chosen by the operator. The function is obtained by shifting the spool (drawer) inside a cavity that has regular and serial openings. The resulting connections of these openings form the requested functional circuits. The displacement of the spool is obtained by means of actuators. They can be either direct (manual) or indirect (electric, pneumatic, hydraulic,

cable, operated, etc.). The control of the position can be active (automatic return) or blocked in different types of construction.

The newest directional valves are prone to comply with all essential functions that make oil hydraulic plants safe and efficient. They include, but are not limited to, the following features: pressure setting and control (relief valve, antishock valve), regulation of the oil flow (integrated with three-way compensated valves), no return function or block of the use, filling up function (anticavitation), to feed and use two circuits (or parts thereof) at the same time (but independently), possibility to build circuits in parallel, single, series and mixed, possibility to connect with other valves using only one source of energy, regulation of the energy by directly acting on the source, and possibility to use more sources of energy.

*Mobile hydraulics*¹³

In the field of mobile hydraulics (central lubrication systems for mobile machines) the trend toward integrating electronics is stronger than ever, not only in motor vehicles and construction machinery, but also in conveying and agricultural technology. This applies to construction machinery, stackers (lift trucks), farm machinery, trucks, buses, rail vehicles, etc. Several firms, including the German company Bosch, are developing highly integrated system solutions to work accurately and reliably even under the toughest conditions. One example is the electro-hydraulic hoisting gear control for farm tractors. Another application, which will be discussed in some detail, is the system employed in rail wheel flange lubrication.

When rail vehicles are in motion, friction between the wheels and rails leads to greater wear and tear on the wheel flanges and sides of the rails. As the vehicle travels through curves this can cause loud screeching. During acceleration substantial energy losses are incurred. Moreover, vehicles are more likely to derail when wheel flanges are not lubricated. Lubricant is selectively applied to the flanges of the

¹³ Information drawn from http://www.boschfluidpower.com/products_mobile_hydraulics.html and <http://www.arm-corp.com/reports/handout1.html>

wheels. The lubricant sprayed onto the first wheel flange in the direction of travel is transferred to the side of the rail, thus lubricating the following wheel flanges (e.g., on passenger coaches or freight cars) as well. Optimally designed wheel-flange lubrication systems can address up to 250 axles. Equipping a large number of motorcars with wheel-flange lubrication assures the network of tracks receives all the necessary lubrication. Effective wheel-flange lubrication systems have been demonstrated to reduce wear and tear on wheels and rails by up to 80 percent, cut track resistance by up to 30 percent, save as much as 12–15 percent on energy and fuel, and lessen derailments.

Wheel-flange lubrication units are generally controlled by time or distance-dependent systems. SH a.s. has employed this methodology. However, with top-of-rail lubrication units (used in Germany, by Deutsche Bahn AG, and in some other countries), the system has to be activated and controlled in the curves, as only the inner rail is sprayed in curves with tighter radii. In conventional curve-controlled wheel flange lubrication systems, the spraying process is always activated too late. When the spraying process is initiated by acceleration sensors or by bogie-interrogation (shifting of aligning truck wheels) through proximity switches, the vehicle is already in the curve before the lubricant is applied to the wheel flange. For this reason, an additional distance controlled activation of the system in curve-dependent wheel flange lubrication systems would be advantageous. In this way the lubricant is applied to the flange before the vehicle goes into the curve. The acceleration sensors then initiate a supplementary lubrication process. With the automatic top-of-rail lubrication units the problem to be solved was how to initiate the spraying process before the curve. A new system developed and patented by the German firm REBS (REBS Zentralschmiertechnik GmbH) is based on transponders mounted between the rails, which, by means of an identification system, trigger the lubrication process before the curve.¹⁴

The principle of the REBS units makes it possible to spray the contact surface of the inner rail without interruption throughout the entire curve, and to adjust the amount of lubricant applied per unit of

¹⁴ Information drawn from http://www.rebs.de/spurkr_e.htm

time or distance. In order to make this principle more economical for wheel-flange lubrication systems, REBS is currently developing a patented system of wheel-flange and top-of-rail lubrication units which is activated for selected areas (e.g., points and tight curves) by a GPS (global positioning system) satellite navigation system working in conjunction with a laptop computer and appropriate software. This process will be substantially more economical than the corresponding transponder identification systems.

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Intuit ProSeries (A)¹

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The managers at Intuit's tax software division in San Diego were feeling pleased that they had successfully released the tax software in time for the 1996 tax preparation season using their new tax-processing system software (TPS) that allowed them to code the tax rules once and then deploy them to the various products: TurboTax (for DOS and Windows) and MacInTax on the consumer side and ProSeries (for DOS and Windows) for professional tax preparers.²

This success drove them right into the next major decision. Computer users were quickly moving away from command line software like MS-DOS to graphical user interfaces (GUI) software like Macintosh Operating System and Windows. On the other hand, professional tax preparers were conservative and less prone to switch from a known product to something less well known. The managers

¹ This case was prepared by Gary Whitney and Ellen Cook, both from the School of Business Administration at the University of San Diego. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way. Copyright © 2001, Gary Whitney. All rights reserved.

² Intuit, ProSeries, TurboTax, MacInTax, Quicken and QuickBooks are registered trademarks of Intuit Inc.

wondered how long they needed to continue producing an MS-DOS based tax preparation software product in parallel to the Windows-based product.

The software engineers were anxious to stop producing a ProSeries MS-DOS product. Even though the tax-processing system eliminated the need to write tax logic separately for each platform, the software engineers still had to write some code specific to each hardware and software platform. Melanie Singer, Vice President for Tax Software Engineering, was concerned because this effort took the time of her most scarce resource: software engineers. Technical support, located in Fredericksburg Virginia, discovered that the Windows 95 products not only required less telephone support than DOS products but also that Windows 3.1 (the graphical user interface used with DOS for the tax program) required a disproportionately high volume of support.

Professional Tax Preparation Industry

Professional tax preparers ranged from big five accounting firms like Arthur Andersen that wrote their own tax preparation software to part-time preparers who worked in their garage using paper, pencil, and adding machines. Professional preparers included CPAs, IRS enrolled agents, accounting professors, and people who had recently attended tax preparation courses offered by H&R Block and others.

In the 1960s and 1970s, service bureaus ran applications of tax software. Tax preparers interviewed clients, filled out worksheets to capture the important information, and sent the worksheets to a service bureau for processing. The service bureau entered the information from the worksheets into their mainframe computer in batches and calculated many tax returns at once, printed the results and sent them back to the professional tax preparers who presented the return to their clients for signature and submission.

Professional tax preparers' productivity increased with the availability of personal computers in the 1980s because they controlled the whole process and did not have to send paper back and forth to a service bureau. By 1993, there were numerous tax software products

for professional preparers that ran on personal computers. Platforms for self-preparers included Macintoshes and PCs but professional preparers strongly preferred PCs.

Renewals and switching costs

Internal Revenue Service rules and regulations changed every year to meet new tax laws and revised interpretations. This was a double-edged sword for tax software developers.

To accommodate these changes, tax software had to be revised annually. Software developers responded with new software every January for the tax year (TY) just ended. For example, in January of calendar year 1992, software for TY 1991 was released.

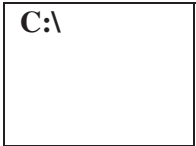
The other edge of the sword was that software developers, once they had a customer, had the opportunity to sell the customer updates every year. Once tax preparers selected a software product they were unlikely to change it in subsequent years because of high switching costs. Switching costs included learning time for the preparer and the difficulty of using customer files created in prior years by other tax preparation software. Time spent learning a new software product was not billable, and therefore, from the preparers' perspective, it was lost productivity. Prior years' tax files were used to avoid re-entry of common data like Social Security numbers, names and addresses. Furthermore, data from prior years' tax returns sometimes had to be carried over to do tax calculations, e.g., depreciable assets.

Intuit ProSeries renewal rates in 1993 were 80 percent. They considered the 20 percent customer loss as unacceptable and set a renewal rate goal of 92 percent by 1998. Because the customers' switching costs were high, lost customers were difficult to reacquire.

Operating systems (OS)

Microsoft Disk Operating System (MS-DOS) was a single user, single tasking, character-based operating system designed for Intel-based personal computers. It was introduced in 1981 with the first IBM PC. By 1993, virtually all IBM compatible computers had MS-DOS preinstalled

by the manufacturer. The MS-DOS user, after starting a computer was faced with a blank screen except for the command prompt



implying the computer was ready to use files loaded on the C drive. The user had to type in the name of the program to execute or the action desired. A few examples are listed below. There were around 80 commands depending on the version of MS-DOS.

Type this after the command prompt	Action
dir	List directories and files in the current directory
copy a:*.exe b:	Copy all executable files from disk a to disk b
rmdir letters	Remove the directory “letters”
ren c:/dox/letters c:/dox/memos	Rename the file “letters” in the dox directory on the C drive to “memos”
c:/..	Move up one level in the directory tree

By 1990, many in the industry referred to Intel-based computers as “Industry Standard Architecture” (ISA) to differentiate them from Apple’s Macintosh computers but to avoid using the term “IBM” since IBM was no longer the dominant personal computer manufacturer.

Apple Macintoshes ran Mac OS, considered by many users to be a superior operating system due to its graphical user interface (GUI). GUIs were much easier for most users to learn but the extra processing time required to decode mouse clicks made them slower to execute. Even though personal tax preparation software was written for Macintoshes, there was no professional tax preparation software for Macintoshes. The number of professional tax preparers using Macintoshes did not justify writing a software product for them.

Microsoft introduced Windows 3.0, its first commercial success as a GUI operating system, in May 1990 and Windows 3.1 nearly two years later. Windows 3.1 was not a full operating system by itself. It was a separate program that ran on top of MS-DOS. It provided users a graphical user interface and improved ease of use for PCs. In addition to Microsoft's DOS and Windows, IBM's OS/2 and several versions of UNIX were also available for PCs but neither played a significant role for professional tax preparers.

Regarding tax preparers' shift from DOS to MS Windows, *The Practical Accountant*³ reported:

"One big change is the migration to a friendlier operating system. Almost every PC sold today ships with some form of Microsoft Windows installed. Frequently, the computer is set up to take you directly into Windows when you flip on the power switch. Many tax practitioners have experienced how much more powerful and intuitive word processing and spreadsheet applications become when they are run under Windows, and this has prompted software developers to move the tax preparation process into this environment as well.

A number of vendors already have Windows-based packages on the market. More have them under development, or will be beta testing them this tax season. And even if a vendor doesn't yet have a Windows package, the odds are good that you can run your current package in a DOS window under Windows and conveniently switch between it and other programs.

And the fun doesn't stop there. Even before many practitioners have adopted Windows 3.1, Microsoft has introduced its next-generation graphical operating system, Windows 95. If you haven't yet committed to Windows 3.1, you'll want to take a really good look at Win95. Many users find it even easier to learn and use than its predecessor, and the DOS compatibility has improved. Many DOS programs that won't run under Windows 3.1 because they need a large amount of memory will run just fine in a DOS session under Win95, so there are good reasons to go straight from DOS to Win95."

³ Tax software: Time for a change? *The Practical Accountant*. Boston, 1996.

Annual cycles: Fiscal Year (FY) and Tax Year (TY)

Personal tax returns or extensions were required by April 15 for the prior tax year, but this was the end of a long cycle for tax preparation software companies. For example, while preparers were doing TY 1992 returns for their customers in spring 1993, software developers were making plans for TY 1993 so that software would be ready to release in late 1993 and early 1994.

Final tax software could not be released until the Internal Revenue Service and the various state tax agencies had released their final tax regulations and forms. Final versions of the forms were often not released until November, December or even January. This delayed the release of final versions of tax preparation software. Late information from the IRS put a high premium on being well prepared to create final software releases quickly. Professional tax preparers wanted the software early so they could install it, learn to use it and begin tax preparations. On the other hand, they could not tolerate software that did not meet Internal Revenue Service and state requirements. Tax preparation software that was either late or faulty caused tax preparers to switch to a competitor. Once customers switched, they were hard to recapture.

Customers and competitors

Intuit Professional Tax Group estimated that customer buying criteria, in order, were:

1. ease of use,
2. timely delivery, reasonable cost, and company reputation,
3. support and service.

The Intuit Professional Tax Group's 1994 Strategic Plan estimated the principal competitors as follows:

Lacerte had 17,000 customers and was perceived as the leader in the mid-range tax packages. They had a reputation for solid, consistent delivery of high quality, on-time products, excellent support and service,

and a loyal customer base (reported renewal rates of 95 percent). They were relatively high priced which was causing some customers to stop but they were willing to discount to retain customers. They publicly stated that a Windows version was at least 2 years away. Lacerte employees were highly paid and professional. Lacerte's disadvantages included apparent disinterest in Windows, older architecture with software developed in BASIC, high price, and lack of features that justified a high price.

Best had 13,000 customers. They acquired CPAid in 1992 to build a high-end customer base while Tax Partner was targeted into the low-end of the market using low prices. They were seen as a threat to low-end as well as to high-end competitors. Their internal Windows development was unsuccessful. Best had recently aborted a public offering. Employee morale was low and management was not trusted.

CCH Computax had 11,000 customers: 7,000 customers for ProSystem fx and 4,000 for 1040 Solutions. Their ProSystem fx was recognized as the best high-end product. They could have been a competitive threat in the middle market if they dropped prices. Their Windows software was comprehensive and thorough — designed for larger offices.

Intuit

Intuit began in 1982 when Scott Cook developed Quicken software to allow users to easily organize, understand, and manage their personal finances. It used an easily recognizable on-screen image of a checkbook that made it easy to use for consumers. By 1994 Cook, and his partner, Tom Proulx, had gone through nearly \$400,000 in initial capital with no success. They were turned down by venture capitalists for additional funding. They eventually found two individuals there were willing to invest another \$150,000. Cook said:⁴

“We got ourselves a distributor, cut the price in half, cut down the packaging, and began to advertise. It was a tiny marketing

⁴ Scott Cook and Intuit (1996) Harvard Business School Publishing. Boston, MA., 1996 (Case 9-396-282)

launch. But it was enough to give us a wedge to get our product into some stores, where it began to sell. We always had a guarantee but we enhanced it later after we had developed more confidence in our product and how to market it. In the meantime, though, we stopped paying salaries for six months. Three of the original seven employees had to leave the company to support themselves.”

Quicken, running on DOS, was a success by 1992. That year, Intuit introduced QuickBooks, a small-business accounting product.

Exceptional customer service was a primary competitive tool for Intuit and Quicken. They provided complete free customer service and technical support.

The tax group, located in San Diego, away from corporate headquarters in Menlo Park, included the Personal Tax Group (Pers) and the Professional Tax Group (Pro).

Intuit enters the tax software business

In November 1993, Intuit acquired ChipSoft Corporation in San Diego for \$306 million. ChipSoft’s consumer tax products included TurboTax for DOS and Windows plus MacInTax for Macintosh. ChipSoft’s professional tax preparer product line was called ProSeries. ProSeries software sales represented about 50 percent of professional tax software units sold. The ChipSoft tax preparation products could read Quicken files to speed preparation of tax returns for individuals that used both products.

There were other mergers and planned mergers in the works. Microsoft offered \$1.5 billion for all the stock of Intuit in 1994 but withdrew the offer in 1995 after the Department of Justice objected.

Issues in 1993

ChipSoft, and later Intuit, were concerned about keeping a clear differentiation between the Personal and Professional products

“...with emphasis on providing the professional strong incentives to purchase the more comprehensive (and expensive) products.”⁵ They did this by designing ProSeries to enhance professional preparers productivity and by producing client management products for professionals.

The introduction to their strategic plan said:

“The principal goal of the income tax development group is to produce high-quality income tax and tax-related computer-based products, at the lowest industry cost.

Our income tax development plan consists of two independent, but related elements. These are our product goals and our development strategies.”

The plan listed dozens of specific issues, improvements, and problem fixes for the products. ProSeries managers were faced with major decisions regarding development strategy.

Intuit’s ProSeries tax group annual cycle was defined by the need to release final versions of the software in time for tax preparers to meet their customers’ needs. After the release of final software for a tax year, they began making decisions about what features to include in the next year’s product. New or improved features included the addition of new forms, faster calculation speed, faster data entry, error checking, improvements requested by their customers, and interfaces with other software — especially other Intuit products like Quicken.

Once commitments to features were made, the tax software was written with shipping targets of early November for the Client Organizer, the last week of December for an initial release of the 1040 for federal taxes, early January for release of the states 1040 equivalents, mid-January for release of 1065, 1120, and 1120S for federal and state taxes, and the last week of January for the final 1040 release.

⁵ Income Tax Development, FY 94 Strategic Plan. ChipSoft. 5 November 1993.

The annual tax software development cycle approximately followed this schedule:

February	Plan for next year's product
March	Commit to and begin programming new or improved features
Early November	Ship Client Organizer software
Late December	Release initial 1040
Early January	Release initial state tax forms
Mid January	Release 1065, 1120, 1120S both federal and state
End of January	Release final 1040

Changing Operating Systems

By 1993, it was clear that Windows, in some version, would be the dominant operating system on PCs. Windows 3.1 was gaining acceptance among PC users and Microsoft's development of 32 bit Windows operating system was well known. It was uncertain how fast DOS users in general would switch to Windows. It was far less certain how fast tax preparers would switch. Professional tax preparers tended to be very conservative — they did not want to deal with the problems involved by changing to something new. Also, it would take them time to learn how to use Windows, programs did not run as fast on Windows, and some would have to upgrade their computer hardware to run Windows effectively. For these reasons, tax preparers were not anxious to make changes without clear benefits.

Intuit decided, in their FY 1994 strategic plan, to offer Personal and ProSeries tax products for both DOS and Windows environments because they did not want to abandon any customers. ProSeries did not have a Macintosh product.

Intuit's software engineers wanted to take advantage of Windows' graphical user interface (GUI). To serve all customer segments, Intuit had to write tax preparation software once for Windows and Macintosh to take advantage of the graphics capabilities and again for DOS with a character-based interface.

Decision to Create TPS

Writing separate code for each platform required multiple development groups working in parallel. They had to create separate products that had the same look and feel as well as meeting the Internal Revenue Service regulations. Problems were:

- It was difficult maintaining the same look and feel.
- It was costly.
- ProSeries was missing the opportunity to expand their product line to include all state versions and business tax forms.
- Writing all the separate code was consuming too much of their engineering resources.
- Talented programmers would better be used to create complementary products (such as client tracking software). In the tax business, it was extremely important to have a full product line.

Even though tax preparation software for DOS (TurboTax and ProSeries) and Macintosh (MacInTax) was written in Pascal, attempts at cross compiling the Pascal code to use on both DOS and Macintosh computers had not been successful.

To achieve the goal of becoming the low-cost producer and meet the tight time schedules, the tax group knew it had to be more efficient at writing the code for all platforms. This required a common calculation code for all personal and professional product lines, and for all operating systems according to VP Melanie Singer. She explained that they wanted to maximize the commonality of the software across platforms yet they knew that some fraction of the code would have to be written unique to each platform and product even though, at the core, all tax software had to comply to the same tax laws and regulations.

The tax-processing system was to be a problem-oriented language, similar in syntax to Pascal. With the tax-processing engine, the tax professionals could interpret the tax laws and regulations and write their tax interpretation code just once. Then the tax-processing system would generate all the specific code for each platform or market

segment that would eventually use it. The software engineers provided the engine with all of the necessary input and output routines and platform-specific technologies.

Some additional programming would still be required to tailor the products to take advantage of the various hardware and operating systems idiosyncrasies. For example, forms layout on the screens was different between the DOS and Windows versions because DOS offered limited control of the screen appearance. The Pro division took great pains to make them appear alike but it was not always possible. Sometimes the DOS version required abbreviations or shorter descriptions than the Windows version. The file structure would be kept compatible between the two versions so a tax preparer could use either or both on the same tax return — an important feature in an office with multiple preparers with different preferences.

The cost advantages were to be realized when the new technology code could be used for both TurboTax and ProSeries tax preparation software across computer platforms. Also, it was necessary to provide speed-to-market advantages since the tax programmers sometimes had only a few months between release of final tax regulations from the state and federal governments and the deadline for release of tax software. Missing a software release date could ruin the product line.

Bill Shepard explained: “Tax software is the business life of professional tax preparers. It is like a truck driver’s truck. If you take his truck away, he can’t make any money. It is different than you or I doing our own taxes. If you take our tax software away, we can say, ‘what the heck! I’ll do it with a pencil this time.’ The professional preparer can’t do that”.

August 1995

By August 1995, the tax-processing system, planned for use in all tax preparation products for January 1996 final release was not progressing according to schedule.

The Advance Technology Group faced a major decision. They believed they could meet the January release date if they reverted to the old system and did not add any features beyond what they offered for TY 1994. On the other hand, it would take programmers’ time

away from developing the new tax-processing system to develop the products for one more year using a soon-to-be obsolete process. They could not help but reflect on the demise of a competitor, who had missed the January distribution deadline.

Bill Shepard recounted a story. He said, “We could not afford to make the mistake that another company made. They attempted to simultaneously switch both DOS and batch processing to the same tax-processing engine in the same tax year. They were unable to do it. The products were delivered in late February or early March, well into the tax preparation season. They took a 50 million dollar company to zero in about two months. They went out of business!”

ProSeries managers believed the new tax processor was a “bet the farm” decision. If the new tax-processor system did not work, there was no attractive fallback position. Nevertheless, they “bet the farm” and were successful. They both completed the TPS and made the January distribution deadline.

The decision to transition customers to Windows

Microsoft released Windows 95 in August 1995. It was a true 32-bit operating system. Its predecessor, Windows 3.1, operating on top of DOS, was a 16-bit operating system that provided a graphical user interface to application software. Windows 95 could run DOS programs in a so-called DOS box for compatibility with older software. See Exhibit 1 for installed base of PC operating systems.

Marketing and sales people were anxious to keep the DOS product alive because it met the needs of a significant minority of their customers and they did not want to abandon any customers even though they agreed that the Windows product was superior in screen layout, printer interfaces, and user convenience.

The TY 1996 plan specified aggressive goals for Intuit’s Pro Division for FY 1997. It called for the ProSeries to “aggressively transition customers to Windows”. There was no doubt that ProSeries would stop producing a DOS product. It was not at all clear when. Exhibit 2 is an example of the issues that were being discussed.

The ProSeries mission statement: “provide high quality products and services that maximize professionals’ productivity” was to be

Exhibit 1. Installed base of desktop operating systems in the United States (%).

	1996	1997	1998
DOS	22.2	16.7	11.6
Windows 3.X	49.2	40.2	21.5
Windows 95	9.8	26.8	51.4
MacOS	9.6	9.0	9.2

Exhibit 2. Memo.**Subject: Dropping Win 3.1**

Author: Bill Shepard

Date: 6/13/96 6:03 AM

After sitting through a painful meeting on Internet implementation for TY96, it's clear we must drop Win 3.1. With Win 95, Internet support is built-in. With Win 3.1, we're buying 3rd party components and trying to integrate them. Costly and difficult.

Agree. (Bob Meighan, Sales and Marketing)

We continue to encounter limitations in an operating system that is neither complete nor stable enough to handle what we need it to do. It costs us in engineering and in tech support. We need to make the commitment and begin telling customers that this is the last year for Win 3.1. Further, we need to begin setting expectations that we only support the current operating system. Or perhaps, we only support the previous version of Windows for 12 months after the release of the last update.

I'm all for this. Setting the expectation now is wise. Plus, the statement about supporting systems for a 12-month period seems reasonable. And it gives customers plenty of time to upgrade.

Win 97 should be on the streets by December 1997. That would say for TY97 we support Win 95 and Win 97. For TY98, we should support Win 97 only.

Bill Shepard

Source: Excerpted from Intuit internal memorandum.

implemented by improving the quality and scope of the Windows products and providing superior customer service.

To promote the use of ProSeries Windows version, Intuit decided to provide superior functionality in the Windows version compared to

the DOS version. They also chose to promote Windows only to new users, to provide free Windows evaluation copies to DOS users, and to emphasize the ease of transition from DOS to Windows (through complete file compatibility) as well as the productivity benefits.

DOS Support

Steve Blundell, Vice President and General Manager, ProSeries Tax group, believed several factors kept professional preparers using DOS versions even though nearly all consumers were using Windows versions of TurboTax.

- Data entry was faster with DOS, especially for preparers with older, slower hardware.
- Some preparers were reluctant to learn Windows because it cut into their production time.
- CPAs are taught to be conservative. They tend to stick to what they know works and they had confidence that the DOS version of the ProSeries would work for them.

Melanie Singer was keenly aware that renewal business was crucial for tax preparation software. She knew that the high fixed cost and low variable cost of software drove unit sales as a key success parameter (see Exhibit 3).

By June 1996, Pro Division believed 50 percent of the customers had converted to Windows. An analysis in September 1996 reported 57 percent Windows usage for all tax products.

The feature set of the ProSeries for DOS was frozen for TY 1997. New tax forms, features, and productivity tools were only added to Windows products, not on the DOS products.

Late 1997

All during 1996 and into 1997 the ProSeries group debated how long they should continue to produce a 16-bit DOS version. It was clear that Win95 was a stable and popular operating system, that WIN 3.1

Exhibit 3. 1996 ProSeries income statement.

	(\$'000)	Percent
Net revenue	40,000	100
Cost of goods sold (COGS)	4,800	12
Operating expenses		
Customer support		
Sales and marketing		
R&D		
Administration		
Total operating expenses	19,200	48
Contribution to overhead	16,000	40

Customer support was the largest operating expense followed closely by R&D.

Source: Modified from 1997 strategic plan.

required more tech support and was difficult to use with Netscape browsers, and that few customers would remain with DOS. On the other hand, Intuit had built its reputation on customer service and the Pro Division was acutely aware that a customer lost was hard to recapture.

An internal analysis in January 1998 (Exhibit 4) estimated a \$960,000 loss in business unit contribution if DOS versions were dropped for TY 1998 but recommended discontinuing the DOS platform after TY98 (FY99). It suggested a renewal campaign beginning in April 1999 (the end of the tax season for preparers) to convert as many DOS customers as possible to WIN95.

Some professional tax preparers were openly skeptical about moving to Windows. For example, Jesse Tarshis, president of Alpine Data Systems in a 1997 comment contended that Windows 95 hinders many practitioners. He said: "We've been playing with two competitors' Windows packages. We find them so cumbersome to use. If I do two less returns today, with an average cost of \$100, that means I'm going to make \$200 less today. I'm running on a 200 MHz Pentium and I am surprised how slow it is."⁶

⁶ Robert Scott, "The Race to Win 95" *Accounting Technology*, July 1997.

Bill Shepard and Bill Harris wondered what other issues they might need to consider. They knew this decision was more than a financial issue. Should they continue with DOS one more year? What will the impact be on the small preparer that prefers to continue using his or her existing computer? What will the effect be on Intuit's reputation for customer service?

Exhibit 4. Excerpt of DOS analysis.

ProSeries proportion of Windows users				
Tax Year	DOS	Windows	Total	Percent Windows
TY 1996	10,696	23,793	34,489	69
TY 1997*	5,142	31,408	36,550	85

*Projected as of 18 January 1998 when sales for TY 1997 were 97 percent complete. This combines all ProSeries products. They do not include the sales of products as a result of the Parsons acquisition.

Estimated business unit contribution if DOS is dropped (\$)	
Estimated total revenue from DOS customers	7,000,000
Additional revenue from price increase TY98	420,000
Subtotal	7,420,000
Expected migration in TY98 if DOS is still offered	3,260,000
Expected additional migration in TY98 if DOS dies	2,080,000
Lost revenue if DOS is dropped	2,080,000
Lost business unit contribution for FY99	960,000

The same memo raised other issues:

1. Will we be at a competitive disadvantage in the professional tax market if we do not have a DOS platform? Most of our competitors advertise that they have both DOS and Windows programs.
2. Will discontinuing DOS in the same year that we increase price drive those customers away at a higher than expected rate?
3. The costs associated with the development and maintenance of the DOS platform would not be eliminated if DOS dies. Although these resources could be redirected to the Windows platform, the actual elimination of these costs seems unlikely.
4. The analysis which justifies the elimination of the 16-bit Windows platform assumed that the DOS platform would be available as a fallback solution for customers wanting to use ProSeries but not able to upgrade Windows 95.

Source: Modified from Intuit internal analysis for ProSeries.

Exhibit 5. Consolidated balance sheets for years ending July 31 (\$'000).

	1994	1995	1996	1997	1998
<i>Assets</i>					
Current assets:					
Cash and cash equivalents	\$19,708	\$70,033	\$44,584	\$46,780	\$138,133
Short-term investments & marketable securities	64,178	121,342	153,434	349,119	743,285
Accounts receivable (net)	10,140	35,256	49,473	42,190	59,417
Inventories	2,320	6,040	4,448	3,295	3,695
Prepaid expenses	6,957	4,100	9,269	13,393	34,896
Deferred income taxes	16,639	22,610	19,205		
Total current assets	119,942	259,381	280,413	454,777	980,125
Property and equipment, net	24,196	48,849	95,611	83,404	69,413
Intangible assets	33,345	28,267	16,449	19,836	85,797
Goodwill	65,346	46,111	15,194	26,935	285,793
Other assets	1,753	1,594	10,353	78,724	77,468
Total assets	\$244,582	\$384,202	\$418,020	\$663,676	\$1,498,596
<i>Liabilities and stockholders' equity</i>					
Current liabilities:					
Accounts payable	\$12,872	\$19,714	\$33,972	\$35,688	\$44,035
Accrued compensation and related liabilities	8,002	14,334	15,473	22,458	23,728

(Continued)

Exhibit 5. (Continued)

	1994	1995	1996	1997	1998
Deferred revenue	5,272	6,038	18,974	22,732	58,560
Other accrued liabilities	24,670	48,390	42,270	99,583	124,820
Income taxes payable		9,607		3,811	3,044
Deferred income taxes				27,310	120,482
Total current liabilities	50,816	98,083	110,689	211,582	374,669
Long-term deferred income taxes	7,943	507	2,513	589	
Long-term notes payable		4,426	5,583	36,444	35,566
Common stock, \$0.01 par value	192	439	458	469	593
Additional paid-in capital	349,989	490,225	530,818	558,391	1,080,554
Deferred compensation	(63)	(30)	(1)		
Unrealized gain on securities (net)				20,668	181,071
Cumulative translation adjustment	(35)	175	(501)	(1,236)	1,531
Retained deficit	(164,260)	(209,623)	(231,539)	(163,231)	(175,388)
Total stockholders' equity	185,823	281,186	299,235	415,061	1,088,361
Total liabilities and stockholders' equity	\$244,582	\$384,202	\$418,020	\$663,676	\$1,498,596

Source: Adapted from Intuit 10K statements.

Exhibit 6. Consolidated statement of operations (\$'000, except per share data).

	Twelve months ended 30 September 1993	Ten months ended 31 July 1994	Twelve months ended 31 July 1995	Twelve months ended 31 July 1996	Twelve months ended 31 July 1997	Twelve months ended 31 July 1998
Net revenue	\$121,372	\$194,126	\$395,729	\$538,608	\$598,925	\$592,736
Costs and expenses:						
Cost of goods sold:						
Product	39,160	50,941	105,603	136,470	137,281	120,538
Amortization of purchased software		18,558	11,369	1,399	1,489	2,905
Customer service and technical support	22,623	34,970	73,359	106,872	119,762	117,714
Selling and marketing	28,575	41,814	99,595	142,319	162,047	164,834
Research and development	12,479	22,057	53,368	75,558	93,018	108,604
General and administrative	5,304	10,544	24,417	33,153	37,460	36,719
Charge for purchased research and development		151,888	52,471	8,043	11,009	53,800
Other acquisition costs		40,412	41,775	40,570	26,543	24,204
Total costs and expenses	108,141	371,184	461,957	544,384	598,965	629,318
Income (loss) from operations	13,231	(177,058)	(66,228)	(5,776)	(40)	(36,582)

(Continued)

Exhibit 6. (Continued)

	Twelve months ended 30 September 1993	Ten months ended 31 July 1994	Twelve months ended 31 July 1995	Twelve months ended 31 July 1996	Twelve months ended 31 July 1997	Twelve months ended 31 July 1998
Nonrecurring items:			41,293	(6,344)	71,240	4,321
Microsoft merger termination fee, gains and losses from discontinued business, etc., net						
Interest and other income, net	624	2,507	4,045	7,646	9,849	12,438
Interest expense	(100)	(10)	(232)			
Income (loss) before income taxes	13,755	(174,561)	(21,122)			
Provision for income taxes (benefit)	5,344	1,752	24,241	16,225	12,741	(7,666)
Net income (loss)	\$8,411	\$(176,313)	\$(45,363)	\$(20,699)	\$68,308	\$(12,157)
Net income (loss) per share	\$0.37	\$(5.22)	\$(1.11)	\$(0.46)	\$1.47	\$(0.24)
Shares used in computing net income (loss) per share	22,700	33,804	40,762	45,149	46,424	49,676

Source: Adapted from Intuit 10K statements.

Exhibit 7: Consolidated statements of cash flows increase/(decrease) in cash and cash equivalents (\$'000) for years ended July 31.

	1996	1997	1998
Cash flows from operating activities			
Net income (loss)	\$(20,699)	\$68,308	\$(12,157)
Adjustments to reconcile net income (loss) to net cash provided by operating activities:			
Net gain on sale of discontinued operations		(71,240)	
Discontinued operations loss offset against gain		(9,668)	
Gain on disposal of business, net of tax			(1,621)
Gain on sale of facility			(1,501)
Charge for purchased research and development	8,043	11,009	53,800
Amortization of goodwill and purchased intangibles	44,502	29,715	24,330
Depreciation	23,853	28,952	28,908
Changes in assets and liabilities:			
Accounts receivable	(10,498)	7,482	(17,055)
Inventories	2,128	1,445	(1,044)
Prepaid expenses	(4,817)	(4,090)	(14,104)
Deferred income tax assets and liabilities	(1,989)	(14,501)	(39,221)
Accounts payable	12,281	(26)	8,206
Accrued compensation and related liabilities	47	6,441	1,403
Deferred revenue	9,723	58	6,320
Accrued acquisition liabilities	(5,733)	1,445	(29,185)
Other accrued liabilities	(4,624)	22,931	43,491
Income taxes payable	9,258	2,888	17,767

(Continued)

Exhibit 7: (*Continued*)

	1996	1997	1998
Net cash provided by operating activities	61,475	81,149	68,337
Cash flows from investing activities:			
Proceeds from sale of facility			9,025
Purchase of property and equipment	(69,321)	(27,597)	(33,561)
Sale of marketable securities		29,500	
Acquisitions and dispositions, net of cash acquired	40	(34,224)	(350,288)
Increase in other assets	(1,628)	(970)	(1,276)
Purchase of short-term investments	(197,003)	(258,892)	(293,306)
Liquidation and maturity of short-term investments	165,046	215,338	213,176
Purchase of long-term investments		(41,150)	(17,009)
Net cash used in investing activities	(102,866)	(117,995)	(473,239)
Cash flows from financing activities:			
Principal payments on long-term debt	(3,187)	(661)	(4,798)
Proceeds from issuance of long-term debt		30,277	
Net proceeds from issuance of common stock	12,864	9,426	501,053
Net cash provided by financing activities	9,677	39,042	496,255
Net increase (decrease) in cash and cash equivalents	(31,714)	2,196	91,353
Cash and cash equivalents at beginning of period	76,298	44,584	46,780
Cash and cash equivalents at the end of period	\$44,584	\$46,780	\$138,133

Source: Adapted from Intuit 10K statements.

Exhibit 8. Selected notes to financial statements.

Mergers and Acquisitions

On 12 December 1993, the Company completed its acquisition of ChipSoft, Inc. (“ChipSoft”). The total purchase price of the acquisition was \$306.4 million in common stock, stock options, and acquisition costs (\$255.3 million net of tangible assets acquired). The acquisition was treated as a purchase for accounting purposes, and accordingly, the assets and liabilities were recorded based on their independently appraised fair values at the date of the acquisition. Of the purchase price \$150.5 million was allocated to in-process research and development, \$33.5 million to intangible assets, and \$82.3 million to goodwill, including approximately \$11.0 million relating to the tax effecting of identified intangibles. The amount of the purchase price allocated to in-process research and development was charged to the Company’s operations at the time of the acquisition. In addition to the in-process research and development charge, the Company incurred merger-related charges of approximately \$20.4 million during the ten months ended 31 July 1994, of which \$13.0 million related to the termination of the Company’s agreement to acquire Legal Knowledge Systems, Inc. Results of operations include ChipSoft from the date of acquisition.

On 27 September 1994, the Company completed its acquisition of Parsons Technology, Inc. (“Parsons”), a privately held consumer software publisher, pursuant to which Parsons became a wholly owned subsidiary of Intuit. Under the terms of the agreement the Company paid approximately \$28.8 million in cash and issued approximately 1,800,000 shares of the Company’s common stock to Parsons’ shareholders. The transaction, which was accounted for as a purchase, had an aggregate purchase price of approximately \$67.3 million, which, in addition to the above amounts, includes approximately \$2.7 million in cash and 138,038 shares of common stock that will be paid as deferred compensation for certain non-competition agreements. Of the purchase price, approximately \$44.0 million was allocated to in-process research and development, \$14.0 million to intangible assets and \$9.9 million to goodwill. The amount allocated to in-process research and development was written-off in the first quarter of fiscal 1995. Results of operations include Parsons from the date of acquisition.

Source: Intuit 10K for fiscal year ended 1995.

Illustrated Items' Immortal Etchants¹

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Background

This case provides an example of a burgeoning movement in the chemical community known as Green Chemistry. “Green Chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.”² In this instance, a company sought external assistance from the Office of Technical Assistance for Toxics Use Reduction (OTA). The OTA is a service provided by the Commonwealth of Massachusetts to businesses using toxic materials, to help them to use safer materials, or less of the toxics they use, and to help them comply with laws relating to the use of toxic materials. The service is confidential — by law, OTA must report only situations that pose an immediate threat to health,

¹ John Warner, of the University of Massachusetts, Lowell developed this case for instructional purposes only. The author thanks Rick Reibstein of the Massachusetts Office of Technical Assistance for Toxics Use Reduction (OTA) for providing the information about the work OTA did with the case study company. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the author or reproduced in any way.

² <http://www.greenchemistry.uml.edu/html/generalinfo/understand.htm>.

safety, or the environment. Many companies are still reluctant to ask OTA on-site, because they think no good will come from a visit from a government agency. The following case study shows how some government environmental agencies do not find and punish violations, but do something very different. The names of the visited companies and their officers have been changed, but nothing else is fictional. This is a real case study.

The Problem

Illustrated Items is an 80-person company that etches designs on a variety of metal products, such as metal labels and decals. They accomplished this through the use of suitable chemical baths, such as a 1:1 mixture of hydrofluoric acid (HF) and nitric acid (HNO_3) for stainless steel. After the company bought the stainless steel etching line of a nearby company, it found that it was violating discharge limits to the local Publicly Owned Treatment Works (POTW). The POTW encouraged the company to address the problem, but it persisted. After a couple of years, a permit audit of the POTW by officials of the US Environmental Protection Agency (EPA) led to a notice of violation and a proposed penalty, from EPA.

At about this time, OTA was sending mailings to Massachusetts industries, alerting them to the availability of its services. Illustrated received the mailing from OTA, and the Company President John Pine gave it serious consideration. Because there was no charge for OTA's help, and because Illustrated was already in trouble with the EPA, he decided to take a chance.

OTA visited Illustrated and received a walk-through of the facility. Pine sat down with the office and explained how the etching process worked. OTA's regional team leader, Paul Richard, thought that perhaps the etchant could be regenerated — made new and effective again, after use, so that it need not have to be discharged. Two years before the visit, OTA had learned about acid regeneration that was being successfully employed at an IBM facility in East Fishkill, New York. OTA had contacted the developer of this process and had arranged for him to come to Massachusetts and give a talk to companies

performing etching operations. Dr Lawrence David of IBM explained to members of the Photochemical Machining Association that by bubbling ozone into spent etchant he had reversed the reduction/oxidation process that had rendered the etchant no longer useful, and he could now reuse it. He explained how he very carefully monitored this process through daily titration and use of ozone gas monitors, and that he rendered his etchant bath "immortal". Once he had disposed of it every 12 days. Now, he used the same amount over and over.

Richard knew that he would have to convince Pine that the ozone regeneration process would work for his production line. He and his team member Roland Beaudette arranged for bench-scale testing at Worcester Polytechnic Institute. (This afforded some engineering students with a very valuable educational project.) OTA also worked with Pine on bath contaminant removal. The bench-scale tests indicated that ozone regeneration would work. OTA contacted vendors of the necessary equipment, and Pine went ahead with adding the regeneration step to his production line. Illustrated Items successfully implemented etchant regeneration. This enabled the company to cease its discharges to the local POTW.

Pine also discussed the project with EPA attorneys, who were pleased to give the company time to pursue etchant regeneration, as it would reduce pollution and serve as a good example. It was also a demonstration of the company's good faith, because Pine was investing time and money in finding a permanent solution to his waste problem. His behavior contrasted well with companies who chose to contest EPA's penalty proposals instead of responding to the problem, or who responded by managing the wastes, rather than preventing them from occurring.

The Outcome

The company was at this time generating 120 drums of etch waste a year, at an estimated cost of about \$200 for disposing of each drum. The etchant regeneration eliminated the wastewater discharge from the line, and cut the number of drums of hazardous waste to 24 drums a year, saving \$19,200. It reduced the need to purchase virgin etchant

from 700 to 1 drum per year, saving \$209,700. In addition, EPA reduced Illustrated's fine by \$45,000, because it implemented the zero wastewater discharge system.

The \$273,900 in total avoided costs does not include a reduced need to manage hazardous waste or wastewater discharge, including time to fill out hazardous waste transport manifests or complete discharge monitoring reports (both legal requirements). These savings accrued annually over a period of about 10 years, when competition with China led to the decline of these operations, to about 10 percent of previous volume.

As this was a low profit manufacturing line, worth only an estimated \$200 K/year, this "marginal business" would likely have simply been discontinued, if OTA's help had not been available. According to Company President John Pine, the line employed approximately six people, and "if OTA wasn't there, there is a good chance those jobs wouldn't be there".

Summary

The following problems and issues need to be considered:

1. What do you think this case says about the relationship between government and the regulated community? Do you think it indicates the possibility for a different kind of relationship, than what most people think of, when they talk about environmental agencies?
2. Can you think about how such a service should be managed? What expertise would you need? How you would make sure the service gave quality advice? How could the service get into trouble and how that could be avoided?
3. How do you think the assistance service and the enforcement agencies should coordinate their work? What do you think about the way EPA responded to the company?
4. How do you think the assistance service should work with private vendors? What if the vendor provides something that does not work?

5. Do you think that, because the service is helping businesses, it should charge a user fee? Or that it should not be competing with private consultants? Do you think there are some things that businesses will not pay for, that they should nevertheless receive?
6. Can you think of other examples of assistance that government provides?

Epilogue

OTA has provided on-site advice to over 1,300 companies in the 17 years it has been operating. Studies show that OTA's work is associated with millions of pounds of toxic use reduction, and that many companies have saved money and jobs as a result of accepting help from this service. A very interesting aspect of this story is that although OTA has developed considerable expertise in many areas of industrial production, OTA staff never walk into any facility knowing more about the production line they view than those who run it. Yet, they constantly find opportunities to improve operations. Why is that?

Companies are very much focused on producing the product that provides them with revenue. Staff are responsible to those above them for implementing production plans. They view the line everyday with an eye toward getting the job done. But OTA takes a different view when they enter a facility. They look at all the ancillary issues. Is material being lost at any point? Is there an alternative that can be used? What would happen if you ran the etching bath at a lower temperature (thus reducing air emissions)? How much is being spent on managing a waste? When chemical X is chosen because it is cheaper than chemical Y, was the extra cost of having to manage chemical X as a hazardous waste considered? What is done about what drops on the floor? Is it hosed down at the end of the day, sending the dropped material to wastewater treatment? Has anyone thought about how that may be one of the reasons a company has problems meeting wastewater discharge limits?

Companies may not have thought about these issues because they are not directly related to their profit-making activities, although they do result in costs, and sometimes those costs are significant enough

to affect profits. But to see the connection, and to see that alternatives might be more attractive in the end, they may need someone to take a fresh look at things and consider aspects that may have been missed. OTA, and the many services like OTA that exist in most states and several countries, operate to help companies take account of the bigger picture. They also share things that they have learned from other companies, without violating confidentiality.

For example, once OTA staff saw at one company equipment that moved granules from a storage bin to the mixing vats by pneumatic tubes, they were able to recommend this method to other companies, where moving paper bags of granules constantly led to material losses and cleanup problems. Once OTA staff learned that one company had coated its mixing vat with Teflon and could thus clean it by scraping down with a giant spatula, instead of filling it with hot water and creating a large amount of wastewater to discharge, the office could share this information with others. Once OTA learned that some companies were using diagnostic maintenance to reduce component change outs, thus reducing waste and better preventing equipment failures, they could help other companies to think about improving the integrity of their operations. In this way, services like OTA help create a kind of shared intellectual capital that promotes the growth of a cleaner industry.

Topic Area 5

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Commercialization of New Technology

Commercialization of a new product may represent a major step for an entire firm. The firm will seek a new place in the market and it will also need to consider how the new product might change its internal operations and strategic direction. Commercialization of a new product may also require introduction of new production lines, reorganization of current operations, or entire new facilities. From an administrative perspective, new department, divisions, or even subsidiaries may be created. For some firms, this will be a relatively simple process while for others, especially smaller firms, it will be a major step into a more competitive world of business.

For most firms, commercialization of a new product begins when top management, typically with the help of the entire new product development group, selects an appropriate prototype as the optimal product for commercialization. The decision regarding which prototype to select for commercialization is based on the results of extensive technical and market testing and resource availability. Top management must consider the nature of the product being introduced to the market and its overall impact on current operations. Market conditions, consumer demand, and economics conditions, among others, may directly impact the future of the product in the market at the time of commercialization.

Investments in manufacturing facilities need to be made to accommodate production of the new product. Top management needs to make these decisions ahead of actual product commercialization. In a highly competitive global business environment many firms may have options regarding their needs for production facilities. Firms today may opt to have their products produced by vendors that specialize only in contract manufacturing. Several geographic areas in the world

today offer substantial production capacity to firms which are reluctant to invest in their own production facilities. This option is dramatically changing conventional production and manufacturing firms, even in more established markets; they become product developers and marketers rather than traditional comprehensive producers or manufacturers. Subcontracting production, and even warehousing or distribution, is an increasingly common occurrence, especially among more internationally active firms.

In addition to outright subcontracting of production, firms also enter into agreements and strategic alliances to reduce production costs. A firm in one market may enter into a cross-production agreement with a firm in another market to produce each other's products in the relevant markets. In situations where a firm becomes a partner in an industrial network or a supply chain, the new partner may be asked to produce the product at the point in the supply chain where the final product is assembled. Such arrangements are found in the automobile, electronics, and even food industries worldwide.

Firms commercializing their products in the highly competitive global environment today have a number of strategic production options. Traditional firms may simply continue to physically expand, or otherwise modify the organizational and operational functions of their business, for the purpose of commercializing another new product. More flexible and innovative firms may, in fact, seek the assistance of other firms that offer production services along with warehousing and distribution services. Some firms could find other firms that even offer commercialization and marketing activities. The various options for product commercialization and marketing have a significant impact on the strategic position of a firm in the contemporary hyper-competitive market. Smaller firms may become more flexible in terms of new product introduction and less burdened by their physical resources or administrative structures.

In spite of the approach that top management decides to take regarding its production strategy, commercialization of new products usually involves a number of well-defined activities. For most firms, product commercialization begins at the end of the new product development process. This process is finished when the product

development team or the product development specialists have completed and tested the prototypes and provided comprehensive documentation on the development process itself and on the technical and market testing of each prototype.

Typically, a committee of top managers responsible for new product selection reviews the prototypes and the necessary documentation and selects a prototype for commercialization. The prototype and documentation are then turned over to commercialization specialists. These specialists are responsible for developing an effective and efficient marketing strategy and introducing the new product in the target market for which it was developed.

Several approaches are used in formulating marketing strategies to commercialize new products. From a marketing perspective, the primary differences between marketing strategies used to commercialize a new product depend on the initial size of the market, availability of the product, and competitive timing. The size of the market may vary from a large mass market to a small market niche; each requiring a different marketing strategy. The availability of a product is also important. If the product is available in large quantities and market demand is growing, a relatively aggressive marketing strategy is needed while a product available in small quantities and with relatively low demand needs another type of marketing strategy. Marketing specialists working closely with top management need to agree on what kind of marketing strategy will be developed. Given the databases available to marketing managers today, customized marketing strategies can be developed and implemented relatively quickly. In most cases, these strategies can be modified as the new product is being marketed depending on how the market responds to the new product.

The general consensus among marketers, especially those managing commercialization of high technology products, is that a product is developed for a specific target market and the marketing strategy being developed must consider both the nature of the product as well as the target market. In reality, there has to be a balance between the product attributes of the product being commercialized and attitudes, perceptions, and preferences of individual consumers or users in the selected target market. This fine balance between the product and the

target market is the main factor that contributes to the market success of a new product.

The core of any marketing strategy is the set of factors that can be directly controlled by marketing specialists. In marketing literature, these factors are known as the marketing mix — the product, the price of the product, its promotion, and distribution. The most fundamental literature in marketing considers these factors as being completely under the control of marketing managers. These factors represent the core ingredients in the formulation of a marketing strategy. Marketing strategy is considered an optimal combination of these ingredients based on the level of expertise of the marketing manager responsible for the ultimate formulation of a marketing strategy. It is also important to realize that any marketing manager formulating a marketing strategy must take the firm's marketing philosophy into consideration.

Although market introduction of a new product assumes that the product is well tuned for the market, some attributes of the product may need to be changed as the product goes through the various stages of consumer acceptance in the market. For example, technologically new products may need to be adjusted for the market after they have been introduced. This is particularly true when the new product requires additional education for its consumers or users. The amount of knowledge necessary to operate the product may have to be reduced, or otherwise simplified, to make it easier for the product in the market.

The budget that top management is willing to approve for the commercialization of the new product is one limiting factor in the development of an optimal marketing strategy. As the marketing strategy for the new product is formulated, the responsible marketing manager needs to prepare a comprehensive budget and present it for approval. Internal financial and accounting information and current estimates from the suppliers of professional services such as advertising, packaging, or even transportation services are required for developing the budget. Top management may accept the budget as presented, ask for revisions, or set financial limits within which the marketing manager may operate.

The changing competitive situation in the market is another limiting factor important for the development of a new product's marketing strategy. Although the competitive situation is monitored throughout the product development process, the competitive situation may change significantly by the time the product is ready for the market. As the product is introduced to the market, sales of competitive products already on the market need to be closely monitored and the ongoing development of new products by key competitors systematically tracked. A number of marketing research and publicity firms track this type of information for their clients. All competitive information must be periodically reviewed, sometimes on a daily basis, depending on the expectations that top management has for the new product.

Top management strategy in some firms suggests that the budget developed for the individual controllable factors of a given marketing strategy is relatively fixed. However, the budget component that is earmarked for competitive positioning of the new product in light of changing competition may have more financial flexibility and is subject to top management's discretion in confronting changing competition in the market.

A comprehensive marketing strategy also needs to consider the environmental framework in which the firm and the market operate. Firms and markets are constrained, or influenced, by the environmental forces that shape the operations of individual firms and their markets. The environment in which firms operate is generally perceived as consisting of technological forces that determine the internal climate of that environment, economic forces shaping the internal climate of the environment, life-style forces of consumers functioning within that environment, and social forces determining the political, ethical, and legal nature of the environment. Firms can freely operate within the limits of these forces, and set their marketing strategies, but cannot operate outside of these forces. For example, a firm may introduce a new high technology product to the market. If the consumers in that market perceive that product as threatening their well being, or destroying their welfare, the consumers will petition their government to stop the selling of that product. Or, if a product is

considered to be damaging to the physical environment in which the consumers function, they will also take steps to remove the product from the market.

Consumers tend to behave in relatively predictable ways. Consumer behavior can be systematically studied with the use of well-developed models and can focus on consumers' acceptance, or non-acceptance, of individual products. When consumers make decisions about their purchases, they tend to proceed through stages. They typically become aware of new products; they become interested in those products and tend to look for information about them. Once they have sufficient information, consumers tend to evaluate each product to determine which product they prefer. If possible, they actually try the preferred product. This trial process may consist of an actual purchase of the product, depending on the price of the product, or some other form of involvement such as an in-store demonstration or a home trial period. If they decide they like the product, they will purchase it.

Studies of consumer behavior and adoption of innovation point out that virtually every target market can be divided into categories of consumers. Although these categories may be labeled differently in different models, they nevertheless are helpful in understanding which consumers tend to purchase market innovations early and which consumers never purchase the innovation. Because different consumers have different levels of propensities to adopt innovations, marketing managers must understand how these propensities differ among the consumers or users in the designated target market. These models are also useful in understanding which categories of potential customers or users require what type of information and what are the information channels that can deliver the appropriate information to them.

Marketing managers also need to be aware of how consumers or users rely on each other in deciding which innovation to accept and which to reject. Individual consumers and users tend to identify individuals who have higher propensities to adopt innovation and communicate with them about their own attitudes, perceptions, and preferences. If they cannot directly communicate with these individuals, they tend

to carefully watch them. Most consumers tend to purchase new products as a result of a testimonial concerning the new product. The influences on the consumers of decision making of other consumers is an important part of diffusion of all types of products, consumer or business-to-business, especially when high technology products are concerned.

The commercialization process also needs to consider the relatively complex process of comparison between existing products and the new product being introduced to the market. Since consumers and users tend to perceive products as a series of improvements, they tend to be suspicious of products that are dramatically new or significantly different in their appearance from the existing products. In commercializing new products, especially high technology products, the innovation needs to have some element of relative advantage over the existing products and, at the same time, there must be an element of compatibility between the old and new products. Consumers tend to ask, why should I pay more for the new product if the old product is just as good? If the new product has incremental innovations built into it, which make the product more desirable, and can still be compared to the old product, consumers may accept it more readily.

New products cannot be technologically so complex that consumers or users need to become more educated in order to use them. Many consumers expect that they can intuitively operate almost any product available on the market. Sometimes consumers or users also insist that they want to try an innovation before they purchase it. However, some high technology products cannot be tried without first training the operator.

Consequently, commercialization of high technology products requires today not only that the marketing strategy specifically focus on the appropriate target market, but also requires that the inherent advantages of the new product, and any innovation, can be effectively communicated to the ultimate consumers or users. If marketing managers cannot communicate these advantages, no matter how dramatic, the consumers or users will not purchase the product.

The process of commercializing products is one of the most important steps in consumer or business-to-business marketing. The

commercialization process serves as a bridge between the new product development effort in the firm and the market for the firm's products. It also represents a transition between the extensive scientific, technical, and engineering know-how needed to successfully develop a product and the business, more specifically, marketing know-how that is needed to determine what potential consumers or users expect from the firm. In reality, the commercialization process facilitates a great deal of communication between the technical and the marketing sides of the firm. Technical specialists provide the information that enabled the product to be developed from the scientific perspective, while the marketing specialists use their skills to communicate the advantages of the new product to the market.

Marketing specialists systematically gathered market information from potential consumers or users during the new product idea generation and conceptualization stages. After the commercialization stage, the technical specialists work closely with the marketing specialists in fine-tuning the product in the market. In new and rapidly growing globally competitive firms, this close cooperation between the technical and the marketing sides of the firm is essential. In fact, an increasing number of scientists and engineers are beginning to function as marketing specialists in order to better understand the rapidly changing market.

New Product Launch and Marketing Research Findings¹

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Henrik Axelsson felt ambivalent as he read through a marketing research report that he had recently commissioned. The findings in the report were positive, but were they positive enough to convince some skeptics on the Board? Henrik looked at the report again and thought — should I contact another marketing researcher or is the study and its findings adequate to make a decision now?

Background

Henrik Axelsson, one of the four product managers at HealthTooth, a mid-sized multinational company situated in northern Sweden, was sitting in his office concerned about the findings of a consumer taste test that he had just read. He thought that the findings were reliable. However, he had hoped for results that none of his fellow managers

¹ This case was developed by George Tesar and Agneta Marell, Umeå School of Business at Umeå University in Sweden, for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

could dispute. He remembered a similar product launched 10 years ago. The product was considered to be clearly a potential success. It had no significant drawbacks; it was judged to be nutritious, healthy, and free of preservatives. None of the consumer studies at that time indicated any problems. Even so, the product failed in the market. The currently proposed product has similar attributes.

In addition to this experience, Henrik knew that, during the last year, the company had launched quite a few new products in different areas and not all of them had been successful. The cost for introducing these products was high and, as the product line increased and demanded more personnel and changes in production lines, margins became smaller and, in turn, the company's profit had dropped significantly enough to be concerned about additional new product introductions. It was obvious that the entire new product development effort inside HealthTooth was being closely observed and managed. Even Board members were regularly informed about new products coming up through the new product development process.

About the HealthTooth

HealthTooth is in the health drinks and food business. Regional growers and farmers provide the raw ingredients for most of its products. HealthTooth was founded in 1958 and, in the beginning, produced only a few products. During the last 10 or 15 years its market focus has changed. Product development efforts increased and, consequently, most product lines were expanded. Different types of packaging concepts were introduced. Refrigeration technology was adopted and refrigerated products were offered to customers. As a result, its competitive posture changed drastically. New product development activities intensified during the last few years. Increased investments in new product development over the last few years have been driven not only by growing competition, but also by changes in consumer preferences and future lifestyle changes.

HealthTooth has about 450 employees. Administration accounts for about 70 employees and the rest are in production. It has four product managers. Each product manager is responsible for either

a few large nationally selling products or a large number of smaller locally distributed products. All product managers have their own budget and they plan and implement all their own marketing activities. Product managers also have a big impact on the Board's decisions.

New Product Efforts

HealthTooth generates a lot of new product ideas. Some of these ideas have a strong potential for becoming great products while other ideas need more careful consideration. New product ideas need to be screened both for commercial feasibility and market acceptance. After new product ideas are screened they are converted into new product concepts. Concepts are developed into product prototypes.

Currently, HealthTooth is in the process of developing a new type of drink. Two versions were developed internally. Prototype α was flavored with orange juice and prototype β with tropical fruit juice. Because the product is either orange-juice- or tropical-juice-based, it is difficult to classify either one as a juice drink or a soft drink. Nevertheless, as part of its product development, HealthTooth wanted to find out what consumers thought about the two alternatives. HealthTooth contracted with a marketing research company to conduct a test to determine consumer preferences for the two prototypes in terms of taste, color, and aroma.

Henrik knew that Edvin Albinsson, the Sales Manager, did not support the development of these two prototypes and consequently would not support the actual launch of either prototype. Edvin was negative throughout the development process. He had been around when one of their competitors launched a similar product 10 years ago and failed. Henrik also knew that Karl Gustafsson, the Marketing Director, did not like the new prototypes either. Karl's son, and some of his son's friends, had tried them and said that they did not like them. Up to now Edvin's and Karl's arguments had not been very strong and persuasive. The product development process proceeded on schedule without any major obstacles. However, due to

constant rumors about these prototypes and the lack of support from Edvin and Karl, a report on the new product development progress was scheduled to be on the Board's agenda again the next week. The entire future of the two prototypes appeared to be at stake. Karl had access to some of the executives in the company; he had good intuition and a reputation for being very convincing in front of the Board.

With all these negative reactions, Henrik wondered if the two prototypes were worth all the effort. He knew that he would be asked about the budget again and that the entire project might be questioned. He felt that he really needed to make a strong case for the two prototypes and convince the Board to go ahead with, at least, a reasonable market test.

Time Limitation

Henrik had additional information; through his outside connections he knew that one of their competitors, an international soft drink company, had developed and was now testing a similar product. Its product was a success in many countries. All its successful products were developed locally by small local subsidiaries. The products were adjusted for local consumer preferences.

Henrik was convinced that HealthTooth needed to have a pioneering advantage in its own market in Sweden. The international competitor was moving closer toward full market introduction of its new product in Sweden. As a Product Manager, Henrik felt a great deal of pressure. Time was running out. The Board was reluctant to fully support his prototypes and competitors were moving closer to the Swedish market.

Which Prototype to Launch?

Henrik went through the consultant's report again and thought of possible questions that could be asked by the Board and what his answers might be. Perhaps he could recommend only one of the two versions. He also carefully reflected on the conclusion

of the report provided by the marketing research firm. In order to be well prepared for the Board meeting, Henrik thought very much about the actual launch the new product would need. He imagined the target market with its individual consumers, the promotional campaign that needed to be developed, the price level which he had tentatively set some time ago, and the necessary modifications that were going to be needed in the distribution channel. Henrik was also concerned about the potential image of the new drink that would be needed in the market to gain profitable acceptance levels. This will be a great challenge for all of us, Henrik thought.

The main concern that preoccupied Henrik was the question of whether or not he could trust the results of the report provided by the marketing research firm! More specifically, had the study been properly conducted and what had been the impact of the introduction of two versions of the product on the study findings? Based on the nature of the data and information produced by the study, he was concerned about the results presented in the report. Henrik was not prepared to fully back the results of the study. He was not confident enough to make an objective decision — which product prototype to launch — α or β ; or, should HealthTooth launch both?

Henrik's concerns and doubts were well founded. He was looking for solid conclusions in the report, but he did not find them. When he started reviewing the details of the study, he found several inconsistencies. Although Henrik did not have extensive training in marketing research, he realized that not only did he not have the information needed to select which prototype to launch, but he also did not even have enough information from the report to explain the general aspects of the study to the Board.

The report submitted by the marketing research firm was relatively short and consisted of a description of the study and a presentation of findings. At the end there was a short but interesting note attached to the report. Henrik proceeded to outline and summarize the report so that he could better understand it. The following is a short description of the study and the main parts of the report.

The study

The study consisted of a total of 250 personal interviews and was organized into two stages: a “taste test” and a “price sensitivity study”. The interviews were conducted among individuals between the ages of 16 and 74. A majority of the participants, 66 percent, were women. The taste tests were conducted over 3 days and the interviews took place in three different locations: (1) the central hall of the Social Science Faculty at the local university, (2) in the entrance hall of the university hospital, and (3) at a local shopping center.

The individuals included in the study were faced with different drink options. Half of the respondents were stopped and invited to taste a juice-based drink that had soda water added to it while the other half of the respondents were asked to taste a soda-water-based drink that had fruit juices added to it. Each prototype was tested in two versions: carbonated water added for “refreshing” quality or soda-water-based with fruit juice added to give it a “healthier” quality. The respondents were randomly assigned to one of two groups.

Price sensitivity was also tested to determine how much consumers would be willing to pay for the product. The participants were randomly assigned to one of three different groups. Each group was presented with different price levels. The first group was assigned a price of 12.00 SEK² per liter of the drink on the retail level, the second group a price of 15.00 SEK per liter, and the third group a price of 18.00 SEK per liter. The respondents had to select which relative price level they would be willing to pay for a liter of the drink purchased at a local retail store.

The findings

Orange for women, tropical for men: The majority of those who tasted the drinks thought that both versions tasted good. Seventy-six percent of those who tasted the drink flavored with orange juice thought

² SEK represent Swedish currency (Swedish Crowns). At the time when this case was being developed \$1.00 equaled approximately 9.72 SEKs.

that the drink was “good” or “very good”. Sixty-eight percent thought that the drink flavored with tropical juice tasted “good” or “very good”. Although most study participants liked both drinks, there were differences of opinion between men and women. Eighty percent of the men thought that the tropical flavor was “good” or “very good”, while only 60 percent of the women responded that the tropical flavor was “good” or “very good”. The opposite was true for the drink flavored with orange juice, where 81 percent of women indicated that it tasted “good” or “very good” while only 60 percent of men indicated the same preferences.

The main reason respondents preferred the orange-juice-based drink was because it had a citrus, specifically, orange taste. The respondents who preferred the tropical-juice-based drink liked it because it tasted sweet. According to the report, these findings could be interpreted as follows: (1) women preferred a “sour taste”, while (2) men preferred a “sweet taste”.

According to the respondents, both drinks were considered to be “refreshing”, “fresh”, and “smooth”. The majority, over 90 percent of the respondents, suggested that these characteristics applied to both products. Over 70 percent of the respondents suggested that the descriptions “full-flavored”, “light”, and “healthy” also apply to both products. However, the women in the study indicated that these descriptions were more suitable for the two products than the men in the study. The men in the study preferred to reserve this description for the tropical-juice-based drink rather than the orange-juice-based one.

Lack fruitiness: Most respondents liked both drinks. Some of the respondents felt the drinks lacked an attribute described as “fruitiness”. This was particularly true for the drink flavored with orange juice — 35 percent of the respondents felt that it needed more “fruitiness”. Only 18 percent of the respondents felt that the tropical-juice-based drink lacked “fruitiness”. Moreover, 20 percent of the respondents felt that the orange-juice-based drink was not “strong enough”. Fifteen percent of the respondents felt the tropical-juice-based drink was not “strong enough”.

Full-flavored texture: Both drinks were considered to have a good “texture”. Only a few respondents felt the texture was not good. The “texture” was described as full-flavored and thick, characteristics considered positive. Some considered the consistency as “smooth”, “light”, and “soft”. The few respondents who did not like the “texture” considered both drinks as “slushy”, not having enough pulp, and described them as “granular”, “floury”, or even “milky”.

Women liked the color of the orange juice drink: The respondents judged the color of the drinks before they were allowed to smell or taste them. When the respondents considered only the color of the drinks, just over half of them felt that the drinks did not “look good”, “fresh”, or “refreshing”.

After tasting the drinks, the respondents reacted differently. The orange-juice-based drink was considered to have a “better color” than the tropical-juice-based drink. About 45 percent of the respondents indicated that the color of the orange-juice-based drink was “good”, while about 30 percent of the respondents felt the same about the tropical-juice-based drink. There was also a difference between the men and women respondents as to how they perceived the color of the drinks. Sixty percent of the women indicated that the orange-juice-based drink looked “well”, while only 29 percent of men agreed.

Only a few respondents were interested in tasting the drinks: Before testing the product the respondents were asked to judge the color of the drink and the attractiveness of its color. This initial step in the procedure resulted in only a few respondents being interested in actually tasting the drinks. Only 29 percent of the participants in the study said they were tempted to taste the drink flavored with orange juice and only 15 percent were willing to taste the drink flavored with tropical juice.

The drinks looked healthy: The participants indicated that both drinks “looked like they would be healthy”. Seventy-six percent of the respondents felt the tropical-juice-flavored drink looked healthy and

66 percent felt the same about the orange-juice-flavored drink. It is interesting to note that all male respondents felt the tropical juice drink looked “very healthy” while only 69 percent of the women thought it looked “very healthy”.

The drinks’ aroma: Almost half of the respondents to the study felt that the drinks had a “good” or “very good” aroma. Forty-seven percent felt that the tropical-juice-flavored drink had a “good” aroma and almost as many, 42 percent, felt that the drink with orange juice had a “good” or “very good” aroma. Only a small percentage, 14 percent, described the drinks’ aroma as “not very good” or “not good at all”.

Men want to buy the drink flavored with tropical juice: Almost half of those interviewed for this study would consider buying one of the drinks. Only a small percentage, about 16 percent, would not consider buying the drinks. There were also differences in preferences between men and women for the tropical-juice-flavored drink. Sixty percent of men indicated that they were “likely” or “very likely” to buy the tropical flavored drink. Only 35 percent of women indicated that they would be “likely” or “very likely” to purchase the product.

No significant differences were found between buying intentions among men and women for the orange-juice-flavored drink. Fifty-three percent of men and 52 percent of women would consider buying this drink.

Less price sensitive for the tropical juice drink: The respondents indicated that they would be willing to pay a higher price for the tropical juice-based drink. Forty-seven percent of the respondents were willing to pay 12.00 SEK for one liter of the tropical-juice-based drink, while 31 percent were willing to pay 12.00 SEK for the orange-juice-based drink.

The same pattern, a higher percentage of respondents willing to pay for the tropical-juice-based drink than for the orange-juice-based drink, is seen for the 15.00 SEK price level. Thirty-six percent were

willing to pay 15.00 SEK for one liter of the tropical-juice-based drink and only 17 percent were willing to pay 15.00 SEK for one liter of the orange-juice-based drink.

Fourteen percent of respondents indicated that they were even willing to pay 18.00 SEK for one liter of the tropical-juice-based drink and 7 percent of the respondents indicated a willingness to pay 18.00 SEK for the orange-juice-based drink.

No differences between the packaging: The results demonstrate that price sensitivity is not influenced by which packaging is shown or if the drink is presented as a fruit-based drink or a soda-based drink. The respondents tended to prefer packaging with a fruit-based label than a soda-water-based label. Those respondents who were offered a soda-based drink had a greater tendency to say that the drink tasted “good”.

Both drinks were liked, but the orange-juice-based drink was preferred: The respondents were initially guarded when they first saw the colors of the drinks prior to the taste test because the colors were not appealing. However, after the taste test, a majority of respondents indicated that the drinks tasted “good”. It should also be noted that the “fruitiness” of the drinks was low, especially for the orange-juice-based drink.

Men and women experienced the tastes of the drinks differently. Women preferred the drink flavored with orange juice since it tasted of oranges and citrus. Men preferred the drink flavored with tropical juice, primarily because it was sweet. Both drinks were considered good and with a good balance of sweetness.

The taste test demonstrated that the respondents were inclined to pay more for the tropical-juice-based drink than for the orange-juice-based drink.

The following summary can be presented in favor of the orange-juice-based drink:

- The orange-juice-based drink was judged by a large percent of those who tested it as having a good taste.

- The orange-juice-based drink was more gender-neutral; both men and women were interested in buying the product, which was not the case with the tropical-juice-based drink.
- The orange-juice-based drink was judged to be visually more appealing.
- Women preferred the orange-juice-based drink more.

The following note was inserted in the report:

“When interpreting this information, it should be remembered that many studies have shown that men are less price-sensitive than women, especially for foods and perishable goods. This is considered a consequence of men doing this type of shopping much less than women. They tend to feel they can ‘afford’ to be less price-sensitive when they do actually shop.”

Henrik’s Dilemma

As a project manager, Henrik was well aware of his difficult position. He had an important position in a relatively small firm with a highly informal communication process and relatively easy access to all managers and top decision-makers. He was also expected to make regular presentations to the Board. His responsibility for new products required that he kept in touch with the market, perhaps through Edvin, the Sales Manager, and he needed to understand the strategic direction of the firm and its future market position, which means that he also needed to talk with Karl, the Marketing Director. Neither Edvin nor Karl were very cooperative or supportive when it came to development of the two prototypes.

On another level, Henrik needed more information from potential consumers. Based on his professional experience, he knew what kind of information he needed to make good decisions. He was willing to pay for good information because the risk of failing in a highly competitive market was relatively high. Both domestic and international competition was moving into the Swedish market. His expectations of getting the information he needed were high. Now that he had read

the report over and over several times, he was not satisfied with the findings.

Henrik carefully reviewed his notes on the findings and considered his alternatives. After a while, he decided that his alternatives ranged from simply going in front of the Board and explaining that both prototypes, α and β , should be shelved, to calling the researchers who prepared the report for additional information. Perhaps he could invite the researchers to assist him with the presentation to the Board. For the first time in his professional life, Henrik felt uncertain as to what alternative to select. Even when he did, how would he be able to defend his position?

Before he could finalize his decision, Henrik decided to learn more about marketing research and intercept studies. He found an older textbook on marketing research and began reading about sampling, taste tests, and writing up results of marketing research studies. After some time, he became even more convinced that he needed to talk with the marketing researchers who conducted the study and prepared the report. There were too many inconsistencies that needed to be cleared up.

On a piece of paper Henrik stated outlining the complexity of his problem. Can he rely on the findings of the study? If he can, then can he make a decision about the two prototypes and recommend the higher priced orange-juice-based drink. However, the question of how the carbonated water as opposed to juice added to the water was controlled still bothered him. If he cannot rely on the results of the study, should he simply commission another study? His budget does not allow for another study. Should he simply tell the Board that neither prototype should be considered for market introduction? He would be giving in to Edvin and Karl. His professional judgment was telling him that he needed to talk to someone with more experience. In his entire professional career, Henrik had never been confronted with a more complicated decision.

Borono-198: New Product Marketing Strategy¹

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On February 2000, Kathy Lewis the CEO of Agro Limited, along with Jon Shantz the COO, were reviewing the market attack plan to introduce Borono-198 in the biocide industry. Borono-198 was a new fungicide in the market targeted toward harmful fungus in cash crops, oak trees, and fluid tanks. Since Borono-198 was the first and currently the only product from this company, Kathy was counting on it to be a highly successful player in the fungicide market. Kathy and Jon determined that they needed to have target sales of at least

¹ This case was developed by Anusree Ganguly, Ph.D., Associate Professor of Chemistry at Ohlone College, Fremont, California and Shekhar Somanath of Qualcomm, Inc., Campbell, California for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the authors or be reproduced in any way.

2,500 boxes during the first year in order for their start-up to takeoff successfully on a strong footing. The company had recently launched a publicity blitz in the trade magazines about their impending product. Although, they had received quite a few enquiries, the enquiries had not translated into significant sales over the next couple of months. Total sales to distributors for the first three months were 50 boxes against the first year target of 2,500 boxes. In discussions with Jon Shantz, Kathy loudly wondered, "I thought this was a hot product! Is there a different marketing strategy that we should be using?" Jon Shantz was also responsible for the marketing of Borono-198. Although the total potential for this market was supposedly estimated to be about \$8.5 million, at the current rate her company did not even come close to securing a small share of that market.

The History

"I don't believe this!" was often the term Kathy Lewis used in her frustration to describe her amazement and despair at the lack of the commercial availability of the key intermediates in her multi-step synthesis of a series of chemical compounds. This was in the late 1980s when Kathy was a graduate student in organic chemistry in the famous laboratory of Dr. Robert Krzyewski at a top research university in Illinois. Kathy's research dealt with the synthesis of chemical targets intended to serve as bioactive molecules in medicine, as fungicides, pesticides, and anti-tumor agents. Quite content with her belief that perhaps the lack of demand was the reason for these intermediates were not apparent in chemical catalogs of commercial companies, she went about her doctoral work spending hours and days in making these intermediates on her own and thus delaying her research by the same time in each step.

After obtaining her PhD in bio-medical organic chemistry, and following a year of post-doctoral work at the University of Nevada-Reno, Kathy Lewis landed the most coveted tenure-track position as an Assistant Professor in the Department of Chemistry at a prestigious university in South Texas. In her interview, she had described her research plans based on the work that she had done in her

dissertation and had indicated to the selection committee that she wanted to continue in the same field of research in the event she was offered a position with the department.

The importance of Kathy's research and the promise of external federal funding that it brought with it immediately caught the selection committee's attention and they made her an offer exactly two days after her return from the interview. The university also provided a fairly sizable amount of start-up funds (to the tune of \$50,000) for her research laboratory set-up which was included as part of the offer. Kathy Lewis did not think twice about accepting this position.

Although the chemical intermediate was a substrate and a "starting material" for a variety of syntheses in organic chemistry, it was actually a simple benzene boronic acid which had been tested by Kathy during her graduate school days against anti-fungal activity. Although this compound itself had showed weak anti-fungal activity, it was the slightly modified version of this compound, containing a chloro group, and now named Borono-198, which showed very strong anti-fungal activity. Borono-198 was also routinely synthesized by Kathy in her lab at Texas and was used as a precursor in her synthesis for a long time before she was aware of the large biological activity that lay hidden in this innocent pale yellow powder. In fact, Kathy decided to test this compound for activity quite by fluke. She had actually synthesized a series of "target" compounds with slight differences in structures that she felt might be strong anti-fungal agents. At the microbiology lab of Dr. William (Bill) Smith, that tested these compounds, an attractive deal was provided for testing five or more compounds. Kathy had nine compounds to be tested and since the price did not change much, she included Borono-198 as a last test compound.

Kathy can never forget the Sunday morning phone call from Dr. Smith at her home. "Kathy, could you come over to lab as soon as possible? I have some data that might blow your mind," said Bill in a highly excited voice. It turned out that none of the nine compounds synthesized by Kathy showed any activity, but the Borono-198 showed an anti-fungal behavior that Bill had never before witnessed in his career. Kathy was taken completely by surprise. This case clearly

demonstrated how little the chemical community knew about connecting chemical structures with biological activity. “Unfortunately, even with all the recent advances in science this area of chemistry remains a “trial and error” zone. If only we had a better understanding of the chemical activities associated with structurally different compounds, we would have probably had a cure for cancer by now” Kathy mused to herself, with a grimace on her face.

Until recently Borono-198 was used in Kathy’s lab as a chemical intermediate that provided a common branching point to all her chemical targets. Thus, it was usually produced in bulk in multigram quantities and stored and used over a two to three month period until the next batch was required to be made. Although, this intermediate seemed, on paper, like a very simple compound to synthesize it was manufactured in the lab in two elaborate steps, each step requiring a synthesis and purification. This process took about a week to produce 5g quantities.

As a graduate student and during the initial years of her professorship at Texas, Kathy routinely synthesized this simple chemical intermediate in the lab. However, she was completely unaware of the importance of the compound she had in hand and did not realize the impact it may have on getting this product to the market.

The Idea

In her first semester at her position in South Texas, Kathy spent most of her time spending her start-up funds in setting up her research laboratory. This included buying instruments, glassware, chemicals, training lab technicians, and setting up research stations and lab protocols. She had spent close to \$40,000 already and one of her biggest expenses was still not addressed. This was the purchase of a power shaker hydrogenator and a hydrogen flow source such as a hydrogen tank which were to be used as a part of the synthesis of Borono-198, the key compound that all her chemical targets would be based upon. The only problem was that this setup alone would cost her about \$10,000, but she still had a list of other things that she needed for her lab. The budget of the department was very tight and strict

memos were already sent to all new faculties that no extensions of start-up funds were possible. This was when Kathy seriously started considering the option of looking into commercial chemical companies to buy this intermediate from, or, as many chemists do nowadays, have the compound synthesized at a smaller company that specialized in the custom synthesis of chemicals. She had not considered this idea seriously in graduate school, and based on her cursory examination of two or three top chemical company catalogs, had come to a conclusion that perhaps this product was not commercially available. She, however, had a nagging thought in her mind that she had not looked hard enough. This seemed like an appropriate time to do a thorough investigation of the availability of this compound. Kathy looked at catalogs of about 30 or more chemical companies and to her disbelief found that this product was not listed in any catalog. Then she turned to catalogs of smaller companies who usually specialize in the sale of unique compounds and found two companies that sold a different version of this product. Their product had a bromo group attached to the boronic acid, rather than the chloro compound that Kathy wanted. It was Kathy's belief that it was this chloro group uniquely positioned in her compound that was probably responsible for the high fungicidal activity. What surprised Kathy even more was the price of this bromine bearing compound — an "astronomical" \$140 for 100 mg of pure material and this compound did not even come close to the kind of activity that was associated with Kathy's material. Kathy Lewis was not thinking about research any more!

One of the critical components of being awarded tenure in a tenure-track position in the sciences is the ability to bring external funding to the university. Typically, this is done by grants from external funding agencies, such as federal/state funding, companies or foundations. However, soon after realizing the potency of her product, Kathy was nervously toying with the idea of another possibility of bringing money to her school. The first idea that came to her mind was getting the product and the procedure patented. She knew that Borono-198 had tremendous possibilities but up to this point she had no inkling about the magnitude of its importance.

When Kathy discussed this idea with Bill Smith, he was very willing and seemed excited about the prospects of setting up an affiliation of the research lab with a small scale company. The company would translate their research into compounds and products that could be commercialized for the market. This would also offer the unique opportunity of being able to channel some of the profits from the company back into research at the labs. In fact, the lab and the university could serve as a forum for conducting advanced applied research and work closely with the R&D division of any company that they would start, thought Bill loudly. When Kathy and Bill met with the university administrators and broached the idea of starting a small-scale company with potential for huge profits that could be funneled back for university research, the university officials were more than happy to provide the necessary support and infrastructure to launch the new business.

At this point, it was obvious to Kathy that her current team lacked the business background and acumen that was necessary for the start of such a venture. To lead them through this endeavor, Kathy called upon her long time friend Jon Shantz, a business consultant with years of experience in helping startup companies develop business plans and procuring venture capital funding. Jon Shantz also had a lot of experience in managing organizations, and was well versed in the field of operations and developing go-to-market strategies for product lines. With the university contracts and agreements in place, Kathy called Jon over the phone and explained the problem and the idea to him and asked for his opinion. Jon wanted to meet Kathy as soon as possible. Obviously, it took him little time to realize the promise this idea and product held.

Company Background

In 1998, Kathy Lewis founded her company Agro Limited, which was intended to be the supplier of special boron-based compounds of biological and medicinal importance. Kathy appointed Jon Shantz as the chief operating officer who would also be responsible for developing a go-to-market strategy for their first line of products. It

was initially estimated that this company would have two major business segments:

1. Agricultural chemicals — herbicides and fungicides for crop diseases.
2. Specialty boron chemicals — for amino boronic acid intermediates used in the biotechnology and the pharmaceutical industry, leading to the formulation of a wide variety of industrial and consumer products.

However, the initial focus of Agro was going to be on developing fungicides for the agricultural market as there seemed to be more interest on that front. Currently, the company's product lines consisted of one product line, that of Borono-198 which was ready for marketing. Soon after his appointment, Jon went about assembling a small management team to cover the key functional areas of operations, sales, and marketing. Jon felt that until the company could establish itself, and get some initial success in establishing a customer base, he would operate with a small infrastructure. Under Jon's guidance, the company started to operate with a very small marketing/sales team of three sales managers supervised by one district manager and a national sales manager. This team was responsible for selling Borono-198 to various markets. Salespeople were assigned to exclusive territories and were supervised by the district managers who reported to a national field sales manager who operated from the company headquarters at Austin, Texas.

All members of the sales force had college degrees in chemistry and an MBA in either sales, marketing or finance. The salesperson's role was to demonstrate the uses of the product to prospective buyers and also show the advantages of this product over other similar ones in the market. They also recommended appropriate chemical dilution levels for different formulations. Salaries for sales managers ranged from \$40,000 to \$67,000 annually, and the managers could earn anywhere from \$70,000 to \$90,000 depending on experience and the sales that they brought in. Salespeople were to be evaluated on several accounts, including new account activity, market penetration,

and quantity sold. All of the three salespeople had contacted almost all of the biocide customers in their respective territories. On average, they spent about 80–90 percent of their time on day trips to prospective buyers and the rest of their time was spent on product demos to these same buyers or users.

Borono-198

Borono-198 was a benzene boronic acid, in which a chloro group (containing the element chlorine) was attached to a benzene ring. It is the boron group coupled with the chloro group that is usually responsible for biological activities that are observed with these classes of compounds.

The commercial importance of biocides in the agricultural industry had triggered an explosion of research in this arena in the last few decades. Microorganisms such as bacteria, fungi, and yeast flourish in the warm aqueous environment of the nutrient soil that is used in growing cash crops. Their presence can cause rotting of roots and lead to eventual plant disease, decay and death causing losses to the agricultural industry amounting to millions of dollars each year. They also accumulate in fluid tanks and as the microorganisms develop, they multiply in long chains to clog filters, flow lines, and drains. In the case of fluid tanks, their foul-smelling, metabolic by-products stain and corrode pipes and the internal lining of the tanks and pollute the work environment.

Fungicides are chemicals that kill the fungus in the soil and on the roots without affecting the plants. Thus, if treated with the right kind of fungicides, healthy plants can be made to grow in a warm nutritious soil environment without attracting any fungus on the roots. Similarly, in fluid tanks, fungicides can kill all traces of fungus without affecting fluid performance. Additionally, they have applications in other manufacturing products such as cosmetics, paper detergents, and latex paints.

Chemical companies that purchase these fungicides in wholesale, often use them in the concentrated version or in different dilutions depending upon consumer needs. Often the companies dilute them

with some proprietary chemicals or add other biocides, emulsified oils and/or special additives to it to improve bio-activity, texture, color or odor. These processes most of the time employ patented methodologies.

With a quick understanding of the market needs and characteristics for their product, the technicians at Agro quickly came up with a commercial version of the fungicide. Jon felt that it would be a good idea to get some feedback from potential customers regarding Agro's first fungicide product. So Jon assembled a team of prospective customers and designed a focus survey to solicit feedback from them regarding their perception on the company's fungicide product. Based on comments from customers in a focus group, market surveys and customer satisfaction in a trial product beta testing, it was believed that Borono-198 was one of the best fungicides available in the market. Its low cost and at the same time its effectiveness in keeping fungi out of the soil for 4–6 months per application made it an extremely lucrative product for the market. Another product Xanon-128, believed to be marketed by Soil Inc. was considered by some to be superior because of its high solubility in water, but it was priced three times higher thus turning away a lot of low-budget customers. In fluid tanks, Borono-198 was eight times more effective than competitive fungicides. One gallon of Borono-198 protected 8000–10,000 gallons of fluid in a central reservoir initially for five weeks. About 8–10 gallons of a competitive product would be required to do the same job.

Customers who were satisfied with the trial testing of Borono-198 had revealed a great deal of interest in the product. Although the product solubility in water in high concentrations came up as a problem in some applications, but for this group of customers the higher end Xanon-128 was a better alternative. This would however be a very small group of users with high specificities for product solubilities and did not represent the bulk of the customer base. A customer survey indicated a unanimous vote for the product to be packaged in small boxes of 100 packets each as that size was the easiest to handle and was most popular. The technicians of Agro Limited responded with an intense effort that led to the final

development of the product packaged and marketed in a way most suitable for the users.

The Fungicide Market

In 1998, there were about 5,534 customers for the fungicide market and approximately 23,250 customers for the biocide market. The biocide market included some fungicide customers as well who liked to buy a biocide that included a fungicide in it. It was estimated that there were 2,223 potential customers for Borono-198 alone. The management team at Agro estimated that there were potentially 15–20 different wholesalers nationwide that covered almost 80 percent of the market through their channels. In the domestic market, microbiologists and chemists were often employed to come up with various brand names of biocides and fungicides. In addition, sales staff were constantly engaged in research to explore options of selling this product on shelves that would get direct customer attention. This would include nurseries, hardware stores such as OSH, Home Depot, etc. Table 1 lists the major competitors in the fungicide market:

In 1999, Agri Ventures, Soil Inc., and Grassroots each had approximately 15 percent share of the fungicide market. Combi Blocks had a share of about 30 percent of the market. It was assumed that Agri Ventures, Soil Inc., and Grassroots each employed 10 salespersons nationwide for marketing their biocides. Combi Blocks in addition to using salesmen, sold directly to distributors and end-users, and

Table 1. Competitors in the fungicide market.

Company	Fungicide	Biocide (these may include fungicide)
Soil Inc.	Xanon-128	—
Dow Chemicals	—	Cultures 98
Agri Ventures	HXP 18	HXT 28
Grassroots Ltd	Chloridine-10	—
Combi Blocks	Trichloroborane-36	Xanthrin
Vanderbilt Chemicals	—	Crops-22

Table 2. Comparative cost-effective tests for top fungicides in the market.

Fungicide	Cost (\$ per lb)	Effectiveness in soil systems (months)	Amount needed to treat 10,000 gallons of fluid system (gallons)
Xanon-128	420	5-7	4
HXP 18	224	2-3	8
Chloridine-10	388	4	7
Trichloroborane-36	125	3	8
Borono-198	78	4-6	1

distributors were supplied at 10 percent off list price. Soil Inc. sold to distributors and end-users at the same price.

Combi Block's Trichloroborane-36, introduced in 1973, was obviously well received by the market. Two other major chemical companies were planning entries into the fungicide/pesticide market: Digital Chemicals with Triton and Pharmacoepa with Gelapps. The rumors on the customer reviews in focus group tests on these products were very promising. Agro Inc. chemists conducted comparative tests (see Table 2) to demonstrate that Borono-198 was still the most cost-effective fungicide for plant and fluid systems.

Distribution Channels

The first level of distributors in this industry were the wholesalers and retailers. They purchased the fungicides in a concentrated form directly from the manufacturers. This concentrated fungicide was either diluted at this point or private branded fungicidal liquid formulations were made and sold directly to large companies and to other dealers who resold it to smaller users. At this time during the branding process, additives to improve the color or texture were added to these fungicides. This often gave them an appearance of uniqueness. Sometimes buffers to adjust pH or corrosion inhibitors were added to them also. These fungicides at this point were packed in smaller packages and were sold via retail channels through the likes of OSH, Home Depot, etc. Each metropolitan area had about

50–60 hardware stores that sold this kind of product. The distributors provided a maintenance package to the customers that usually included delivery, demos on soil and fluid system application, initial monitoring for fungal growth, and also a money back guarantee if the product failed to satisfy.

The industrial supply houses that were also involved in the fungicide market ranged from small, family-owned businesses in rural areas to large professionally managed companies in urban areas. A major metropolitan area might have over 100 supply houses serving a variety of industries. There were telecommunications sales staff that took telephone and online orders from regular customers. Outside salespeople generated new accounts and made day field trips. Typically, large industrial companies purchased fungicides directly from the manufacturers or from their distributors. Small companies, however, relied mostly on industrial supply houses for all their needs.

Pricing and Marketing Strategy for Borono-198

Agro Inc. decided initially that they would target the entire North American market for Borono-198. They contacted the top 10 distributors of concentrated fungicide along with the industrial supply houses in an effort to sell it through those channels. The company also offered private branding on Borono-198. Borono-198 was packed in boxes containing 100 packets, each packet weighing an ounce. Quantity prices to distributors were as follows:

- 1–2 boxes \$100,
- 3–4 boxes \$150,
- 5–8 boxes \$175.

Jon Shantz estimated the manufacturing cost per packet to be about 35 cents. Although the company did not specify a price to end-users at this time, they figured that the competition charged end-users and other dealers approximately \$1.50 per packet. Some competitors had a strong secondary distribution network consisting of 100–150 industry supply houses.

The product was launched in January 1999 accompanied by a press release to the nation's top magazines in the industry, namely, *Western Agros*, *Farming Today*, and *Yard Beautiful*. Discount coupons for the product were given in these magazines and also in the Sunday newspaper in most metropolitan areas. In addition, TV ads were shown in the HGTV daytime programs. The announcement also included specific information of Borono-198 and its benefits. Although there were quite a few enquiries that Agro received for their product, by the end of 1999, the direct sales force of Agro along with their distributors network had managed to sell just \$25,000 worth of Borono-198.

The Future

Disappointed with the performance of Borono-198 in the first three months of its introduction, Kathy and Jon decided to review their marketing plan. Kathy was not sure if they had the right marketing strategy for new product introduction in the fungicide market. She decided to look at the plan and take any corrective actions necessary to turn the company around. Kathy sought the advice of Dr. Smith and also discussed the issue with the faculty of the business school.

Jon and Kathy got differing opinions from their advisors regarding the issue. While some felt that they needed to wait for a while longer to see if there would be any impact of their marketing strategy on product sales, others felt the initial marketing strategy might not have been the best suited for the product. Krish Patel, a marketing professor at the university argued that they were in the market for speciality chemicals and needed to offer a completely educated but differentiated solution to customer's products. He encouraged the management of Agro to review the marketing plan.

Kathy had limited budget for any kind of support activities. As much as she would have liked Jon to research the market thoroughly, Kathy knew that time and money were not on their side. Kathy and Jon felt that they should once again contact the people who had expressed strong interest in Borono-198 during the beta trials. They embarked quickly on a survey by contacting their original participants.

From the result of the survey, they learned that only about 20 percent of the original participants remembered receiving any additional information or discount coupons on the Borono-198 product. When asked about the image of the product conveyed by the promotional literature, many had expressed that this product was worth trying but they had some apprehension about the safety of using it in concentrated form. Users of products similar to Borono-198, obtained their fungicides and biocides from local hardware stores, formulators, and industrial supply shops. The majority sourced from two or more small, local stores or supply shops within 15 miles of their businesses, as well as one of the large national distributors. Users occasionally found it necessary to write to a large national distributor for supplies that were not locally available. The survey also revealed that users of fungicides and biocides were not particularly cognizant of the brand they used. They also did not seem to particularly care for the contents of the product, and as such were not aware of the manufacturers of the concentrate in a product.

Armed with additional information about the market characteristics, Kathy pondered if she and Jon would be able to answer a number of questions that arose in her mind on how to turn the strategy around for Borono-198.

1. Did they have the right kind of product or should they modify the product for the biocide market? Did they understand the requirements of their customers?
2. Do they need to disclose additional information about the product and its usefulness to create more awareness?
3. Should they raise the price of the product in order to increase end-user perception of its value? What short-term and long-term sales and market share targets were appropriate for Borono-198?
4. Should Agro continue to target the entire fungicide market or should they have a more focused approach toward selling?
5. What other alternatives existed to her current channels strategy for distribution of Borono-198? Should Agro concentrate on developing a regional strategy for product entry? Should Borono-198 be marketed as a fungicide to be sold only through the retail channels?

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From Laboratory Bench to Marketplace — The “Chontrol®” Story: A Legacy to Government–Academia–Industry Partnerships¹

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Chondrostereum purpureum-PFC 2139, and its end-use product, Chontrol® Paste, were developed by MycoLogic, Inc. through a collaborative research agreement with the Natural Resources Canada — Canadian Forest Service and Pacific Forestry Center. These mycoherbicides products were reviewed jointly by Health Canada’s Pest Management Regulatory Agency (PMRA) and the United States (US) Environmental Protection Agency (EPA) within the North American Free Trade Agreement’s Technical Working Group (NAFTA TWG) on Pesticides Joint Review Program. On 23 September 2004, EPA issued the registration for the manufacturing use product (CP-PFC 2139) and its end-use product (Chontrol® Paste).

¹ This case was developed by Simon Francis Shamoun of Canadian Forest Service, Victoria, British Columbia, Canada for instructional purposes only. Any similarity to an actual managerial situation or an actual firm is coincidental. The case was prepared as a basis for classroom discussion rather than to illustrate either effective or ineffective handling of a business situation and cannot be used without the written permission of the author or be reproduced in any way.

Chontrol® Paste is a vegetation management product intended to inhibit sprouting and regrowth in cut stumps of certain deciduous tree species in rights-of-way (ROW) and forests. *Chondrostereum purpureum* strain PFC 2139, is a naturally occurring fungus. The only reported ecological niche for *C. purpureum* is in the xylem of living or recently dead broadleaf trees and shrubs. It is not host specific, having a wide host range as a wound pathogen. Despite its broad host range, its impact is limited. *C. purpureum* can invade only through fresh wounds in the xylem, and it is a weak pathogen, affecting only compromised trees. Healthy trees repel fungal infection with antifungal metabolites (phytoalexins) and by compartmentalizing infected tissues. Because the fungus can survive as a saprophyte, there is little selection pressure toward greater virulence or host specialization. *C. purpureum* is disseminated through the production of numerous short-lived basidiospores from fertile fruiting bodies (basidiocarps).

A storage stability study showed a significant loss in potency over 90 days. Therefore, the applicant must continue to ensure that the product release standards include a titre of at least 10^6 Colony Forming Units (CFU)/kg, and change the product label to reflect the limited storage stability of this product. Final license agreement was signed between NRCan-CFS/PFC and Mycologic Inc. in July 2006.

Background

In response to a growing demand for increased productivity and sustainability in forestry, millions of conifer seedlings are being planted for reforestation on harvested forest sites throughout Canada every year. (Wall *et al.*, 1996). Tall-growing deciduous species are also problematic when growing in utility company ROW where trees can encroach upon power and telephone transmission lines and cause fires and power outages. Environmental concerns have called for the reduction of chemical herbicide use in forests and given support to the concept of integrated vegetation management (Becker *et al.*, 2001).

The development of fungal plant pathogens as mycoherbicides for management of forest weeds will have to follow few precedents similar to the mycoherbicides for agricultural weeds, but in general involves three phases: (1) discovery (2) development and (3) deployment. The discovery phase includes various activities such as collection of diseases forest weeds, isolation of fungal pathogens, demonstration of Koch’s postulates, identification, and long-term storage of the purified fungal pathogens in liquid nitrogen. The development phase includes determination of conditions for optimum inoculum production and disease development, determination of host range (including non-target hosts), and if these tests indicate that an effective product can be developed, steps may then be taken to register it for use. This process will usually involve patenting the technology. The deployment phase has generally involves close interaction with the industrial sector for scale-up production, suitable formulation and application technology, testing for toxic or allergenic effects on animals, environmental fate and risk assessment studies after deployment, regulatory aspects, and marketing of the mycoherbicide product.

Registration and commercialization are expensive and time consuming processes, and the market for individual mycoherbicides may be small. For these reasons, many potentially good products may not reach marketplace. Since this is a relatively new area of research in agriculture and forestry, constant modification of regulations governing registration will be necessary to balance potential risks against benefits.

Chronology of Research and Development of *Chondrostereum Purpureum* as Chontrol®

A special research program on development of biological control of forest weeds was established at the Canadian Forest Service–Pacific Forestry Center (CFS–PFC) in 1986. Among target weeds considered were *Acer macrophyllum* Pursh., *Alnus rubra* Bong., *Calamagrostis canadensis* (Michx.) Beauv., *Epilobium angustifolium* L., *Gaultheria shallon* Pursh., *Populus tremuloides* Michx., *Rubus* spp., including

wild red raspberry [*R. strigosus* Michx. = *R. idaeus* var. *strigosus* (Michx.) Focke], thimbleberry (*R. parviflorus* Nutt.), and salmonberry (*R. spectabilis* Pursh.), and *Ribes* spp. (alternate host of the white pine blister rust disease). Fungal plant pathogens from these weeds have been isolated, identified and tested for their potential use as biological control agents (Dorworth, 1990).

Research activities at the Canadian Forest Service have been successful in obtaining six US patents on different biological control pathosystems. These includes biological control of *C. canadensis* with *Colletotrichum* and *Fusarium* species, as well as, low temperature basidiomycete (*Coprinus psychromorbidus*), control of *A. rubra* with *Nectria ditissima* Tul., biological control of weed trees with *C. purpureum* (Wall *et al.*, 1996), biological control of weedy *Rubus* spp. with *Fusarium avenaceum* and culture, formulation, and delivery technique of *Valdensinia heterodoxa* for use as a biological control agent of salal *Gaultheria shallon*. To date, CFS-PFC's efforts are underway to register these biological control agents and/or licensing these technologies through a "technology transfer agreement" with commercial partners or consortium in order to make these biocontrol agents commercially available.

Chondrostereum purpureum (Pers. ex Fr.) Pouzar is a wood-inhabiting fungus which grows saprophytically in logs and stumps of numerous deciduous tree species, has been further tested on hardwood weed species in conifer regeneration sites and utility ROW. In 1995, a collaborative research agreement was established between CFS-PFC and its commercial partner MycoLogic Innovative Biologicals Inc. — University of Victoria, British Columbia, Canada, with financial support from BC Hydro, Natural Sciences and Engineering of Canada (NSERC), National Research Council, Science Council BC, Private Sector Funding, BC Ministry of Forests and the CFS. The aim of this research agreement is directed toward registration and commercialization of *C. purpureum* in North America as a mycoherbicide under a proposed trade name "Chontrol®." A statement of work (SOW) was developed to fulfill the registration requirements by the Environmental Protection Agency (EPA) in the United States and Pest Management Regulatory Agency (PMRA) in Canada.

The SOW included: (1) Product specification, (2) characterization of microbial agent — including the genetic characterization of the active ingredient, (3) occurrence of *C. purpureum* near waterways, (4) quality control assessment, (5) storage and shelf life of the product, (6) assessment of infectivity, (7) acute toxicity testing, (8) feed residue studies, (9) environmental fate and risk assessment and (10) efficacy — including national field trials and ROW field trials as well as operational field trials.

Formulation Technology of Chontrol® Developed by CFS-PFC and National Field Trials

Chontrol® is a formulated product of the white-rot fungus *C. purpureum*. The fungus can infect most of the hardwood trees and shrubs, invading the cambium and sapwood and causes the silver leaf symptom (separation of leaf layers) in Rosaceae plants.

A formulated product (clay based) of *C. purpureum* was produced at CFS-PFC and a US patent was obtained. Briefly, the procedure for the production of the formulated product is as follows: inoculum of *C. purpureum* (isolate CP-PFC 2139) was prepared from actively growing Petri dish cultures growing on 1.25 percent malt extract agar. Inoculum plugs, 5–8 mm diameter were removed aseptically from the advancing zone of the culture, macerated, and suspended in 100 ml aliquots of 1 percent malt extract broth in Ehrlenmeyer flasks. Flasks were placed on 100 r.p.m. rotary shakers at room temperature for two to five days and the contents then aseptically added to the dry formulation. The dry formulation consisted of 375 g talc, 100 g kaolin clay, 12.5 g corn starch, 5 g pectin, 5 g monosodium glutamate, 1 g monopotassium phosphate, and 1.5 g yeast extract. Ingredients were thoroughly mixed, placed in autoclaveable plastic bags and autoclaved at 15 p.s.i. for 20 min. After cooling, the bags were inoculated with malt broth inoculum; controls (formulation only) receiving sterile malt broth. After inoculation, the contents of each bag were agitated to incorporate the mycelial fragments and the bags incubated at room temperature for three to eight weeks. During incubation, bags were agitated at weekly intervals to maintain uniform growth.

Immediately before inoculation in the field, the contents of each bag were mixed with 600 ml of sterile 1 percent sucrose, 200 ml canola oil, 60 g finely powdered cellulose and the yolks from two large eggs. The mixture was stirred vigorously to form a smooth paste and applied to cut stumps in a plastic squeeze bottle. The application of the “Chontrol®” product is simply a topical treatment on the cut stumps of the target weedy hardwood species.

Our commercial partner, MyCologic Inc., has improved the paste formulation by developing a spray formulation (peat based) that proved to be cost-effective and practical in use under forestry situations. The development of spray formulation can be better integrated in operational trials and has been demonstrated under field conditions with great success.

The Canadian Forest Service (Atlantic, Great Lakes and Pacific centers), British Columbia Ministry of Forests, Ontario Ministry of Natural Resources and MycoLogic Innovative Biologicals Inc. collaborated and installed a coordinated set of national field trials aimed at providing field efficacy data critical to the registration and subsequent use of *C. purpureum*. This collaborative effort resulted in a common experimental protocol being implemented in three major Canadian provinces namely, New Brunswick, Ontario and British Columbia. In each province, trembling aspen (*Populus tremuloides* Michx.) was studied as a species of national importance, while red maple (*Acer rubrum* L.), speckled alder (*Alnus rugosa* (Du Roi) Spreng.), and sitka alder (*Alnus viridis* ssp. *Sinuata* (Regel) A. Love & Love) were studied as target weeds of regional importance, respectively. Genetic characterization, epidemiology and environmental fate studies were completed as essential components for the registration of *C. purpureum*.

The commercial partner of the CFS-PFC, MycoLogic Innovative Biologicals Inc. has compiled all the relevant information and data related to registration requirements in the registration package submitted to Pest Management Regulatory Agency (PMRA), in Canada and Environmental Protection Agency (EPA) in United States for the registration of *C. purpureum* (isolate CP-PFC 2139) as Chontrol®.

Chondrostereum purpureum-PFC 2139, and its end-use product, Chontrol® Paste, were developed by MycoLogic, Inc. through a

collaborative research agreement with the Natural Resources Canada — Canadian Forest Service, and Pacific Forestry Center. These mycoherbicides products were reviewed jointly by Health Canada’s Pest Management Regulatory Agency (PMRA) and the United States (US) Environmental Protection Agency (EPA) within the North American Free Trade Agreement’s Technical Working Group (NAFTA TWG) on Pesticides Joint Review Program. On 23 September 2004, EPA issued a registration for the manufacturing use product (CP-PFC 2139) and its end-use product (Chontrol® Paste). This joint research venture and the production of the first mycoherbicide for management of woody weedy forest vegetation is a true legacy to the government–academia–industry partnership.

Constraints in the Development of Mycoherbicides for Management of Forest Weeds

There are several constraints in the development of commercial mycoherbicides need to be overcome. Mycoherbicides need to be predictable, easy to use and provide to certain extent the same level of forest weed control comparable to the registered chemical herbicides before they will have general acceptance from industry and end-users. The use of fungal plant pathogens as biological control agents is not risk-free, which need to be seriously and thoroughly assessed. Their safety, persistent survival, and potential for genetic change are major concerns to scientists, regulatory agencies, and public at large. The following constraints in the development of mycoherbicides for forest weeds arise because of the desire to produce perfect analog of chemical herbicides:

1. *Biological constraints*: including host specificity, host range, resistance mechanisms, and interaction with other organisms.
2. *Environmental constraints*: involving aerial, soil, environments, as well as, compatibility with other synergists including plant growth regulators, adjuvants, and pesticides.
3. *Technological constraints*: involving production of active ingredients of organisms, formulation, shelf life, and application of the mycoherbicides.

4. *Commercial constraints*: which deal with market size, patent protection and secrecy, cost of production, and strict regulations.

Conclusions

This article has described how a joint research venture between a government research laboratory, academia and industry partnership has resulted in a development of a biological control product based on the fungus *Chondrostereum purpureum* as (Chontrol® Paste) for control of forest competing vegetation in areas used by utilities and forest management agencies.

Chondrostereum purpureum-PFC 2139, and its end-use product, Chontrol® Paste, were developed by MycoLogic, Inc. through a collaborative research agreement with the Natural Resources Canada — Canadian Forest Service, Pacific Forestry Center.

The product (Chontrol® Paste) was reviewed jointly by Health Canada's Pest Management Regulatory Agency (PMRA) and the United States Environmental Protection Agency (EPA) within the North American Free Trade Agreement's Technical Working Group (NAFTA TWG) on Pesticides Joint Review Program. On 23 September 2004, EPA issued a registration for the manufacturing use product (CP-PFC 2139) and its end-use product (Chontrol® Paste).

The use of Chontrol® Paste will result in a reduction in the frequency of manual/mechanical brush control and reduce the reliance on chemical herbicide use. This attribute of the biological control agent *C. purpureum* will contribute to reduced costs of management of weedy forest vegetation in conifer plantations and utility ROW.

Summary

The following issues and challenges need to be addressed in the case of discussion:

1. Why is there an urgent need for exploitation of other plurivorous wood-rot fungi that shows better results than *C. purpureum* for management of other tolerant woody weedy forest vegetation?

2. How can a spray formulation and delivery technologies for *C. purpureum* improve the efficacy and cost-effectiveness of the product?
3. How can we better utilize and understand the use of PCR-DNA technology to address the requirements of the regulatory agencies with respect to genetic fingerprinting, environmental fate and persistent of *C. purpureum* after deployment in the field situation?
4. What are tools and techniques used to educate end-users and scientists unfamiliar with mycoherbicide strategy to improve technology transfer from Government Research Laboratory to Commercial Partner?

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Integration of Material

The most important element on management today is the ability of managers to effectively communicate across organizational lines. As firms become smaller, maintain fewer levels of management and remove functional barriers, technical specialists must communicate with the business or marketing specialists. And as competition becomes more intensive, technical or marketing managers hold more exhaustive and focused discussions to improve the competitive position of their firm. Scientists, engineers and other technical personnel responsible for management of research facilities, engineering laboratories or development shops must also discuss financial, marketing and management problems with the firm's business and marketing managers.

Managers in traditional firms were most likely trained in business management areas such as accounting, finance, marketing or human resources management. Although scientists and engineers are often considered for most management positions, they are more likely placed in operational positions unless they have an advanced degree in business management. For similar reasons scientists or engineers who want to become top-level decision-makers need to get additional, mostly graduate, education in business management. In most cases, however, additional education in business management is not designed to retrain scientists and engineers as financial, marketing, or other top management specialists, but rather it is designed to enable them to communicate on the same level as their business counterparts, managers trained initially in business management. Scientists and engineers are trained to use the same management terminology and to make decisions in parallel with business-trained managers.

Top managers operating smaller high-technology firms tend to be somewhat different. Scientists, such as physicists, chemists, medical doctors, electronic engineers, or other individuals with

advanced science degrees, start many of these firms. Entire firms are often built on a single scientifically advanced idea which provided the necessary platform for the new product, the needed venture capital, and a ready market. When the single high-technology product starts to lose its competitive position, top management realizes that it does not have the managerial skills to monitor the market, generate new ideas for additional products, or simply undertake an effective marketing strategy to increase sales. Top management starts appointing professional business managers. The introduction of business-trained managers creates the same dilemma that exists in more conventional firms — professional business managers communicate and make decisions differently. There is a need in both cases to open the communication process between the science-based and business-based managers.

The inability to communicate is only part of the overall problem. The deeper problem lies in the abilities of the two types of managers to understand each other's world and to learn how each carries out responsibilities. Scientists and engineers rely on their scientific training; they use the scientific method to discover new relationships, explain new theories or research a new pharmaceutical product. The scientific method is the key tool in their research and their decisions are based on the outcome of the scientific method. Also, their quantitative research tools rely on a different level of accuracy and even their experiments follow well-established scientifically based procedures.

The world of practicing business managers is intrinsically different. Their decision-making styles are less formal, based on experience and observations, and on less than complete information. Although the results of marketing research studies provide the foundation for many critical decisions, such studies are not infallible. Even when marketing research studies are based on well-developed consumer behavior models, on proven techniques, on concepts borrowed from the social sciences, it is difficult to design research instruments such as questionnaires, focus group interviews, or panel studies that provide sufficiently reliable information. Some consumer preferences such as taste, aroma, or touch are difficult to research

and equally difficult to measure. Marketing research specialists do not have uniform across-the-board standards or scales that they can use to measure differences among consumer or user groups. Consequently, the results of some marketing research studies may be provisional estimates.

In high-technology firms that routinely develop products, the technical and marketing managers sometimes operate in very different, almost bipolar, worlds. The existence of these conflicting worlds is particularly obvious during the product development process. The entire product development process in high-technology firms symbolizes the conflict between scientists, engineers, other technical personnel and the marketing managers. During the product development process, scientists insist on better testing procedures and longer development time; engineers insist on trying new materials, integrating the latest technological developments, or improving the functional attributes of the product; and the marketing managers are anxious to have the product on the market because their sales force watches competitors that already have a product on the market. Thus, conflicting roles and objectives contribute to inefficiencies, time delays and lower profitability.

Increasing challenges from a growing number of global competitors force many firms to resolve these conflicts. Competitive pressure compels firms to develop new products faster, commercialize them as soon as they are developed, and manage existing products more aggressively against competing products. Therefore, the product development process must be considered, in a firm, as the lowest common denominator in interactions between scientists and engineers on one side and business managers on the other. Since the product development process brings these two sides together and also serves as the source of corporate competitive advantage, top management must realize that these two sides must work together closely.

The formation of teams, both cross-functional and multi-functional, significantly improve the communication process between a firm's technical and the business sides. Joint decision-making within such teams also improves. Some managers, however, still do not understand how much and what kind of information is sufficient to make

business decisions. In order to reduce the need for a lot of information, many business managers frequently rely on conceptual or theoretical frameworks in making decisions. These frameworks also help scientists and engineers develop a better understanding of how business managers, more specifically marketing managers, make decisions.

One such decision-making framework used to develop new products typically begins with the process of generating and screening new product ideas and continues with the development and evaluation of new product concepts. These two basic steps in this framework are followed by a formal business analysis and assessment of market potential. As the next steps in this framework, product prototypes are developed, tested, and selected for commercialization. Finally, new products are introduced in the market. Models such as these are very useful for managers making decisions about new product development. However, they must also be supplemented with information about market conditions, the external business environment and the competition.

In order to improve understanding about decision-making between scientists, engineers and business managers, it is important for them to develop a common understanding about other concerns which directly impact the product development process. Scientists and engineers view some concerns differently from business managers. Integrating the understanding of decision-making between scientists and engineers and business managers requires that each firm develop a better understanding because the importance of each topic may be of different importance between firms. Some of the topics generally considered to be important for this purpose can be presented as follows.

Cost analysis associated with technology trade-off is one topic very much under discussion between technical managers and marketing managers. Because technical managers tend to be more concerned with the technology trade-off rather than with the associated costs, they tend to favor improved technology while marketing managers tend to be less concerned with improved technology and more with costs.

The technical and marketing managers also tend to place different emphasis on formulating business plans and developing strategies for marketing technological innovations. Marketing managers tend to put more emphasis on the functional aspects of technological innovations and to stress the functional benefits of the product in the business plan and marketing strategy. Technical managers tend to be more concerned with the actual technological innovation, its scientific or engineering content, and not necessarily what the innovation can do functionally for the ultimate consumer.

Sources of venture capital often become another topic of conflicting managerial views. Venture capitalists tend to follow their own guidelines in evaluating the potential of new technology or products. Their emphasis tends to be more on the future benefits of the new technology or products. Business plans developed by marketing managers tend to stress the anticipated needs of consumers in the market, as the marketing managers understand the new technology or the resulting products, and tend to be concerned about the potential growth of the market. Technical managers, however, tend to be concerned with the impact of the technology on broader aspects of the market and consumption of products based on a particular technology. When venture capitalists conduct their due diligence within a particular firm, they confront both sides of management and frequently receive inconsistent information. Most venture capitalists realize that they need to objectively integrate the information they receive in order to make a decision.

Another topic that tends to be an obstacle to effective development and market introduction of products is the actual management of research and development (R&D). In most firms today, there is often a manager who is solely responsible for R&D. This individual typically has a scientific or engineering training and is responsible for introducing new technology into the firm, integrating that technology into new products and assisting with marketing new products. This manager is also responsible for communicating and professionally working with the firm's business managers. The business managers tend to perceive technological changes as disturbing and costly.

Team management by science or business managers is also a topic that tends to create conflict between the two types of managers. Teams managed by a science manager tend to communicate and set priorities differently than teams managed by business managers. Larger firms that manage a number of teams tend to select team managers based on their expectations of the team's accomplishments and time frame.

Computer-aided design (CAD) and manufacturing management (CAM) is a subject of great deal of discussion between the technical and business managers. Business managers tend to view the CAD/CAM process as a continuous process that begins with new product ideas and ends with a completed product, already packaged, and on the way to market. Technical managers tend to focus only on their particular part of product development and, perhaps, on assisting with technological improvements in the manufacturing or production process. Some firms today systematically involve technical managers in the entire CAD/CAM process.

Technical communication within the firm and between technical and business managers is often singled out as a major obstacle in introducing new technology into the firm and also in providing technical support services for the entire business side of the firm. Misunderstandings between technical and business managers over technical communication may involve preparation of documentation concerning various stages of product development, the results of testing procedures and even performance data. The language used in developing operational and maintenance handbooks tends to be difficult to resolve, particularly in high technology firms. Training of production and sales personnel can also create a major technical communication problem.

Although dealing with patents and environmental law issues are ultimately the responsibility of top management working with legal departments outside law firms, the discussions leading up to filing for patents or meeting environmental regulations can be sources of conflict between technical and business managers. Top management must carefully manage the release of information about potential patents. Technical managers tend to wait before releasing any information

after the patent filing papers have been submitted to the patent office. Business managers, particularly marketing and sales specialists, want to use the information as soon as possible for competitive positioning with their clients or in the market.

Technology and government regulations are also a topic frequently subject to conflicting views among technical and business managers. Individual firms, especially high-technology firms, tend to develop technology and technological options that may be ahead of governmental standards. Some of this technology may also be ahead of prevailing attitudes of most of the population. Recent developments in biotechnology and natural resource management clearly indicate advancements by individual firms for which the government may develop new standards. The key point of discussion between technical and business managers seems to be the impact of governmental regulations on the firm's technological climate and on the market in which the firm operates.

In many cases, the discussion within the firm about government regulations also impacts individual products. Governmental agencies promulgate laws and regulations with respect to products' performance, safety requirements and effective life. Business managers of some firms perceive these laws and regulations as obstacles to product development or actual sales. Technical managers, often perceive the same laws and regulations as opportunities to improve the product or its performance. The point of differences may be the costs associated with meeting the laws or regulations.

Probably the most discussed topic that highlights the differences between technical and business managers is the question of ethical issues and the appropriate use of technology in firms today. Ethical issues today relate not only to questions of the overall financial performance of a firm, but also to specific issues dealing with its products, packaging, advertising, sales, distribution, etc. Ethical issues concerning competition and competitive market positioning also create major confrontations between technical and marketing managers that have different philosophical perspectives. In some firms, not only is the entire product development process subject to ethical discussion

among the technical and marketing managers, but individual products are also the focus of ethical questions, for example, in the software industry.

Other topics that produce conflicts based on differing philosophies between the technical and business managers include diffusion of innovation in various global markets, marketing and sales of obsolete products, globalization efforts by management, restrictive trade agreements, internationalization of smaller firms and human resource management, among others. Firms are typically perceived as entities that tend to think and behave uniformly as far as their human resources are concerned. Recent conflicts between technical and business managers, and with top management, suggest that individual managers, regardless of whether they are technical or business managers, assert their educational and professional values into their managerial positions. This tendency suggests that a generation of new managers may be emerging.

It is becoming apparent that the new generation of managers in some firms will have a different set of professional values and will manage accordingly. This new generation of managers will consider a firm as systematically monitoring technological developments in the external business environment, internalizing them in the firm, and using them to offer their customers and users the best possible technological alternatives at a given education level. These managers will closely monitor market dynamics using advanced data and information processing procedures and use the data and information to make better decisions about their consumers and users, target markets, market segments and, most of all, consumers' lifestyles. And, finally, the new generation of managers will monitor their competitive position more accurately and aggressively in order to achieve an optimal balance between the allocation of their resources and the satisfaction of their consumers or users in the light of competitors' products.

The new generation of managers will have educational backgrounds and professional experiences that carefully balance their scientific and managerial training. Managers with education and training either in sciences or engineering, or only in business management, will not be successful in facing the increasingly hypercompetitive global market.

Future Developments

The above concepts, illustration and explanation are still relevant and need to be considered in all aspects of scientific, engineering and business management. However, there are additional developments that point to the future. These developments suggest that the integration of scientific, engineering, and business management will increase at a rapid pace. The scientific and engineering community generates technological knowledge at a rate that produces an “understanding gap” between them and their business management colleagues.

The emerging trends can be described as follows. Perhaps the most important trend is the rapid technological change in scientific inventions and discoveries. This trend is reinforced by increased use of computers for all types of technological and business management decision-making. To further speed up decision-making, many universities, corporations and governmental research facilities encourage individuals to be more entrepreneurial in their areas of expertise. This trend has produced many new inventions and discoveries. However, corporate entrepreneurship is growing the fastest. This trend is partly stimulating growing societal demands for more ethical behavior among corporate entrepreneurs.

At the same time, societies are experiencing escalating market demands by consumers for scientific solutions to their problems. Consumers want to live longer, be more active and healthier. They look to the scientists and engineers to help them realize these objectives. This will, in turn, even further stimulate demand for scientists and engineers. As a transition into the future, many of the present business managers may require additional training to bridge the gap with scientists and engineers today.

Another issue that is emerging as a consequence of the rapidly rising technological developments and options is the difficulty in securing venture capital. Venture capitalists today have many investment options. They are more selective regarding options that have greater return potential. This makes the financial assessment of technological options more important and essential in attracting venture capital.

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List of Websites

Website name	Website address
3Com	http://www.3com.com
3M Worldwide	http://www.3m.com
AAAS/ICS REPORT ON STEM CELL RESEARCH	http://www.aaas.org/spp/sfml/projects/stem/main. htm
Abbott Laboratories	http://abbott.com
Almanac of Policy Issues	http://www.policyalmanac.org/health/archive/ crs_stem_cell.shtml
American Ag-Tec International, Ltd. Resource Center	http://www.ag-tec.com
American Catholic	http://www.americancatholic.org/News/StemCell/ default.asp
American Production and Inventory Control Society	http://www.apics.org
American Society for Quality	http://www.asq.org
Automotive Industry Action Group	http://www.aiag.org
Baxter	http://www.baxter.com
Biodevices Business Site Providing Current Info in Biotech Field	http://www.biodevicesbiz.com
Bristol-Myers Squibb	http://www.bristolmyers.com/landing/data/ index.html
BSI ISO-14000 International Environmental Systems Information	http://www.iso14000.net
CNN (Cable News Network)	http://www.cnn.com/2001/HEALTH/07/18/ stem.cell.senate/index.html

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Website name	Website address
Dell.com	http://www.dell.com
Edenspace Systems Company	http://www.edenspace.com
Eli Lilly and Company	http://www.lilly.com
EnviroLink Resource Link for Environmental Issues	http://www.envirolink.org
European Statistics	http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1090,30070682,1090_33076576&_dad=portal&_schema=PORTAL
Facility Manager	http://www.todayfacilitymanager.com/tfm_03_01_news4.asp
Federal Aviation Administration	http://www2.faa.gov
Food and Drug Administration	http://www.fda.gov
GE Medical Systems	http://www.gemedicalsystems.com
GlaxoSmithKline	http://www.gsk.com
Global Green Standards ISO-14000 Information Center	http://iisd1.iisd.ca/greenstand
IBM	http://www.ibm.com
Intel	http://www.intel.com
International Organization for Standardization	http://www.iso.ch/iso/en/ISOOnline.openerpage
ISO-22000 Food Safety Management System	http://www.qsinnovations.com/iso22000.html
ISO-22000 Food Safety Management System Concepts	http://praxiom.com/iso-22000-definitions.htm
ISO-22000 Food Safety Management System Resources	http://www.iso-22000.blogspot.com
Joint Commission on Accreditation of Healthcare Organizations	http://www.jcaho.org

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Website name	Website address
La Salle University Integrated Science Business and Technology Program	http://www.lasalle.edu/academ/isbt
Listing of Pharmaceutical Products Manufacturers	http://www.ispex.ca/companies/diapharm.html
Merck	http://www.merck.com
Microsoft	http://www.microsoft.com
Milwaukee School of Engineering	http://www.msoe.edu/business/bsm
Monitor	http://www.monitor.net/monitor/0201a/ stemcellmapc.html
MVS Solutions, Inc. The Business of Science Newsletter	http://www.mvssolutions.com/ezone.html?source= overture
NASA Small Business Innovation Research & Small Business Technology Transfer	http://sbir.nasa.gov/SBIR/front1.html
National Agriculture Library Technology Transfer Information Center	http://www.nal.usda.gov/ttic/guide.htm
National Agricultural Library Water Quality Information Center	http://www.nal.usda.gov/wqic
National Biotech Register	http://www.biotech-register.com
National Institute of Health	http://www.nih.gov
National Institute of Standards and Technology	http://www.nist.gov
National Technology Transfer Center	http://www.nttc.edu
National Transportation Safety Board	http://www.nts.gov

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Website name	Website address
Northern Environmental Engineering and Consulting Company	http://www.northern-env.com
Nucor Corporation	http://www.nucor.com
PAX Technology Transfer Resource Center	http://www.pax.co.uk/PROCESS.CFM?PAGEID=20
Penn State University	http://search.psu.edu
Pfizer & Warner-Lambert	http://pfizer.com
Pharmacia Corporation	http://www.pharmacia.com
Population Reference Bureau	http://www.prb.org
Procter & Gamble	http://www.pg.com
Procter & Gamble Pharmaceuticals	http://pgpharma.com
Sandvik, Inc.	http://www.sandvik.com
SC Johnson	http://www.scjohnson.com
Sony	http://www.sony.com
State of Wisconsin Department of Natural Resources	http://www.dnr.state.wi.us
StemCells	http://www.stemcells.ca/
StemCells: Regulation of Stem Cell Research	http://www.stemcells.ca/reg.html
SUNY-Stony Brook Technology Transfer Center	http://www.research.sunysb.edu/islandwired/tech.html
The Age	http://www.theage.com.au/articles/2002/06/17/1023864403565.html
The EMS Information Center	http://ems-hsms.com/index.htm
The Honing Process Simulation	http://www.iwf.ing.tu-bs.de/Mitarbeiter/Weber/englisch/eanihon.htm
The New York Public Library	http://www.nypl.org/research/sibl
The Volvo Group	http://www.volvo.com/group/global/en-gb
UNAIDS Web Site	http://www.unaids.org/en/AboutUNAIDS/default.asp

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Website name	Website address
United Nations Environment Protection Program	http://www.grid.unep.ch
University of Notre Dame Undergraduate Science Program	http://www.science.nd.edu/science_undergrad
University of Wisconsin-Stout B.S. in Applied Science Program	http://www.uwstout.edu/programs/bsas/cs.html
University of Wisconsin-Whitewater Science-Business Integrated Major	http://academics.uww.edu/sci-bus/index.html
US Agency for International Development Global Health	http://www.usaid.gov/pop_health/aids
US Department of Defense Small Business Innovation Research & Small Business Technology Transfer	http://www.acq.osd.mil/sadbu/sbir
US Department of Energy National Renewable Energy Laboratory	http://www.nrel.gov
US Environmental Protection Agency	http://www.epa.gov
US Environmental Protection Agency AirNow Program	http://www.epa.gov/airnow
US Environmental Protection Agency Oil Program	http://www.epa.gov/oilspill
US Food and Drug Administration (HACCP)	http://vm.cfsan.fda.gov/~lrd/haccp.html

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Website name	Website Address
US Food and Drug Administration (Seafood HACCP)	http://www.cfsan.fda.gov/~comm/haccpsea.html
US Food Safety Information Center	http://foodsafety.nal.usda.gov/nal_display/index. php?info_center=16&tax_level=1&tax_subject= 177
Wheeling Jesuit University	http://www.wju.edu

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