Review of Innovation Practices in Small Manufacturing Companies

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Executive Summary

This document is the final report for Task Order #5 (Appendix 1). The report is framed to answer the following question. "How do SMEs, both domestic and foreign, identify, develop, acquire, and implement innovations in their businesses?"

The following definition of innovation was adopted:

> **Successful innovation is the use of new technological knowledge, market knowledge, and business models that can deliver a new product or service, or product/service combinations, to customers who will purchase at prices that will provide profits.**

This definition served as a guide to develop three primary categories of organizational functions, internal, external, and bridging (see table below). Within each primary category, a set of key factors was hypothesized to be related to innovation success. These hypothetized relationships were based on secondary research from the academic and business literature. They were tested by conducting interviews with senior executives of SMEs that had shown a persistent and successful history of innovation, and represented a variety of market sectors, both domestic and foreign. The strategy for taxonomy development was to identify one or more patterns of factors that were related to success, and associate firms with them. A second strategy for taxonomy development was to take existing foreign models of innovation and assess their respective merits and applicability to the U.S. context. The foreign models were Mittelstand companies, geographical clusters, and chaebol/kereitsu.

Primary Categories	Key Success Factors
Internal	IP management, knowledge management, IT applications, maturity, governance, culture, human resource practices.
External	Closeness to customers, supply chain and competitor knowledge, proactive engagement with the environment for acquisition of technology, knowledge, etc.
Bridging	Creative business model, partnerships, integration across stages of the product development cycle, balance between external and internal factors.

The research assumed that innovation is not on option but a necessity for all corporations in an economic environment that is global, intensely competitive, knowledge driven, and subject to uncertainty and rapid changes. Aspects of this environment were explored both from a recent historical perspective and, more importantly, within emerging trends that will impact innovation in the mid-term (3-5 years) future, e.g., geographical and virtual clusters, open architecture and on-demand information technology, private vs. public ownership, joint development

partnerships, corporate cultures, education, etc. The impact of these environmental aspects on the future viability of the innovation models that underlie the two taxonomies is explored.

The companies selected for primary research in this study broadly fit within the definition of an SME with regard to business activities and number of employees. In the cases where the total number of employees exceeded 500, we determined that the operational divisions with which we spoke were largely autonomous, and hence behaved much like an SME.

Interviews with fourteen companies were analyzed for properties that were hypothesized to be associated with successful innovation management. Three of these companies were eliminated from the analysis as their claims of success were not verifiable. The properties of the remaining eleven companies were mapped against the hypothetical relationships. A high degree of correlation between company properties and innovation success was observed. This correlation, albeit from a restricted sample, was independent of market sector, and firm location. Summarizing the analyses, we found that:

Innovative success in SMEs, in general, DOES NOT depend upon:

- Industry sector in which the company operates
- Age of the enterprise
- Being an incumbent or entrant in a given market
- Type of Innovation – incremental or radical, etc.

On the other hand, innovative success in SMEs DOES STRONGLY depend upon:

- Focusing on core knowledge and markets, with the intent to dominate a niche
- Integrating internally developed technology with externally acquired technology
- Keeping close, even "informationally intimate", with customers
- Having a clearly defined IP and R&D strategy
- Having an open and inclusive "corporate culture" that embraces innovation
- Bundling customized services with products

In addition, innovative success in SMEs may also be enhanced by:

- Innovative IT applications
- Private rather then public ownership structure
- Moderate marketing aggressiveness
- Acceptance of moderate risk in entering new markets
- Formation of partnerships to access complementary assets

Our research shows that innovation in SMEs aimed at sustaining and growing in an increasingly competitive and rapidly changing global economy is substantially different from the "traditional" models of unique products and/or unique manufacturing processes. We did not specifically study the forms of innovation that larger corporations need to employ in order to be successful in the long run. However, we note that SMEs are more likely to be able to change their business model due to the lack of cultural inertia that is more typical in larger organizations.

Fundamental shifts have occurred or are incipient that will dictate how SMEs must manage, including:

- Businesses now compete on a global basis for resources including intellectual capital - reliance on purely local support and resources is not sufficient; this shift may weaken the advantages that firms may derive from membership in a location-based cluster and strengthen advantages from membership in virtual clusters.

- No company, however large, can expect to sustain all of its core competencies internally. This is particularly true for SMEs with limited internal resources and capital. Therefore innovation increasingly occurs through inter-enterprise cooperation, including universities, corporations and even individual specialists. Some companies prefer to acquire the intellectual asset when needed; others are willing to share the benefits. Whatever the cultural bias, continually "searching at the edge of the current business domain" for new ideas and forming relationships, permanently or temporarily with mutually benefiting third parties is a necessity;

- Corporate cultures that support innovation are becoming much more important, breaking down hierarchies and promoting initiatives for individuals to take balanced risk;

- Developments in IT infrastructures can be beneficial to SMEs as architectures become open and applications are accessed on demand. SMEs must learn how to use IT creatively to sustain competitiveness and use acquired data to provide better customer service and to create barriers to hinder later market entrants from simply copying the methods and techniques of the leader;

- IP policies and management in all forms is crucial;

- Innovation in business models, often centered on IT applications, is as important as technical innovations.

These fundamental shifts will challenge SME managers in unaccustomed ways for which past experience is little help for the future. We recommend two new important roles for the MEP program to help SME managers:

- **Educate MEP field professionals, and through them, SME managers in the new innovation paradigms and their application.**
- **Catalyze SME access to innovation resources and external intellectual capital.**

For MEP to address these needs requires access to talent and resources that are in very short supply. We propose four scalable activities:

- **Provide reports and cases to help current MEP field staff educate clients on innovation models.**

- **Develop an on-line supported problem-based learning environment for MEP field professionals to train them in how their clients must innovate. Subsequently expand this environment to encompass SME managers directly.**
- **Create structures and relationships that link SMEs with leading MBA programs through the MEP network.**
- **Explore a collaborative web-portal for innovation between SMEs.**

1. Background

The Manufacturing Extension Partnership Program (MEP) within NIST is reviewing its overall mission and strategy to determine whether any modifications are required to the assistance programs for small and medium-sized enterprises, or SMEs. Perhaps the most important topic is innovation. With the current national spotlight on outsourcing, intellectual property (IP) policies, economic recovery without substantial increase in the number of higher paying jobs and increasing white collar and technical skills in many countries (e.g., India, China, Korea, etc.), innovation is seen to be the one area where U.S. companies can grow successfully, competing with overseas companies and resources. Indeed, innovation is seen as the primary attribute that the U.S. can use to maintain and increase its role in the global economy and wealth creation for Americans. (Further discussion of these topics is provided in Appendix 2: "Current Debate on Innovation, Competitiveness and Offshoring").

With this in mind, it is important to understand exactly what innovation means in today's global economic climate as applied to U.S.-based SMEs and how appropriate innovation and execution skills might be enhanced by federal, state and local outreach programs.

Figure 1: Accelerating Waves of Technology Driven Social Disruptions.

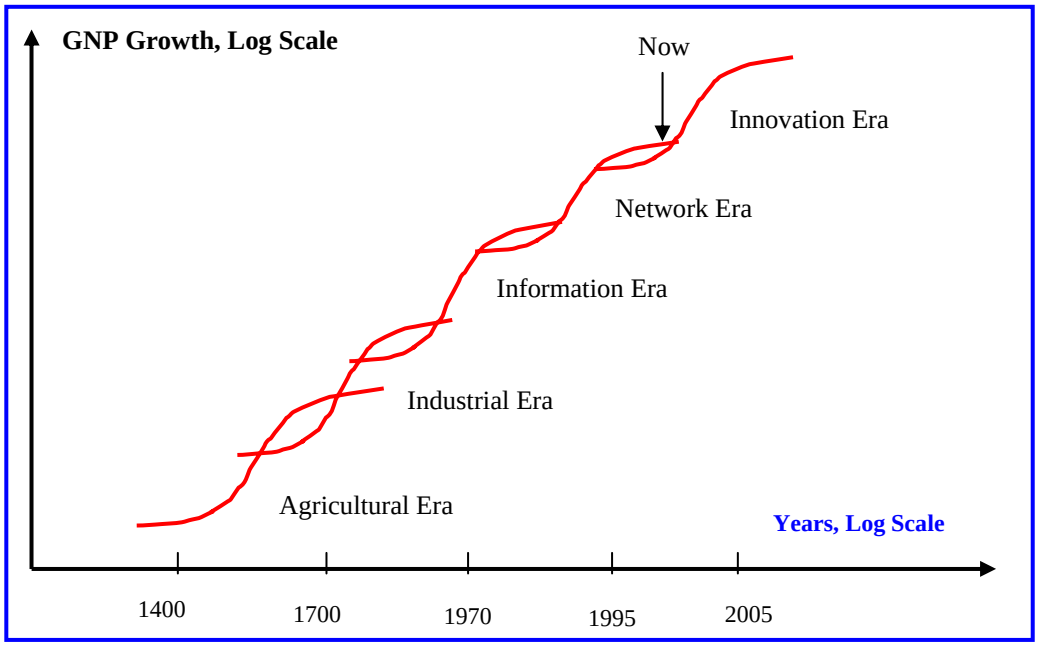


Figure 1 shows how growth in wealth over the ages has been driven by major changes in economic drivers. Over the last thirty years we have seen growth driven by "information technology". Originally computers were primarily "back-office" productivity tools. Now, in the developed nations, computers are ubiquitous and entirely interconnected, which has allowed everyone to have access to knowledge – the so-called "network or knowledge era".

Along with this "knowledge era" comes the collapse of protective barriers. Some of the protective barriers that are falling quickly are highlighted below:

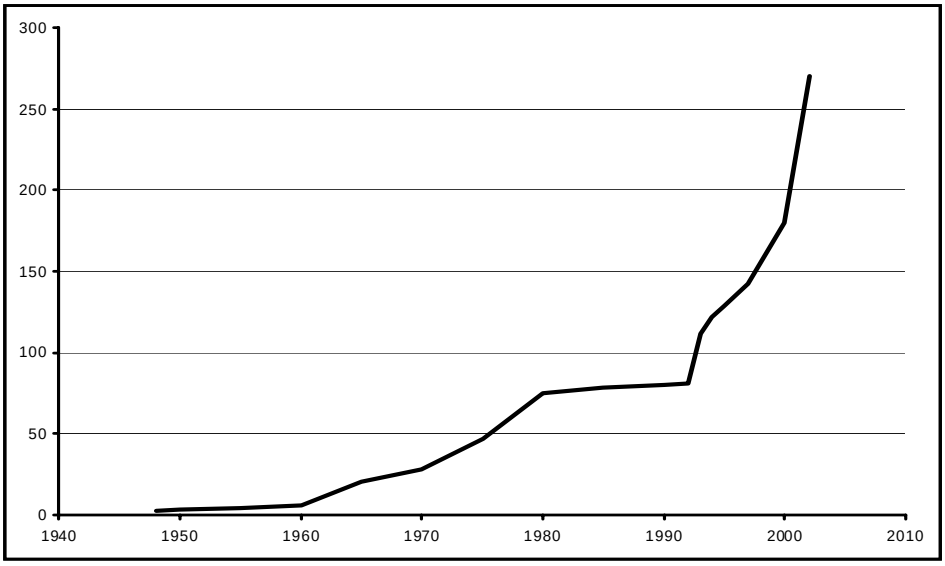
Access to knowledge

There is an increased amount of access to knowledge at minimal costs. To remain competitive today, it is no longer sufficient to rely on local know-how; indeed it is vital to access the best ideas, technologies, research resources, experts, wherever they are.

Trade-Barriers

Historical trade barriers for goods and services are rapidly being dismantled opening up all markets to global suppliers. Figure 2, compiled from WTO data shows the rapid acceleration of trade agreement implementation. Barriers to competition from import/export controls that companies could hide behind in the past are dissolving. There may be occasional short-term restrictions applied for political reasons, but the overall trend is clear.

Figure 2: Growth in Number of Trade Agreements



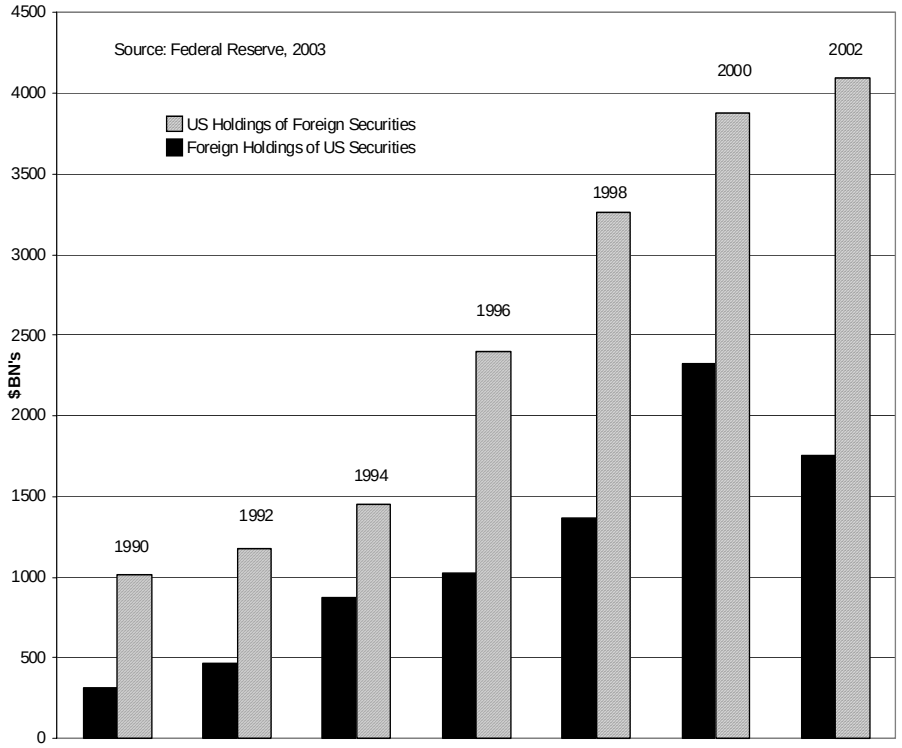
Source: World Trade Organization

Access to Capital

With the elimination of trade barriers for goods and services, restrictions on currency trading have also been almost entirely removed. Now daily cross-border trading in currency dwarfs the value of imports and exports. Although most currency trading is on a short term basis, the lack of restrictions in the majority of economies to inward or outward foreign investment means that funds may now seek opportunities on a global basis and firms must compete internationally for both debt and equity finance. Fully 20% in mutual funds managed in the U.S., and a mainstay of U.S. personally managed pensions are now invested overseas. 2004 will be a record year for U.S. investors to place their investment bets overseas, with $90 B slated to flow into foreign

corporations (WSJ, August 4, 2004). Figure 3 shows the growth in value of international holdings in securities. Geographical location no longer provides any significant advantage to major sources of capital. Of course, there are still local economic development grants but as they have proliferated, they are no longer a real differentiating factor.

Figure 3: International Securities Ownership – 1990-2002

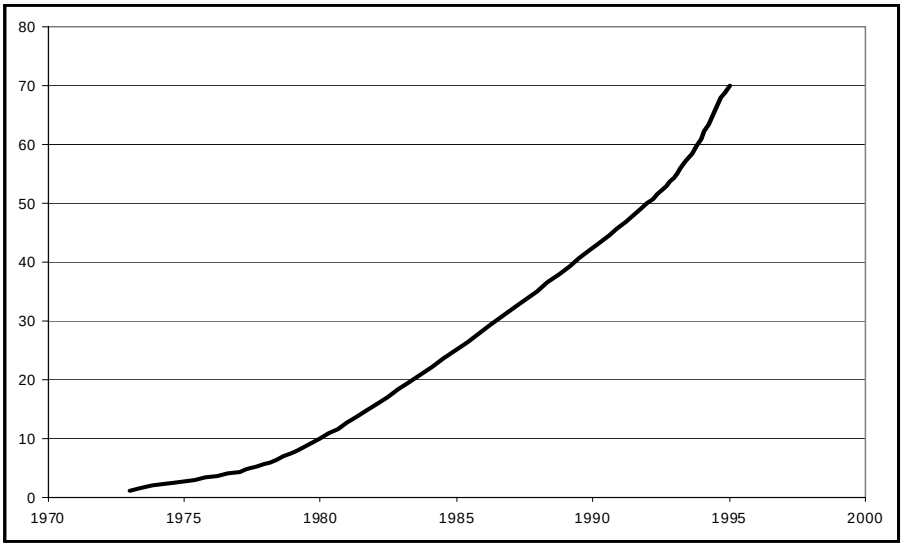


Source: Federal Reserve Bank, Annual Report, 2003

Venture Capital remains one source of funding that prefers proximity; but overall, VC funds are a very small part of total growth capital. Even venture capital is trending international. U.S. VC firms on Sandhill Road have considered early stage private equity investments in Asia (Fannin, 2003). At least one of the larger firms, Draper, Fisher, Jurveston, is currently raising a fund for this prupose (Draper, 2004). These experienced, U.S.-based venture capitalists anticipate bringing their start-up management skills into markets where U.S. style venture investing is little know. Clearly they are not finding sufficiently attractive opportunities domestically.

As an indicator of how internationalism has flourished in liquid asset deployment, Figure 4 shows the growth in the daily *ratio* of international currency flows as a multiple of international trade. Today, more than one hundred times as much currency flows across borders every day than the value of goods and services (Siegel, 1998).

Figure 4: International Currency Flows as a Multiple of Trade



Source: *Control of International Capital: A Survey of Policy Options*, M. Siegel, Global Policy Forum, White Paper, November 1998.

Technological Obsolescence

We often hear that product lifecycles are declining; however, it is notoriously difficult to find hard data supporting this fact. Clearly, it is much more likely to be true in fast moving consumer products such as food and detergents, and in products in which the underpinning technology is driven by Moore's law, or is impacted by major technological shifts. According to an internal study in the mid-nineties by Hewlett-Packard (Hohmann, personal communication to A. Warren, September, 1995), the average period that their products remained major contributors to sales has fallen from four years in 1980 to well below two years in 1995. More recent studies (discussion between Warren and IBM CTO, August, 2003 and Teresko, Industry Week, January 2004) measure product development times. These have shortened from an average of 225 days three years ago to 207 days now. In the portable communicator business sector populated by such companies as Motorola, Nokia, Research in Motion (RIM), etc., market life cycles are now less than product development cycles, challenging even the most efficient engineering departments. To meet these challenges companies are developing new methods to reduce their product development times by employing 24/7 activities spread around the world. The Munich- based lead team hands over to Beijing at the end of the day, whose team, in turn at sunset, hands over to Denver. In many cases these teams may not be on the staff of the lead company, but may be joint development partners that are assembled quickly to meet an urgent deadline. Managing such complex projects across corporate, national and cultural boundaries requires new skills that ensure that "getting it right first time" can be achieved. There is no room for error. An indicator of this phenomenon is the emergence of the dozens of software providers that provide the support systems for both rapid product development and product life-cycle optimization.

Of course, in slower moving sectors such as machine tools and locomotives, the evidence for rapidly declining product life-cycles is not so obvious. However, even here, the impact of low-cost electronic computing power and the ubiquity of the Internet are accelerating the upgrades

that customers expect to provide them more than just a product; they anticipate nothing less than a total solution to their requirements throughout their ownership. These additional service components may cover not only financing and operator training, but remote condition monitoring for 24/7 on-line support and maintenance, performance guarantees with financial penalties, and even taking back the product for re-cycling at the end of its life-cycle. Each of these service components demands implementation of new technologies within even the most traditional of engineering sectors.

From the above information it is evident that we are rapidly approaching a state where everyone in developed regions can access, essentially free, all accumulated knowledge, leading thinkers, and peers. In addition, with a global openness for trade and finance, every company has the ability to find and access intellectual and physical assets anywhere. Therefore, as these trends play out in the early 21st century, we inevitably must migrate to an "innovation era", in which wealth will be created through innovation – not the individualized or local form of the past, (as exemplified by Bell and Ford) but innovation in networks and partnerships made possible as we move out of the pure knowledge era. Figure 1 also illustrates how these cycles of economic drivers are accelerating over time – changes coming so rapidly that it is dangerous to base decisions on what has transpired in the past, only on what is anticipated in the near future. Continuous change and learning are now a necessity for business success.

This report, therefore, takes today's best practices in successfully innovating SMEs and attempts to put these into a framework that will be useful in recognizing the patterns in the new ways of innovating and providing a structure to support SME managers in adapting to change. We start by looking at a broad definition of innovation and develop a taxonomy that is based on components of this definition.

This taxonomy is then used to classify successfully innovating SMEs not only within the U.S., but also in other business environments overseas. The attributes and behaviors that are included in this taxonomy are based on existing research and informed speculation, which we subsequently test with interviews with senior executives from a range of domestic and foreign SMEs from different industry sectors. We also will explore a second taxonomy that is based on Mittelstand companies, clusters and chaebol/keiretsu models to determine whether any of these can and should be transferred successfully to the U.S. SME sector. Finally, the results from the study of both taxonomies will be used to draw implications and recommendations for the MEP program.

Subsequent to commencing this project, one of the authors (Warren) was invited to participate in a major set of activities spearheaded by the Sam Palmisano, Chairman and CEO of IBM and Wayne Clough, President of the Georgia Institute of Technology, entitled the "National Innovation Initiative" (NII). Specifically, Warren sits on the "21st Century Innovation Subgroup" which has the role of creating a recommendation consensus from the other six sub-panels. This work has enabled Warren to work with over 100 professionals from government, academia and industry with diverse views on how to promote innovation throughout the nation. This has aided substantially in reaching the conclusions in this report around a subject that has traditionally been difficult to define and stimulated the development of a practical framework for executive actions.

We also make the premise, borrowed from the venture capital industry, that successful innovative companies continue to generate high gross margins, typically 50-60%, while keeping overheads in check. A high gross margin implies that customers are willing to pay for value that the vendor delivers and that there are few, if any alternatives for customers. In this situation, customers have limited economic power to push margins down to commodity levels. A major source of this differentiation comes from innovation.

Several of the topics that we explored during the project provided extensive information, some directly pertinent, others less relevant. In an attempt to keep the core issues concise, we have moved the details to separate appendices.

2. Definition of Innovation Applied to this Project

In order to focus the activities within this task and to create a uniform terminology for interpreting the results, we start by defining "innovation" in the context of SMEs. After reviewing published literature on innovation together with an initial survey of successful mid-sized manufacturing companies, we chose the following definition:

> **Successful innovation is the use of new technological knowledge, market knowledge, and business models that can deliver a new product or service, or product/service combinations, to customers who will purchase at prices that will provide profits.**

This definition is built on the generally accepted work of Afuah (2003). In order to apply his definition to the SME manufacturers we added:

"Successful…." in order to emphasize that we are not interested in innovation that fails to deliver and maintain value within the innovating enterprise.

"…business models…" in order to stress that innovation in business models is as important, perhaps more so, than purely product or process technology. This new emphasis on business models is emerging as a key point in our research. It arises from major changes in the business environment such as product life cycles, information intensity and transfer, and globalization of markets and resources. These factors challenge the ability of an innovator to retain the value derived from their innovations.

"…who will purchase at a price that will provide profits." in order to stress that success requires the innovator to be able to extract benefit from the value that they create. Afuah's (2003) definition includes innovations that customers may want but will not pay enough for, or innovations where the value created by the innovator migrates to another enterprise that can be offshore and therefore does not necessarily increase the economic wealth of the U.S.

Creation and RETENTION of value are required for the continual growth of wealth in the U.S. that can be distributed, as in the past, for the benefit of the broad population. Innovation is the means to create this retained value.

Chesbrough and Rosenbloom's (2002) perspective on business models influenced our definition of innovation. They maintain that technology has no single inherent value; its value remains latent until it is embedded in a product or service and is based on what a set of customers is willing to pay for it. The business model is a mediator between technology and economics that forces technologists and marketers to focus on common ground. This is only a start, however, because making a profit depends on how the customer pays for the product/service, e.g., buys, leases, licenses, or subscribes, and how well the innovating firm builds a value chain to develop, make and deliver a product/service, and. where applicable, negotiates with those who own complementary assets. An effective business model consists of making consistent and mutually reinforcing choices regarding value chain members. The firm also must tie the business model to a competitive strategy that prevent rivals from imitating its innovation, and customers and owners of complementary assets from negotiating an excessive share of the innovation's value.

We also view the business model as a mediating or "bridging function" that integrates internal and external organizational factors. The innovating firms that we studied devoted considerable attention and resources to protecting their intellectual property. They also increasingly sought partners to configure and deploy assets to take advantage of quickly developing opportunities. The Internet makes it easier to find partners for these opportunities and to coordinate with these partners across multiple firm boundaries. Chesbrough and Rosenbloom (2002) caution, however, that successful business models are double-edged swords. They encourage common focus across organizational functions, but cognitive bias as well, which can lead firms to view new ventures through the lens of previously successful business models that may be inappropriate for the new venture. New ventures may require new business models and organizational units to manage them. As the next section suggests, these requirement are strong indicators of a radical or disruptive innovation.

3. Models of Innovation

We reviewed several articles and books to identify innovation models that might be relevant to SME innovation success. Broadly speaking, innovation models can be categorized as static or dynamic. The static category is most relevant for our purposes because it focuses on attributes and behaviors of firms and members of their value chain that relate to innovation success as well as to properties of the innovations themselves. The category is called static because it focuses on the properties of firms and innovations at a given point in time, and we will not be tracking firms or innovations longitudinally. We assume that the properties that concern us will be stable for a reasonable time period. The dynamic category focuses less on firms and more on the properties of innovations themselves and their degree and rate of change. For example, product innovations typically precede process innovations, and firms shift their focus from product performance to cost as innovations mature (Abernathy & Utterback, 1978). While these dynamics are certainly relevant to the study of innovation, they are less relevant for our immediate purpose.

Most static models of innovation focus on the match between a firm's properties and the types of innovation that it introduces or adopts. This suggests that a firm and its innovations should be studied together. For example, incumbent firms in an existing market are more likely to introduce incremental innovations than radical ones. Incremental innovations rely on the

incumbent firm's accumulated technological and/or market knowledge to sustain or enhance their position in its market. New entrants are more likely to introduce radical innovations that dramatically enhance the performance of existing products or create new product categories or markets. Radical innovations rely on different types of knowledge than do incremental innovations, which incumbents generally do not possess. If entrants don't already possess this type of knowledge, they are willing to invest the time and resources necessary to accumulate it.

Incremental innovations are "competence enhancing" to incumbent firms because they rely on their existing knowledge base for success (Tushman & Anderson, 1986). Radical innovations are "competence destroying" to incumbents because they make their knowledge base obsolete. For these reasons, incumbents are less likely to introduce radical innovations successfully. We can improve our ability to predict innovation success by expanding this dichotomy to include details about the type of competence that is enhanced or destroyed and about the nature of the innovations themselves. For example, an innovation may enhance or destroy technological or market knowledge (Abernathy & Clark, 1985). Some incumbents can adjust readily to innovations that make obsolete one type of knowledge, but not both. Also, the radical versus incremental distinction can be expanded to radical, incremental, modular and architectural (Henderson & Clark (1990). This expansion takes into consideration changes to a new product's components (modular) or relationships between components (architectural). Changes in neither are incremental and changes in both are radical. Incumbent firms often misidentify architectural innovations as incremental ones, and thus misjudge the difficulty of introducing them.

Incumbent firms also have difficulty adopting disruptive innovations. These innovations have properties that their current customers do not value, and are inferior on properties that they do value (Christensen, 1997, 2003). Consequently, they fail to meet most investment hurdle rates. Entrant firms search for customers who value the properties of disruptive innovations, and thus are more likely to adopt them.

Innovations have other properties that challenge firms and affect their likelihood of successful adoption and commercialization. For example, tacit knowledge is more difficult to manage than codified knowledge, but also easier to protect from imitation. Ability to imitate an innovation and whether commercialization depends on ownership or control of complementary assets will influence how much profit the innovating firm will realize from its investment (Teece, 1986).

Successful innovation, of course, depends on strategic leadership and organizational structures and processes that are appropriate to the type of innovation adopted (Roberts and Berry, 1985). It depends also on the organization's values, decision-making style, culture and rewards (Duncan, 1972).

We chose to retain the radical versus incremental dichotomy to characterize the innovations of the firms that we interviewed, even though a more detailed analysis of the specific innovations of any firm might lead to a more refined characterization. The eleven firms that we interviewed were all established firms with a history of successful innovation in the markets that they served. Most of their innovations were incremental. A few firms initially introduced radical innovations, which required a new technology knowledge base, but relied on knowledge of their existing customers. Their subsequent innovations tended to be incremental. These firms may have been

entrants when they entered their current markets. However, when we conducted our interviews, these firms were incumbent firms as they were now firmly established in these markets. Finally, Christensen (1997, 2003) would consider these innovations to be sustaining rather than disruptive because they enhanced performance on properties that their current customers valued or those of new customers that they sought. Disruptive innovations have properties that the firm's current customers do not value, and require firms to set up independent units to serve them effectively. We saw little evidence of this happening in the firms that we interviewed.

One of the primary purposes of this research is to develop taxonomies of innovating firms. The first taxonomy that we will consider is derived from the models of innovation that were discussed above. Incumbent versus entrant firms and incremental versus radical innovation are useful dichotomies with which to begin a taxonomy. We will introduce other properties of innovating firms that can be organized into categories or ordinal scales, e.g., high, medium, and low. Their initial inclusion in the taxonomy will be based on existing research or informed speculation. They will be tested with a sample of innovating firms to verify their relationship to successful innovation. We also will explore whether different patterns of properties emerge for entrant and incumbent firms that produce radical versus incremental innovations.

The second taxonomy that we will consider is derived from models of innovating firms that were developed outside the U.S., i.e., Mittelstand (Germany), geographical clusters (Italy), and kereitsu/chaebol (Japan/Korea). We will explore these innovation models and assess their applicability for U.S. based SMEs. This exploration will be based on analysis of data collected from secondary sources.

4. Taxonomy Derived by Testing Factors Related to Innovation Success

4.1. Development of Primary Categories and Key Factors

We identified a substantial number of firms that are highly profitable and dominate their markets through innovative practices. These firms display attributes and behaviors that can be grouped into three primary categories (see Table 1) that we believe are essential to development of taxonomy.

Our research suggests that a specific set of attributes and behaviors within these three categories is necessary to create and sustain innovation within an SME. The first two categories are, of course, to be expected. However, the third "bridging" category is less obvious yet emerges as a key component of a successfully innovating company. A creative business model is the primary bridging function that integrates internal and external factors and creates the successful innovating enterprise.

The firms that we identified have an exceptionally deep knowledge of technologies that underlie the development and delivery of products and services that they offer to their customers, and equally deep knowledge of their customers' needs and the conditions that enhance and support

Table 1: Primary Categories for a Taxonomy

Primary Categories	Key Success Factors
Internal	IP management, knowledge management, IT applications, maturity, governance, culture, human resource practices.
External	Closeness to customers, supply chain and competitor knowledge, proactive engagement with the environment for acquisition of technology, knowledge, etc.
Bridging	Creative business model, partnerships, integration across stages of the product development cycle, balance between external and internal factors.

their customer's profitability. These firms are relentless in their pursuit of such knowledge and have developed novel means to acquire, interpret, store and access such knowledge. They approach new business development through integration forward or backward across stages of the product development cycle and across functions within the firm. This integration may be either to create more value for their customers or to complement manufacturing with tailored services that precede or follow the manufacturing of products.

With regard to IP management, the successful firms aggressively protect the proprietary knowledge that they have developed through a fortress of patents or intense secrecy. Some of their proprietary knowledge is deeply embedded in organizational routines that are difficult to imitate because they cannot be codified and would take years for competitors to develop or because they are embedded in proprietary software and/or databases. Note that many SMEs, being privately held, often have a culture of secrecy and non-disclosure so that patent count and patent quality may not be a good indicator of a successful SME. Trade secrets are often the chosen method for IP protection.

These firms tend to centralize decision-making with regard to strategic goal setting and have a simple governance structure, which is seen most often with private ownership. They also tend to be reasonably mature organizations, having been in existence long enough to develop coherent and consistent policies and practices, especially with regard to human resource management. Their policies and practices generate intense loyalty among employees, thereby reducing loss of talent and potential leakage of proprietary knowledge through turnover. Their compensation practices also assure that employees focus on priorities that are consistent with those of top management.

We conducted interviews with eleven firms, being guided by the set of attributes and behaviors that we believe are related to successful innovation or merited exploration of their relationship to innovation. These interviews permitted us to dig deeper into the actual innovation practices of these firms. They were undertaken across a broad range of industry sectors in order to explore whether fundamental patterns differ across markets. We will explore whether a single profile or multiple profiles of the fifteen attributes and behaviors emerge among the firms, which, in the latter case, would suggest different approaches to successful innovation. If multiple profiles of success emerge, we will label them accordingly.

The set of factors that we identified at the start of the project was based largely on experience and existing research, and was modified slightly during the primary research as new insights emerged. Table 2 shows the key success factors within the three primary categories: internal, external and bridging, and provides some detail regarding their meaning and why they were chosen. We added incumbents versus new entrants and radical versus incremental innovations at the bottom of the table. As only one of the eleven firms is a new entrant into its market, we won't be able to learn very much about the profile for such firms. We might expect, however, that new entrants would be found in the high market entry risk category.

***Internal*:**

1. ***Intellectual Property (IP) Management*** – We explored whether IP, principally patents and trade secrets (and to a lesser extent trademarks, service marks and copyrights), is considered key to a company's ongoing success. In addition, we explored how these assets are managed including the forms of IP selected, how IP generation is built into innovation processes, whether there is a formal plan in place to manage IP and if so, how is it constituted, and what is the absorptive capacity of the enterprise to access and use IP. Our results show that successful innovative SMEs have a formal plan for managing IP. Surprisingly, the content ranges widely between a strong emphasis on patents to an almost complete reliance on trade-secrets. Included in this factor is the R&D level within the enterprise.
2. ***Innovative IT Applications*** – Manufactured products often have embedded software content, or interact with a proprietary software program either locally or increasingly web-hosted. In addition, corporate resident software may be a means to provide customization capability of a product, or level of service provision. We have observed innovative IT applications within business models that create a significant competitive advantage for companies.
3. ***Ownership*** – Ownership may affect scope and style of decision-making, governance, focus, culture etc. We believe that privately held companies (family-owned or private non-family-owned) are willing to make decisions with longer-term paybacks or consequences than public companies.
4. ***Age of the Enterprise (maturity)*** – This factor is introduced to reflect accumulated experience and social capital and its importance for longer-term competitiveness. Rather than hypothesize any specific enterprise age as optimal for long-term competitiveness, we wanted to see if any pattern was discernable in the current sample of companies.
5. ***Employee Turnover*** – We use turnover as an indicator of an open and inclusive culture, the capacity to retain and use tacit knowledge, a lack of IP leakage, etc.
6. ***Profit Sharing Program*** – This may reflect on the ability to encourage and exploit innovation and can be an indicator of a team oriented, low hierarchical organization.

***External*:**

7. ***Closeness to Customers*** – This refers to understanding the customer's needs, both explicit and implicit and the process used for this purpose. Frequent interaction with customers is generally considered to be a spur for innovation.

8. ***Market Focus*** – This refers to product/service focus, not geographical sectors. We wish to understand whether narrow market focus is a positive or negative with regard to successful innovation execution. Is concentration on a niche more likely to lead to success? We believe that it is. We note that many SMEs (generally not those selected for this study) become squeezed within a supply chain where they have no economic power and hence low gross margins. This is not uncommon for suppliers in the automotive sector. Such "commoditized" companies may feel a need to shift to another sector where their core skills can command more economic power and hence higher margins. We would, however, caution companies that are under severe margin pressure in their current markets not to rush into new unrelated markets before analyzing whether their core competencies will enable them to do better in a field where they have less "domain" knowledge and will compete with entrenched rivals. We suggest that innovation rather than market shift is a better strategy to follow. Indeed, we researched and interviewed several successful SMEs that, through innovation, can command high margins in the automotive sector where their less innovative peers are suffering.
9. ***Geographical Focus*** – We are interested in whether companies can be successful with a limited market outreach or operate on a global scale.
10. ***Market Entry Risk*** – This factor refers to a company's willingness to enter new unrelated markets, whether emerging or established, that differ significantly from those that the company already serves.
11. ***Marketing Aggressiveness*** – This factor relates to the market positioning and communication skills shown by the company in introducing new products and services. This may be a reflection on the innovative capacity of a company. "High" relates to a company that is driven by marketing, "medium" indicates focused low profile peer-to-peer marketing and "low" indicates sales come purely by reputation and recommendations.

Bridging.

12. ***Technology Integration*** – This factor refers specifically to processes that combine internally developed technology and externally accessed technology from independent third parties, partners, customers or vendors within an integrated plan.
13. ***Service/Manufacturing Mix*** – We postulate that manufacturing prowess is no longer sufficient for sustained competitiveness and that every successful company should have a service content to its business model. We see a trend to service rather than product models, together with customization of this to individual customers.
14. ***Competitive Advantage*** – We explore whether this arises from product quality, time to market, technological innovation, service content and customer satisfaction, IP, etc.
15. ***Partner Relationships*** – Firm relationships may be important for continued success as "soft" or ambivalent firm boundaries and partnerships grow in importance. As the time span that products can command high profits in the market shortens, and international markets become readily accessible, new business models may be required to meet the fleeting "windows of opportunity". Although none of the firms interviewed was a member of a geographical cluster, many formed partnerships with other firms that had assets that complemented their own, e.g., research, marketing, or distribution. Geographical proximity played little if any role in the formation of such relationships.

Much has been written on the importance of local networks of mutually supportive companies sharing knowledge and know-how. Indeed, economic development programs are often based on cluster support. The field of location-specific clusters is currently highly debated; we therefore devote a full section to the evolution and importance of clusters (see section 6.2).

Table 2: Secondary Factors for Taxonomy Development

(Bolded Text indicates our hypothesized attributes for success prior to the primary research)

	Category	Factor(s):			
1	Internal	Intellectual Property	**High**	Medium	Low
2	Internal	Innovative IT Applications	High	**Medium**	Low
3	Internal	Ownership	**Private (Family Owned)**	**Private (Non-Family Owned)**	Public
4	Internal	Age of Enterprise (in years)	< 25 Years	25-50	> 50
5	Internal	Employee Turnover	High	Medium	**Low**
6	Internal	Profit-sharing Programs	**Yes**	N. A	. No
7	External	Closeness to Customer	**High**	Medium	Low
8	External	Market Focus	**High (i.e., narrow)**	Medium	Low
9	External	Geographical Focus	**International**	Regional	Domestic.
10	External	Market Entry Risk	High	**Medium**	Low
11	External	Marketing Aggressiveness	High	**Medium**	Low
12	Bridging	Technology Integration	**High**	Medium	Low
13	Bridging	Service / Manufacturing Mix	**Service/ Manu-facturing**	Service	Manufacturing
14	Bridging	Competitive Advantage (value creation)	**Technology Innovation**.	.Service	Product Quality
15	Bridging	Partner Relationships	**High**	Medium	Low
		Innovation Type	Radical		Incremental
		Firm Type	Entrants		Incumbent

4.2. Research Methodology

A questionnaire/discussion guide was generated to explore the set of attributes and behaviors that we considered to be related to successful innovation. This guide, together with a short summary of the task order intent, was provided to interviewees several days prior to a telephone or face-to-face discussion. This time was to enable them to ponder the topics, and to think about other areas that might be pertinent to our study. The design was such that we were certain that we would cover all the topics that we deemed relevant, yet not too constrained so that we might miss other key areas. The interviews were taped only if the interviewee agreed; otherwise, notes were

taken during the conversation. We generally had at least two persons in attendance from Penn State.

Prior to getting to the questions, we described our role, the procedures, the expected outcomes, and then asked the interviewee to give a general background of the company. This usually included history, products/services, locations, people, partnerships, business model, etc. Subsequent to going through the twenty questions, we usually engaged in more general discussion for perhaps a further 15-30 minutes, which often gave more in depth insights into personal philosophy and corporate culture.

The targeted companies were chosen in two ways. First, there were several companies known personally to the team that we knew had been successfully innovating for a number of years. Secondly we accessed two databases listing 'most successful U.S. innovative companies', the first in *Industry Week*, which derives its list through peer analysis and from Chi Research, which derives its list through intellectual property analyses.

By eliminating companies that were not truly manufacturing SMEs, we narrowed this list down to 34 targeted companies. Letters were written to the CEO's of these companies to ask them to be participate in our study. Follow-up phone calls elicited our final interviewees. We found that many of the successful SMEs were extremely reticent to being subjects of a study of this type. Even when they agreed to be interviewed, in many cases, they would not provide any information that might in some way be used against them by competitors, suppliers, or customers. Three of the interviewed companies were removed from our analysis as it had transpired that they had not achieved the promises that others attributed to them or they had claimed. Eleven companies remained in the final analysis.

The outline for discussion is shown in Table 3.

Table 4 provides a brief description of the final interviewee list used in the analysis. Three of the companies are identified only by letter as the interviewees preferred to remain anonymous. In the business description column, we indicate the type of innovation practiced in the enterprise. "**I**" indicates incremental, "**R**" indicates radical. Where the company commenced with a radical innovation and has continued to make incremental changes, we show "**R,I**", etc. We designated innovations with this pattern as radical.

4.3. Results

It can be seen immediately in Table 5 that most of our hypotheses stand up well to the analyses from the interviews. Although our sample is relatively small, we are confident that successful

Table 3: Outline for Discussion

	Attribute Type	Questions
1	External	How do you keep up with technological change that relates to developing, producing or delivering your products and services?
2	Internal	Do you conduct any of your own research? How much?
3	External	How do you learn about outside technology developments?
4	Internal	Where and how do you capture and store technology knowledge until you need it?
5	External	How do you learn about your customers' needs and priorities?
6	Bridging	Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire?
7	External	How do you keep in-touch and up-to-date with any changes in your customers' needs or priorities?
8	Bridging	Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?
9	Bridging	What have you done recently (within last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?
10	Internal Bridging	Do you take any special measures or precautions to assure that competitors can't use any knowledge that you acquire about your technologies or customers and imitate your products or services? These may include patents or informal policies and practices, or could arise naturally from the way you make products or relate to customers.
11	Internal	Did you design and develop your current organization structure, policies and practices with any conscious and consistent values or objectives in mind? If so, what were these values or objectives?
12	Internal	Do any of your answers to previous questions apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these policies and practices? Have they had their intended consequences?
13	Bridging	Is there a traceable pattern among your innovations in the last 5 years? I.e. how do you proceed from one major product innovation to the next? E.g. product innovations may be based on common technology or combinations of technologies, related products, or similar types of customers. Is any basis more prevalent than another?
14	External	How do you stay current with developments that relate to your innovations?
15	Internal	Who gathers such information?
16	Internal	Is special training or experience required in order to understand these developments?
17	External	What types of contacts were made in the past 2 years? How or where did they occur?
18	External	How many of these contacts occurred during this time period, e.g., less than 5, between 5 and 10, more than 10?
19	External	Were these contacts made specifically for the purpose of staying current with developments or were they chance encounters?
20	General	Are there any other topics that you feel we have not covered and are relevant?

Table 4: Final List of Interviewees

Company	Location	Brief Business Description	Contact
Taprogge, T	Germany	**(R,I)** Water Treatment Systems	CEO
PBR, P	Australia	**(I)** Automotive brakes	Ch. Eng.
B	Italy	**(I)** Maker and exporter of automotive brake systems focusing on high-end cars, motorcycles and trucks. Publicly listed but family controlled. Grown with above typical margins by investing heavily in technology and patents to command "high-end" where performance is premium. Uses F1 presence as key to image building. Recognized for quality and responsiveness to customers. Now moving down market for growth - may affect margins. Within Milan region but no interaction with others in the -auto cluster.	Ex-Ch. Eng.
ChemStation (C)	USA	**(R,I)** De-commoditized industrial cleaner market with a unique business model. Delivers dispensing tanks to the client and fills JIT with cleaners blended for specific task. Uses Internet to tie together franchised branches, which have access to proprietary database of formulas. Guarantees large customers consistency at all locations. Capital raised using franchising, now buying back branches from cash flow. IP lies in database, which is kept centrally and patent on dispenser.	CEO
DeAngelo Brothers/DBI. (D)	USA	**(R,I)** See mini-case 4 on p 23. Now expanding to road, and retention ponds. Company manufactures own equipment to provide a service. Grown to around $70M and self funded. Now seeking ways to operate overseas.	CEO
Lutron (E)	USA	**(I)** E designs electronic products for lighting control both consumer and professional. Undertakes own R&D but uses outside consultants and searches actively for ideas externally. Noted for innovation protected by broad patents. Segments teams for security, but involves everyone in collegiate culture resulting in low staff turnover. Has grown and prospered in highly competitive market through continuous innovation. Now branching out into related areas such as "ambience management". Secretive on financial performance, but open on cultural issues.	C'man
Summit Industries (F)	USA	**(I)** Founded in 1984, Summit focuses at the low-end of the film radiography market and all innovations are targeted at derivative improvements in ergonomics and pricing. Summit operates in an inner city and fulfills a broader social mission by providing training and an open culture. IP is all in trade secret productivity improvements. It has close relationships with its customers and creates new products to meet customers' expressed needs. In the veterinary market they have 60% market share and have chosen to focus on this niche. Sales are $20MM, only 5% export.	COO + VP MFG.
G	USA	**(R,I,R,I)** G provides innovative media packaging solutions product - CDs, including jewel boxes, sleeves, and DJ cases. G also makes loose-leaf binders and packaging equipment. They have a constantly evolving product line that has the breadth and flexibility to meet a wide variety of applications. Further, most of their products can be customized to meet the unique and diverse needs of their corporate customers. IP is via patents. G manufactures at two U.S. sites and Ireland. Formed in 1988, sales >$20mm, 100 employees.	CEO
H	USA	**(R,R,R,I,I,I)** Intellectual property is the core of this highly innovative company. This is exploited through partnerships that usually have a limited time-span. Appendix16 provides some insightful notes on how the company operates, its attention to information and knowledge management, its open and inclusive cultures, emphasis on team building etc.	VP De.
Restek , R	USA	**(I)** Chromatography Supplies	Board
Lake Shore, L	USA	**(I)** Innovative measurement and control technologies	COO, VPs

Table 5: Results of Interviews Mapped onto Taxonomy

(*Red bolded italicized text* indicates our hypotheses prior to the primary research, *blue bolded italicized text* shows fit to hypothesis, black non-bolded text indicates no direct fit to hypothesis. Thus red/blue indicates close match to hypothesis)

	Category	Factor(s)			
1	Internal	Intellectual Property	***High*** ***P, T, B, C, D, E, G, H,***	Medium R	Low L, F
2	Internal	Innovative IT Applications	High ***P B D,E***	***Medium*** ***C, G, H, R***	Low L, F
3	Internal	Ownership	***Private (Family Owned)*** ***T, C, D, E, G, L, H, R***	***Private (Non-Family Owned)*** F	Public P, B
4	Internal	Age of Enterprise (in years)	< 25 Years ***C, F, G, R***	25-50 B, D, E, H, L	> 50 T, P
5	Internal	Employee Turnover	High	N.A. P, B, L	***Low*** ***D, T, G, C, E, F, H, R***
6	Internal	Profit-sharing Programs	***Yes*** ***D, G, H, R***	N. A. T, P, E, B, F, L	No C
7	External	Closeness to Customer	***High*** ***T, D, C, E, H, R, L***	Medium P, B, G, F	Low
8	External	Market Focus	***High*** ***P, T, B, C, D, E, F, R, L, H***	Medium G	Low
9	External	Geographical Focus	***International*** ***P, T, B, D, E, G, H, R, L***	Regional	Domestic C, F
10	External	Market Entry Risk	High H	***Medium*** ***P, B,C,D,E,G,F,R***	Low T, L
11	External	Marketing Aggressiveness	High H	***Medium*** ***P, T, B, C, D, E, F, G, R, L***	Low
12	Bridging	Technology Integration	***High*** ***P, T, B, D, E, G, H, R***	Medium C	Low L, F
13	Bridging	Service/Manufacturing Mix	***Service/Manufacturing*** ***T, C, D, F, G, H, R***	Service	Manufacturing P, B, E, L
14	Bridging	Competitive Advantage	***Technology/Innovation*** ***P, T, B, D, E, G, H, R, L***	Service	Product Quality C, F
15	Bridging	Partner Relationships	***High*** P, C, F	Medium ***B, G, H, R***	Low T, D, E, L
		Innovation Type	Radical T, C, D, G, H		Incremental P, B, E, F, R, L
		Firm Type	Entrants G		Incumbent T, P, B, C, D, E, F, H, R, L

innovative SMEs share a common pattern of attributes and behaviors. Based on these results therefore we can make the following statements regarding the attributes of successful innovative SMEs:

Innovative success in SMEs, in general, DOES NOT depend upon:

- Industry sector in which the company operates
- Age of the Enterprise
- Firm Type (Incumbent or Entrant) in a given market
- Innovation Type (Incremental or Radical)

On the other hand, innovative success in SMEs DOES STRONGLY depend upon:

- Focusing on core knowledge and markets, with the intent to dominate a niche
- Integrating internally developed technology with externally acquired technology
- Keeping close, even "informationally intimate", with customers
- Having a clearly defined IP and R&D strategy
- Embracing innovation with an open and inclusive "corporate culture"
- Bundling customized services with products

In addition, innovative success in SMEs may also be enhanced by:

- Innovative IT applications
- Private rather then public ownership structure
- Moderate marketing aggressiveness, i.e., low profile peer-to-peer marketing
- Accept moderate risk in entering new markets
- Partnering to access complementary assets

Most SMEs would do quite well if they were to emulate the dominant pattern shown in the table, i.e., the set of cells in which most firms are bunched. However, it is interesting to note that five firms (P, T, C, G, H) are often outliers from the dominant pattern. Four of these five were considered radical innovators. There are too few firms to reveal a consistent alternate pattern to the dominant one, but this might warrant further examination in a future study. It does suggest, however, that even if a modal or dominant pattern exists, there may be more than one path to success.

It appears that SMEs are at an interesting and challenging crossroad. They must continually innovate to sustain and grow. Yet the models for innovation practice applicable today are not those with which SME executives grew up or learned in school and college.

In many cases, SMEs must compete on a global basis. They must use information technology and knowledge in novel ways, not merely as productivity tools, but as a unique component of their business model. They must embrace new technologies that may be created at the other side of the world and work seamlessly with partners that bring complementary skills. They must have a clear strategy for managing their intellectual property and they must develop new products at break-neck speeds in parallel procedures getting it right the first time. Most

importantly, they must create and embrace an inclusive and trusting culture that supports rather than suppresses innovation in all aspects of the business.

Despite these daunting challenges, SMEs can have significant advantages over larger enterprises. These include speed to execute new ideas, ease of decision making, and in most cases, relief from the burden of public ownership and its pressure on short-term thinking.

MEP can have a vital role in moving many of its clients towards a continuous innovation business model. Section 7 covers our recommendations in this regard.

5. Support for Factors Included in the Empirically Derived Taxonomy

In this section, we explore in depth some of the factors that we included in the first taxonomy. We believe that they are important enough to warrant further discussion in a separate section.

5.1. Manufacturing OR Service?

In reviewing the literature, individual experiences and interviews, it is apparent that "customers," wherever they reside within the supply chain, expect service to be a part of what they receive from a vendor with any product they purchase. Moreover, customers more and more expect their products to be "customized" for them and to be able to access this customization in a self-service model. The rise of the Internet has accelerated these trends. Dell of course, was built from the ground-up creating its successful business model on these premises and has continually enhanced it along the way:

Mini-case 1: Although no longer an SME, **Dell's** business model is based on two key basics: a) the customer gets a product configured and manufactured just for them – it can be different from any other computer that Dell has ever made and b) they exhibit total lean manufacturing to minimize the cost of production. When they act as a vendor, they permit the customer to "self-serve and self-design" on-line providing a totally customized product coupled with minimal selling costs. Dell, as a customer to their suppliers, requires that vendors own their components until Dell is ready to assemble the computer. "Own" in this context implies total service to Dell. Intel, for example, delivers microprocessors within a "cage" which is delivered by Intel right to the assembly cell. Until Dell removes a Pentium chip from the cage, Intel must insure the product, guarantee its quality and have the investment in the inventory. As the chip is removed, ownership transfers to Dell, which owns the microprocessor for less than two hours before the product is shipped and ownership is transferred to the customer. Overseas suppliers operate similarly. Major offshore suppliers to Dell must own their own freight aircraft to ensure JIT delivery. This efficient supply chain illustrates how each member of the supply chain is tied together through data exchange, and provides the down-stream "customer" at each stage, not only product but full service.

Automotive suppliers are gradually moving to providing a total service approach to their customers from pre-purchase to end of use. For example, Toyota prints high quality personalized brochures once a potential customer has selected the color and options at Toyota's web-site while concurrently reserving the manufacturing slot and delivery date for the potential customer. GM's online system is gradually integrating all of the in-use needs of its customers. An example is a service package in which customers are automatically booked in for service with a pick-up and courtesy car available to fit the (electronic) diary of the customer rather than the availability of the service personnel, etc. We can anticipate that the Dell model will migrate to the automotive sector, with all that implies on its upstream component manufacturers and downstream dealer networks.

Mini-case 2: Greif Packaging is a U.S. Mid-West supplier of metal drums for shipping bulk chemicals, many of which are toxic. The company realized that it had no real competitive position and hence margins were eroding to a commodity status. After listening carefully to its customers, it saw there were unmet needs that were highly valuable. They converted their business model to being a "trip leasing" company for specialty chemicals. Now it solves the total trip problem for its customers – drum supply, cleaning and refurbishing, regulatory compliance, transportation, and tracking. Although the company sub-contracts out most of the support functions, Greif captures the value in the supply chain and builds long-lasting client relationships. This shift has significantly improved its margins and cash flow, which it can direct to further innovations.

These examples illustrate that the line between being a service provider and a manufacturer is becoming blurred; indeed, we must question whether this traditional split in classification is useful anymore. Even more troubling perhaps is that this historical split might itself create a linguistic framework that hinders innovation in business models. A related issue is how government at various levels captures statistics on various companies. The NAICS and SIC code systems force a company to choose, for statistical purposes at least, what industry it is in. How much might that forced taxonomy, used by the Census Bureau and the Bureau of Labor Statistics, among others, affect company mindsets about what business they are in? From an analytical viewpoint, if the statistics are only available this way, how much information about what is really going on is lost or unavailable without doing special studies?

5.2 The Role of Information Technology on Innovation

Information Technology (IT) is changing rapidly from back-office mainframes to ubiquitous access to computing power, intranets and the Internet. Software resides not only on corporate computers but can be web-resident. There is a move to open source software, database standards, secure protocols, etc. IT can no longer be considered as a separate service function within an enterprise, but as an intimate factor that is embedded innovatively into business practices and models, collaborative partnerships etc. We therefore consider, using some illustrative examples, how IT's role is changing.

IT as embedded support for novel business models.

Building on themes from the service/manufacturing debate of Section 4.1, we consider the enabling tools that modern IT offers innovative companies. As we investigate a number of successful SMEs or see emerging companies that will become new members of this group, we continually come across examples where IT creates new opportunities for competitive strength:

Mini-case 3: General Fasteners manufactures bolts and other metal fasteners primarily for the automotive industry. These products are oversupplied commodities in which suppliers are forced to seek differentiation to increase margins. General Fasteners has chosen to use an innovative business model, again a hybrid between service and product supply. First, it undertakes the engineering design for new car platforms, essentially taking responsibility for how the car will be reliably assembled. This requires a high skill level. It then contracts to supply the OEM with JIT components directly to the production lines, with 100% quality inspection. GF purchases fasteners either internally or from other suppliers and serves as a totally integrated supply chain from design to final assembly. This requires that GF's computer architecture seamlessly integrate with the OEM plant that they are supplying. Without this ability to exchange data in real-time, and react on it while preserving confidential integrity, this business model would not be feasible. At the same time, GF is "locked-in" to its customers making it much more difficult for competitors to take away business as it provides a total outsource function for automotive assembly. GF diversifies its own customer base to mitigate against being too dependent on "locked-in" accounts.

The GF model is not the only path that competitors follow. Other companies in the automotive fastener sector such as Fontana and Agrati in Italy, have chosen to compete solely on quality, as the automotive sector reduces its number of suppliers and demands 100% inspection and zero defects.

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Mini-case 4: DeAngelo Brothers/DBI, based in Pennsylvania, provides "vegetation management" for businesses, including Class I railroads which are regulated by the federal government on the amount of vegetation that may grow on rights of way. The company has a dominant position in this sector by designing and building its own vegetation treatment vehicles. These vehicles detect the location and type of vegetation along the line and then mix herbicides in real-time optimized for the vegetation, and spot-spray them using robot arms. This enables the company to use the minimum amount of chemicals. By recording the exact location of every plant using GPS technology, the company ensures that its next service run can be accomplished in minimum time with high utilization of chemicals and equipment. The company has selectively used local universities for acquisition of its technology. The proprietary data that the company collects from its operations are a major competitive advantage. In this case, DBI manufactures proprietary equipment using acquired technology for its own use to provide a unique service.

Cases like these indicate that "embedded" software and innovative IT applications are increasingly necessary, indeed vital for SMEs not just for running their businesses in "conventional" models, but as key tools for innovation and sustaining competitiveness. Interestingly, although we can find several examples of the innovative use of IT and data acquisition underpinning manufacturing companies, the research literature is very thin in this area.

IT as an aid to the innovation process:

Among emerging uses of open architecture IT are applications that enhance and manage the innovation process. These techniques allow corporations of all sizes to access not only their own employees' innovative capacity but also to tap into external experts, suppliers, customers, etc. to create new opportunities in response to specific challenges.

This concept was pioneered by Peter Schwartz, now Chairman of Global Business Network, www.gbn.org. Schwartz is recognized as a leader in scenario planning methods and has assembled a network of luminaries that responds to specific challenges posed to them. In this way, governments and private enterprises can tap into a unique knowledge network "on demand". The use of electronic networks to assemble virtual teams on demand to respond to challenges and opportunities is referred to as "dynamic knowledge management". Knowledge is tapped on demand rather than residing in a static database in a supply-side model.

Software tools are now available for any enterprise to practice dynamic knowledge management for innovation. One example is a product entitled "Idea Central", available from www.Imaginatik.com in Boston. We can expect that innovation in "virtual teams" using such tools will become more common, enabling SMEs to tap into a broader resource of ideas.

Such software enabling technologies are also relevant to cluster formation (see below) and possibly in problem-based learning environments (see section 7.2). One of the recommendations from this study is to explore such tools to help SMEs innovate across corporate boundaries.

IT as a leveling factor between large companies and SMEs.

A recent forum at Penn State was assembled to discuss trends in information technology that may impact corporations' ability to respond flexibly and innovatively to a rapidly changing competitive environment. A number of these trends will be beneficial to SMEs as they will enable them to access IT functions now typically limited to larger corporations. The forum made the following predictions for the next 2-4 years:

- Software applications will move to be on-demand rather than in-house. Corporations will therefore be able to access them on a pay-as-you-go basis. Thus SMEs will not have to invest in large systems to compete but will need to be cognizant of the latest applications so that they can buy access as needed.
- Web security problems will be solved and therefore fears of loss of data and secrecy, perhaps more prevalent in SMEs, will be alleviated.

- Network security including disaster recovery will be based on a "grid computing" structure.
- Standards for datasets and transmission will continue to evolve towards open systems enabling SMEs to partner seamlessly with larger companies. SMEs will have growing opportunities as suppliers and outsource resources for larger corporations as they become leaner. This implies that SMEs must be both specialized and highly flexible. They will be sharing data with their suppliers and customers as part of an integrated, flexible supply chain.
- IT and business processes/models will become more intimately entwined. IT will enable the move from purely manufacturing operations to services and hybrid forms.
- Corporations will increasingly develop models that offer customers the ability to access the resources of the company in a self-service mode.

5.3 Business Model Innovation: The Bridging Function

Stemming from the concepts in 4.1 and 4.2, we see two important new challenges/opportunities for innovation in SMEs:

- Blurring of the boundaries between service and product along both directions of the supply chain towards suppliers and customers.
- Creative use of IT to provide greater value to customers, tighter lock-in to both vendors and customers, and acquisition of intellectual assets in the form of accumulated and mineable data.

Combined with technological advances from internal R&D or external sources, the above two developments can be configured in powerful new ways that allow SMEs to compete successfully. Companies can use IT creatively to help define value for a specified set of identified customers. This definition of value combines the first two elements of what Chesbrough and Rosenbloom (2002) consider essential to a successful business model. The third and fourth elements concern articulation of a value chain and determination of profitability. The fifth and six elements concern establishing and maintaining competitive advantage, respectively. Creative use of IT is one of the most effective ways to assure that competitors cannot imitate the product/service that is offered.

A majority of the companies that we researched and interviewed expressed the view that business model innovation was as important, perhaps more so, than product or technology *per se*.

5.4 Corporate Culture

Repeatedly in our interviews and from past and current research we determined that successful creative companies had developed and nurtured a culture that explicitly and, more importantly, implicitly supported innovation.

There has been much research in this area, and many business books written about the field. We have been researching this field at the Smeal College for several years. One aim of this work has been to develop a set of readily understandable attributes that occur in nearly every successful

innovative company so that managers can adapt their management styles, communication skills, incentive structures, etc. to strengthen the culture for creative actions. We have narrowed these attributes down to ten factors. Ideally, these factors are mutually orthogonal: i.e., each does not depend on any other. Of course, this is difficult to achieve, but by attempting this construct, it is easier for managers to identify areas where improvement might be required, without too much concern that changes will create other problems.

Table 6 lists the attributes, their definitions, and an illustrative statement that might be casually overheard within the enterprise. These factors were explored during our primary research interviews.

We also developed an analytical tool that probes these cultural indicators in a non-challenging, agnostic format within an enterprise. We found that the tool provides a structured framework for the managers of enterprises to table these issues and open up a dialog within the organization that, in and of itself, helps create openness and understanding and can be a trigger to promote a more supportive environment for innovation.

MEP might consider using such a tool to help its clients. We have not included this as one of our main recommendations, however, as it is not a scalable methodology.

We did not probe our interviewees in depth on each of these attributes during the interviews, as this was not the focus of our research. One of the companies, however, was sufficiently intrigued with our culture taxonomy and chose to undertake an in-house survey and share the results with us.

As we undertook the interviews, we were aware of these cultural factors and explored whether there were any major discrepancies between the factors and the value systems that were tacitly indicated by the corporations. In no case did we find any indication that successful companies were not practicing the cultural values listed in Table 6.

5.5 Knowledge Management to Support Dynamic Product Development

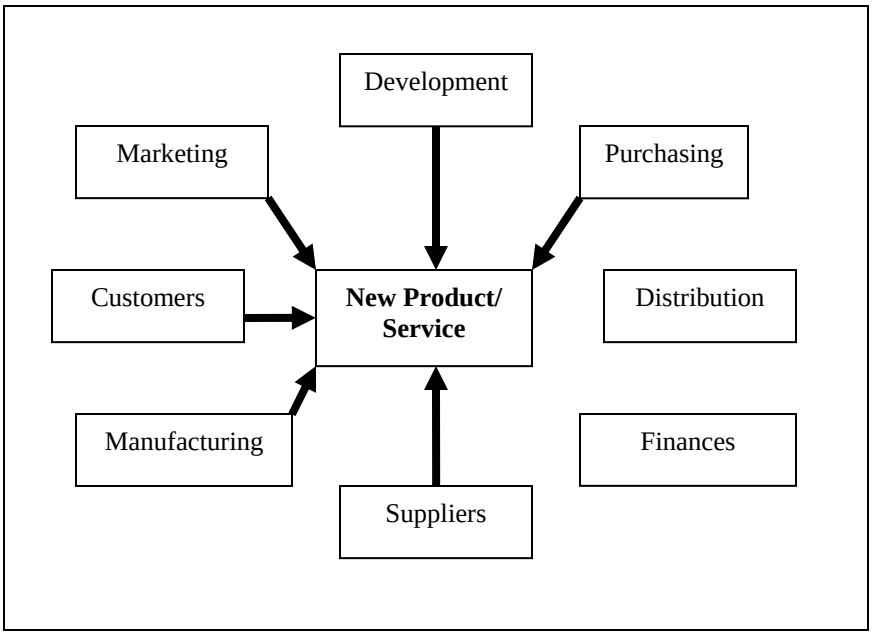
As we saw in the introduction, the environment that every business must operate within is changing ever more rapidly as knowledge, resources and markets become globally accessible. This constant acceleration of complex competitive forces is reducing product life cycles inexorably. Traditional “linear” product development cycles ensure lengthy time to market and slow integration of knowledge acquired in the process. Enterprises are therefore examining ways to accelerate their product development cycles and “getting it right the first time”. To do this, they must access and apply all of the accumulated knowledge both within their enterprise and from other entities with which they interact. “Reinventing the wheel” is unacceptable. Successfully innovating corporations manage information, collecting and converting tacit into explicit knowledge. By making such understanding from all company functions available to development teams, companies can more rapidly incorporate knowledge and understanding into new products in less time. The new model for product development is shown in Figure 5. Ensuring simultaneous sharing of knowledge between all functions continuously may, of course,

Table 6: Cultural Attributes of Successful Innovative Enterprises

Attribute	Definition	Example Statements
Honesty	The degree to which each employee has total confidence in the integrity, ability and good character of other employees and the organization, regardless of their role	"I trust the people I work with; I find it easy to be open and honest with people from other departments"
Alignment	The degree to which the interests and actions of each employee support the clearly stated and communicated key goals of the organization	"We have clear aims and objectives which everyone understands; we build consensus around key objectives; we recognize and reward loyalty"
Risk	The degree to which the organization, employees and managers take risk	"I am encouraged to experiment; we take calculated risks; we encourage trial and error"
Teams	The degree to which team performance is emphasized over individual performance	"We promote teamwork and make it the center of everything that we do; there are usually people from other departments in my team; we have both problem-solvers and 'out-of-the-box' thinkers in our teams"
Empowerment	The degree to which each employee feels empowered by managers and the organization	"As a manager, I am expected to delegate; we have a 'no-blame' culture; we allow staff to make decisions"
Freedom	The degree to which self-initiated and unofficial activities are tolerated and approved throughout the organization	"I am allowed to do my own thing; we encourage people to take initiatives; we recognize the individual"
Support	The degree to which new ideas are encouraged from all sources and responded to promptly and appropriately	"We encourage fresh ideas and new approaches; we reward innovative individuals; we reward innovative teams"
Engagement	The degree to which all levels of the organization are engaged with the customer and the operations of the organization	"Management understands the operations of the company; I can share problems with my managers; I know why my job is important"
Stimuli	The degree to which it is understood that unrelated knowledge can impact product, service and operations improvements	"I am encouraged to search externally for information; I obtain data from many different sources; we listen to suggestions from suppliers; we use consultants in focused roles"
Communication	The degree to which there is planned and random interaction between functions and divisions at all levels of the organization	"I am kept in the picture on how we are performing; we have excellent formal channels of communications; we use best practice knowledge transfer between departments; we actively manage our intellectual assets".

create major challenges to the organizational structures. The corporate culture attributes described earlier can overcome some of these challenges by reducing communication barriers and promoting teamwork.

Figure 5: Synchronous Product Development



Simultaneous input from all company functions into product development should include the following stakeholders:

- Customer: Provides valuable information about the product design and functionality so that he gets what he needs.
- Development: Uses comprehensive product information to design the product right the first time.
- Finance: Follows production costs and warns developers if they're choosing a component or part that will be too costly in the final product.
- Manufacturing: Makes sure that a viable process for producing the product exists.
- Marketing: Keeps tabs on the marketplace to make sure that the product is well accepted when it's launched.
- Purchasing: Establishes reliable relationships with vendors to make sure that they deliver parts on time.
- Distribution: leverages multiple access points to the market while avoiding channel conflicts
- Suppliers: collaboration with suppliers stimulates innovation while tying in valuable partners

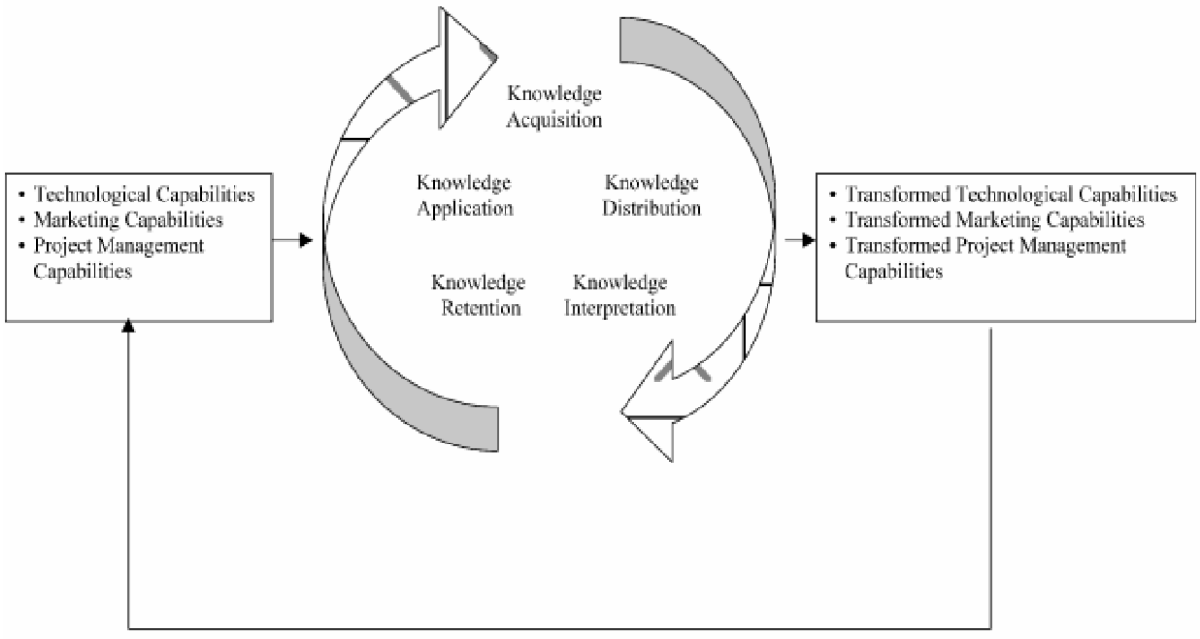
To achieve a smooth incorporation of all this knowledge into the product development function, knowledge management procedures must bridge the following activities:

- Acquisition: Past knowledge of success and failure must be captured and used to avoid future repetition of costly mistakes and to continually hone internal procedures.
- Distribution: Tacit knowledge exists in every member of an organization. Mentoring programs, internal education programs, and social events are essential to the diffusion and survivability of such knowledge.
- Interpretation: When new developments are undertaken, the identification and codification (whenever possible) of knowledge and understanding held by experts within an organization is important.
- Retention: After knowledge is interpreted, it must be implemented in the form of procedures, systems, and capabilities.
- Application and Action

Codifying tacit knowledge does not guarantee its maximum utility as part of product development cycles. Development teams must actively build upon previous understanding with controlled experiments that add additional value.

A successful knowledge management system creates a virtuous circle of intellectual capacity as input into future innovations. This is illustrated in Figure 6.

Figure 6: Virtuous Knowledge Management Cycles



Source: *Building Dynamic Capabilities in New Product Development through Intertemporal Integration*, Sarah J. Marsh and Gregory N. Stock, Journal of Product Innovation Management, 2003:20:136-148.

As product development extends across corporate boundaries in joint development projects, new software tools are available to support complex project design, 24/7 global development

activities, etc. SMEs may need to use these tools as they become members of partnerships for product development. PSU is actively involved in developing these collaborative tools. Appendix 7 describes one such activity currently being undertaken by a consortium of leading universities on behalf of the European Union. The "e-Hub" tool is being developed specifically to enable SMEs to work together in rapid product development programs in a web-hosted environment that is secure and engenders trust.

One of the companies interviewed in this project, PBR, Pty. competes effectively and internationally in the highly competitive automotive component sector by establishing joint development partnerships in rapid succession, thereby accessing "best of breed" complementary technologies and resources for rapid product development. PBR views this ability to manage such programs as key to its business success. "While our competitors are putting a development project team together in-house, we have completed the task with our partners". (See Appendix 10 for case details).

In fact a similar skill set was described in a recent article in *Fortune* on Apple Computer:

> The primary reason Apple Computer was able to get to market so fast with its iPod™ portable music player, now a runaway market leader, was its ability to line up partners. To build the iPod™, Apple persuaded a little-known Silicon Valley startup to provide and customize key software and worked with Toshiba to come up with a tiny but capacious hard disk. The product, which contractors assemble in Taiwan, came together in less than nine months. Apple's payoff for being the first mover: The iPod™ claims the lion's share of all the revenues generated by sales of MP3 players worldwide.

5.6 Education and Outreach Implications

It is clear from the above discussions, substantially supported by our primary research, that the management skills required to innovate and execute at a holistic level in a hybrid SME (i.e., an integrated service/manufacture enterprise) are typically not widely recognized or understood and hence not available. In addition, our educational institutes have traditionally not focused on experiential learning nor taught [redacted] skills that enable interdisciplinary innovation. On the contrary, education is still largely textbook, "chalk-and-talk" driven rather than problem-based, and it is governed within a "vertical silo, academically focused" organization. It is not the aim of this project to address these major educational issues that will be the subject of debate for many years. However, it is worth devoting a short section to some of the work that we are pioneering at Penn State that may be relevant to the specific mission of MEP in the light of the preceding remarks.

Penn State has for several years experimented with the concept of problem based learning (PBL) – a pedagogy that immerses students into real problems, which they solve under a mentoring umbrella. There is ample research evidence that shows that skills learned in this way are retained longer and are more practical than through a "conventional" pedagogy. One of the challenges of

PBL is that, until recently at least, it is not scalable – i.e., it is difficult for mentors to spread their experience to a large number of students. Over the last few years, under partial funding from the Kauffman Foundation, we have been developing "mixed material" courses whereby students undertake much of the rote material learning, analysis and teamwork without a mentor. The mentor may interact on line, or perhaps in regular team meetings once every two weeks or so. This method has evolved to a stage where we believe we have developed a scalable education model to provide "holistic" innovation learning to large numbers of students. The impact of this extended nationally could be extremely significant for the overall economy and is being put forward within a white paper for the National Innovation Initiative. In our recommendations we will describe how this already developed and tested learning platform could be used for training the SME field specialists and subsequently as a tool for managers of SMEs to migrate to more innovation driven business models.

6. Taxonomy Based on Current Foreign Innovation Models

6.1 Mittelstand Companies.

One of the authors (Warren) spent several years consulting to large and mid-size companies in Europe. During that period, he worked with a number of Mittelstand companies which are particularly prevalent in Germany, although not exclusively.

The Mittelstand (literally mid-sized), are a major part of the German economy, perhaps the efficient core that supports what otherwise is seen to be a rather stolid slow-moving business sector, highly regulated, with restrictive labor laws and resultant high labor costs. These companies grew up from the time the Marshall plan was deployed in postwar Germany. Everybody started out with essentially nothing and the Mittelstand companies were the result of the desire to rebuild the country from scratch. There is tremendous pride resident in these companies because of this heritage. The reasoning for studying this group of companies was that, if we could find innovative, sustaining companies successfully operating with perhaps even more structural and regulatory constraints than we have in the U.S., there may be valuable lessons to be learned.

We are fortunate that there is a highly respected researcher in this field, Hermann Simon (1996), who has worked and studied both in the U.S. and Germany. He has published his findings broadly and they are summarized in a book entitled *Hidden Champions*. What follows is a brief summary of his work. Further details are provided in Appendix 3. Note that his focus is not entirely on Mittelstand companies but on companies that "stay below the radar". However, the overlap between Mittelstand companies and Simons' research population is highly correlated such that the results are highly relevant.

Summarizing Simon's work on the Mittelstand:

> Mittelstand, which encompasses all small and medium-size companies, describes a complex network of distinct values shared by thousands of German firms. At its core are values like desire for independence, fascination with quality, and good labor relations.

> Thus, strikes are almost non-existent in the sample companies. In general, Germany is always at the low end of strike statistics, and the hidden champions are among the lowest in this respect. About 50% of them offer profit-sharing programs and many provide clubs and organize activities for employees and their families.
>
> All in all the Mittelstand philosophy is traditional and conservative at its core. It believes in giving value and quality to customers and in demanding fair prices. 'Keep it simple' is a recurring theme. Mittelstand thinking is sober and not prone to new buzzwords. There is nothing spectacular about their organizations and cultures. With no single key factor to success, they just do a thousand little things a little better than their competitors.

There is some concern in Germany now that the age of the Mittelstand dominance may be coming to an end. This is a result of succession planning challenges as the founders and the first generation heirs are retiring. Certainly the concentration of family controlling ownership is declining. Indeed, this has triggered the emergence of a number of MBO private equity firms in Germany that are providing continuity of management if not ownership. It remains to be seen whether the loss of family focus will dampen the success of these firms.

Interestingly, the Mittelstand companies exhibit many of the traits that we have found important in companies that continue to compete successfully through innovation. Among these traits are:

- a tendency towards secrecy
- domination of selected market niche
- a focus on mission
- openness to external technology
- a paternalistic open culture with low staff turnover
- pride in customer relationships rather than relying on "marketing" as a vehicle for growth
- a clearly articulated and executed IP strategy
- passion about quality
- dedication to continuous innovation, usually incremental rather than radical.

Overall the German Mittelstand companies, operating in an even more regulated and cost disadvantaged economy than the U.S., provide key lessons for U.S. companies in innovative management practices. However, because of the historical and cultural differences in Germany there are some attributes that do not translate entirely to the U.S. Mittelstand companies tend to be older. They are lower risk takers and hence their innovations tend to be incremental rather than radical. One area where Mittelstand or "Hidden Champions" differ significantly from our model of an ideal innovative company is a wariness of partners and a need to be in control of assets both intellectual and physical that they require. This penchant may turn out to be a weakness for them as we move into the later stages of the knowledge/network era where

corporate boundaries become blurred and partnerships enable SMEs to compete with larger firms by combining complementary resources. In all other aspects, there is much to learn from the Mittelstand.

Appendix 3 provides more details on the Mittelstand and Appendix 8 is a detailed case history of a "typical" Mittelstand company, Taprogge GmbH, one of our chosen interviewee SMEs.

6.2 Clusters.

As part of our efforts within this project, we conducted research on clusters in the current business literature. Our research included definitions of clusters, as well as specific clusters around the world. Our position is that SMEs don't need to be in location specific clusters in order to be innovative.

6.2.1 Definitions of Clusters

We have found several definitions of cluster in the literature. Two of the more comprehensive are the following:

> An industrial cluster is a socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region. Within an industrial cluster, a significant part of both the social community and the economic agents work together in economically linked activities, sharing and nurturing a common stock of product, technology and organizational knowledge in order to generate superior products and services in the marketplace. (Morosini, 2004)

> A cluster is a geographically proximate group of companies and associated institutions in a particular field, linked by commonalities and complementarities. (Porter, 1998)

Summarizing the many papers and conferences devoted to the issue, a cluster can be defined as a geographical grouping of firms that belong predominantly to one activity sector. Italian *distretti*, with their complex set of social history and institutions, would then be specially advanced cases of clusters, characterized by a high degree of voluntary collaborative actions within cluster firms.

The United Nations Industrial Development Organization (UNIDO), defines clusters as:

> …a sectoral and geographical concentration of enterprises that produce and sell a range of related or complementary products and thus face common challenges and opportunities.

A term often confused with “cluster” is “networks.” Networks are, instead, “groups of firms that cooperate on a joint development project complementing each other and specializing in order to overcome common problems, achieve collective efficiency and penetrate markets beyond their individual reach.” Networks are termed horizontal when formed by small and medium enterprises only, and vertical when large-scale enterprises are involved. UNIDO also describes the relationship between the two terms: networks can develop within or outside of clusters. Clusters lead sometimes to the development of networks within them. Also, a network can eventually evolve into a cluster, as it develops business development services providers, enterprise associations and the involvement of public institutions. (Bisso, 2003)

There are three conditions for a cluster to be successful:

- The "land" must be fertile, meaning that there must be a capacity of absorption of know-how "seeds," and the availability of labor and space. These conditions were present in Italy after WWII, when some of the workers who had migrated to the advanced economies of Germany, Switzerland, etc., returned to their home cities bringing new "seeds" of industrial know-how.

- The links that allow know-how transfer such as technical centers, secondary or tertiary learning institutions, etc. must be present. In the case of Italy, labor and space were available, but so was a climate of "cooperation" that allowed the know-how to be shared by many new small firms.

- The "ecology" must grow in variety, producing *differentiation* among its components, as labor division grows when the many suppliers of specific inputs develop, usually as spin offs from existing small companies. Small companies concentrate in a core of well-known competencies, while they outsource components from other small companies. Within a true cluster there is a "capacity for exploration," for experimenting new processes, new products, or new markets. (Bisso, 2003)

There are three reasons for a firm’s choice of a given geographical setting:

- the existence of a pool of adequate labor
- the existence of specialized suppliers, and
- the possibility of external spillovers, that is, the rapid transfer of know-how and ideas.

These three conditions tend to be present primarily in clusters. (Bisso, 2003)

A fourth condition that is mentioned is the following:

> While external economies occur in clusters spontaneously, this is, without a voluntary decision by the firms to engage in cooperation with others, it is the *voluntary, planned cooperation* that gives force to the firms located in a given cluster. Example of voluntary cooperation is the joint organization of a presence on a trade fair,

> aimed to enter a foreign market. From a policy-making point of view, the empirical evidence supports the importance of voluntary cooperation, which implies the need, for clusters containing larger numbers of firms, of institutions that promote, organize and manage that cooperation. This is certainly the case of the Italian distretti, where often several institutions handle many of the inter-firm cooperation activities. (Bisso, 2003)

6.2.2 Cooperation and Competition within a Cluster:

The functioning of clusters can be understood better by analyzing the cooperation and competition tendencies inside them. Rabellotti (1999) has studied the mechanism that firms use when planning cooperative actions, as those of compensation (rewarding mutually beneficial behavior), and exclusion, used to punish opportunistic behavior. Mutually beneficial cooperation is favored by the existence of trust and "social embeddedness."

Cluster cooperation can be further classified as vertical (with suppliers or clients), horizontal (with "colleague" firms), or multilateral (involving not only firms but institutions, which provide business services: consulting, lobbying, training, funding, quality certification, etc.).

A caveat about the natural evolution of clusters: it is far from "natural" that clusters evolve always towards more and more positive (non-collusive) cooperation. Also, there are several examples in Italy where firms move away from a cluster location to be able to exclude cluster competitors from the production-specific advantages they have acquired. (Bisso, 2003)

Within the U.S., the data on clusters tend to put all agglomerations of economic activity under a single category. Thus the financial district of NYC is listed with Silicon Valley, Route 128 and “bone valley” in Indiana. Within the context of this study, we felt it was necessary to separate out those clusters that are most relevant. Within these sub-categories several classes are noteworthy:

- The high-tech regions that are centered around one or more research universities in a location that has sufficient social capital to develop. Clear examples are Silicon Valley and Boston. Where the social capital support is weak, the technology economy lags. Clear examples are State College, PA, and College Station, TX. Partial successes are Minneapolis, Ann Arbor, and Gainesville.
- The high-tech clusters that are centered around one or more research universities where additional long-term support infrastructure funding from state governments has promoted the cluster. An excellent example of this type is RTP in North Carolina; another is Silicon Glen in the Edinburgh-Glasgow corridor.
- The manufacturing clusters that have evolved around specific market sectors. Within the U.S. we have selected two for analysis – the orthopedic center in Warsaw, IN, and the golf equipment cluster in Carlsbad, CA. (See Appendices 4 and 5).

We also reviewed a recent study commissioned by the Department of Trade and Industry (DTI) (2003) in the U.K. entitled "A Practical Guide to Cluster Development," as well as the National Governors' Association's 2002 report entitled *A Governor's Guide to Cluster-Based Economic Development*.

The most appropriate cluster type that matches SMEs in the manufacturing sector is the third listed in the box above. Interestingly, in each of the manufacturing clusters that have been analyzed, the origin seems to be entirely serendipitous and very long-term in development. In this type of cluster, we cannot see any valid role for government intervention – clusters will occur where they will and only grow if sufficient social capital is available.

Newer rapidly growing clusters tend to be in fast-moving sectors such as specialized software e.g. advertising and design related in NYC, Internet gaming near Edinburgh, Scotland and the well documented "off-shoring" software clusters in Bangalore and Hyderabad in India.

The literature also is ambiguous on the value of clusters, listing their downsides as well as advantages. For example, clusters with their large social infrastructure mean high job mobility. This allows intellectual asset leakage and uncertainty between competitors. Indeed HP moved some of its plants to Oregon to mitigate this problem, which they found endemic in Silicon Valley.

Generally recognized as valuable however, is the networking that exists within a cluster, with help, resources, collaboration opportunities, access to patent lawyers, etc. There is an active debate on whether these networks can be "virtual," that is, enabled through the Internet. Thus the intellectual leakage through job shifts can be mitigated while access to networks maintained.

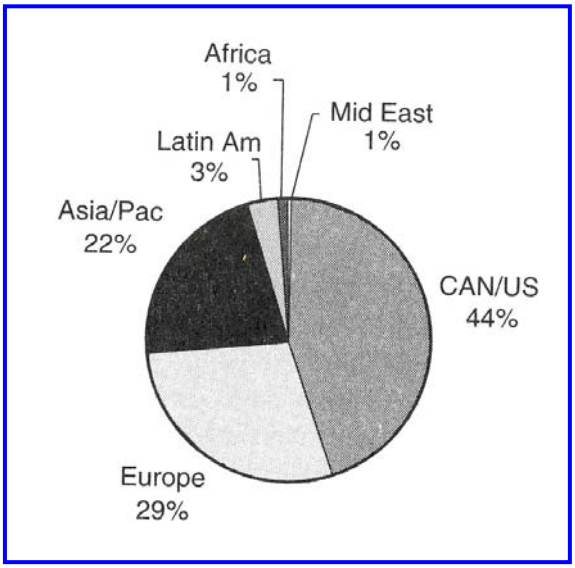
6.2.3 Virtual Clusters: Challenging Cluster Conventions

Clusters have historically been conceived as requiring a list of specific criteria with **geography** being the keystone. Research on government-industry partnerships and virtual clusters (also called knowledge networks), however, is shaking this notion, relying instead on more global commonalities with **innovative zeal** as the keystone.

Considering clusters as a function of geography fosters notions of individual country success factors (typically GDP and GDP/capita) rather than global advancement of knowledge and quality of life. If clustering no longer requires geography, achievements and benefits thereby obtained have more global implications, though not completely, owing to the Internet's limited availability in much of the world. (See Figure 7.)

In considering success factors for virtual clusters, the analysis of geographic clusters may not shed sufficient light on the requirements. Observing post-facto that a condition existed as a

Figure 7: Percentage of Population with Access to the Internet (2002)



Source: Estimates from Cyveillance, an Internet Statistics Firm, www.zakon.org/robert/internet/timeline/ and http://wcp.oclc.org/

cluster emerged is not necessarily a prerequisite for its emergence. Beyond the emergence of a cluster, its success requires defined purpose, not merely a Petri dish of resources.

One of the most interesting examples of virtual clusters that is in use today is the "professional idea exchange forum." Professionals in specialized areas such as "mass spectrometry design," "java-based server programming," and "SAP implementation" use free membership-based online forums to post problem-specific questions. More often than not, industry issues of a more general/philosophical nature are discussed among the members. Professionals share their experiences, opinions and/or proven solutions to the questions posted. Especially in a SME atmosphere where professionals are often the "experts" in their organization, these forums are the most time-efficient way to find answers to problems faced on a daily basis. There is a sense of community in these forums, and just like a "face-to-face" environment, the overall outcome is a learning/networking experience that is akin to what a geographical cluster offers.

An analysis of government-industry partnership success factors shows what elements must be present to accelerate innovation through collaboration, especially in areas of basic research (chemistry, physics, engineering - areas that are not product-focused) where corporate sponsorship is leaner and government sponsorship is essential:

- *Industry Leadership* - Expertise, experience, and flexibility are essential to establish initial credibility and provide an umbrella capable of fostering collaborative innovation across corporate and geographic boundaries

- *Roadmaps* - Outlining goals is essential for consortia and collaborative partnerships no less than clusters. Establishing relationships among science, technology, and applications provides reference points for researchers, technologists, product managers, suppliers, and users, allowing more effective contribution.

- *Shared Commitment and Costs* - Stake in outcome enhances the commitment of those involved, increasing output and success.

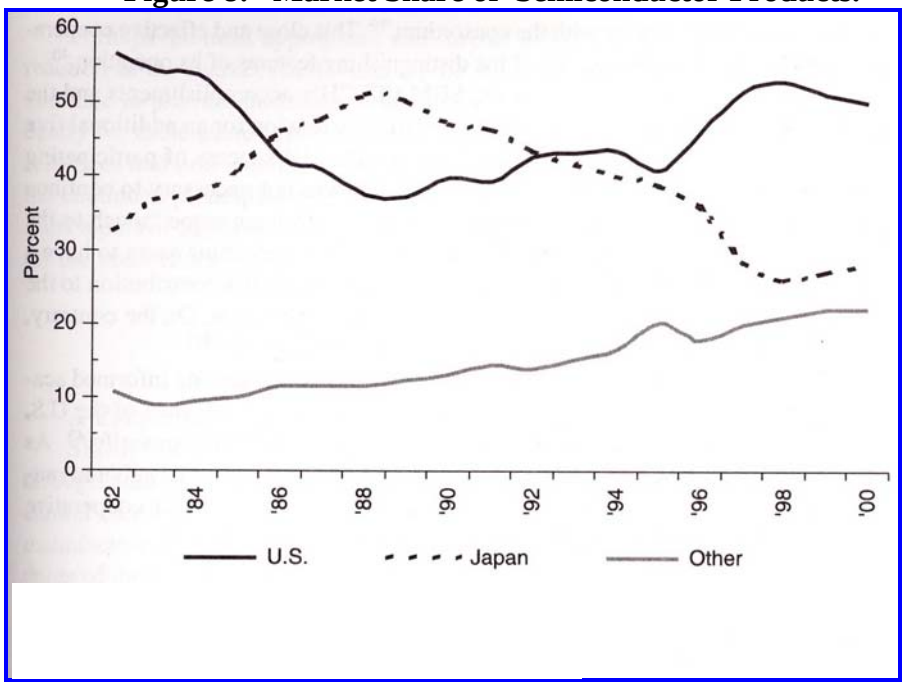
- *Assessment* - Regular and rigorous evaluations and feedback gauge projects' technological and commercial merit as well as contributing to the tacit knowledge accumulated. Diffusion of both successes and failures assists in revising roadmaps.

For a virtual cluster to be effective, these four factors should be in place. Another way of looking at the functionality of a virtual cluster or knowledge network is as a "distributed partnership."

An interesting well–documented example of such a structured virtual partnership is SEMATECH in which a government/industry collaboration was formed to improve the U.S. standing in the semiconductor sector. Formed in 1987 in response to what was then referred to as a crisis in the U.S. Semiconductor Industry, SEMATECH comprised 14 U.S. Semiconductor Manufacturers and the Federal Government. Companies invested $100 Million, matched annually with federal funds. From 1987 to 1996, the government invested $850 Million. This investment played a significant (though unquantified) role in the resurgence of the U.S. industry. Figure 8 illustrates the possible effect that SEMATECH had on the U.S. position in the semiconductor sector. SEMATECH formally possessed and leveraged all four success factors identified above.

Additional recent research on virtual clusters is summarized in Appendices 6 and 7.

Figure 8: Market Share of Semiconductor Products.



Source: Semiconductor Industry Association, Annual Blue Book, 2001. www.SIA-online.org

6.2.4 Implications of the Secondary Research on Clusters.

(This section includes concepts developed with Richard Seline of New Economy Strategies, an Economic Development Consulting Firm in Washington, DC.)

Michael Porter's (1998) research on cluster emergence, while extensive, is a historical analysis of those that have emerged, providing no formula for their creation, duplication, or sustenance in the face of change. He also does not adequately consider the effects of information technologies and the rapidly evolving and maturing knowledge economy. As such, his model is one of twentieth century business practices, not those of the new millennia.

Companies of all sizes, especially, but not only, those in clusters, must continually look outward to identify new opportunities. Success is not merely the efficient operation of an organization; it is the continued evolution of an organization in response to and anticipation of a changing global environment.

There are three dynamics that can cause the failure of a cluster:

- *Technology Shift:* Industries experience constant changes due to technological advancement. Clusters built on expertise in a given technology, but lack the means to constantly scan the field for emerging ideas and resources, bring them into the cluster, and thereby profit are subject to obsolescence and ultimate failure, to the detriment of entire regions. The Warsaw, Indiana medical device cluster is an excellent example. Built on expertise in metals without scanning, adopting, and building competence in new technologies, it may be threatened by being ill-suited to cope with the industry shift to polymers and ceramics.

- *Business Model Shift:* As technology evolves, so too do companies' means of generating revenues and improving their cost structures. Such changes include the adoption of global supply chains, move to product customization models, and the increasing customization of service offerings. One of the reasons that the Electronics Cluster in Columbus, OH failed after peaking in late 1960's was a shift in the business model of the three large companies that dominated the electronics industry in the region, Western Electric, Bell Labs and Accuray (Taratec Corp., 2004).

- *Resources Mismatch*: Clusters are well suited to solve the needs of the present, possessing intellectual and human capital in great abundance. Both become dated without continued improvement in management understanding and business structure, requiring outward examination, recruitment, and acquisition.

As we have seen, traditional industrial clusters are networks of enterprises, large and small; they may encompass universities. Each member adds a distinct product or service value, which is then added to the value of the local network as a whole. While individual jurisdictions allocate funds to the creation of clusters, they require an appropriate combination of resources and an impetus, a spark, to begin. Allocating funds does not ensure one will emerge, nor is a spark without resources sufficient. Once in motion, clusters can take years to build momentum, and once they do, they are subject to limitation by the very resources that spawned them. Our research finds that companies need a new means of looking outward, not a trait that is encouraged by conventional localized clusters.

The current jurisdictional funding and support focus is intended to cultivate local new businesses with resulting tax revenues. This narrow, geographic focus forces inward-looking strategies and prevents clusters from adapting to industry change. Broadband telecommunications technology continually improves the ability of companies to collaborate with resources outside funded jurisdictions. Outwardness can be greatly accelerated by using emerging "virtual knowledge networks." Such endeavors are already underway in Europe, Canada and Australia, making use of centralized server and peer-to-peer models.

Looking outward is a difficult task. It requires the identification of appropriate resources and proper posing of specific needs for innovation. Large organizations, which pride themselves on innovation as a means of success and survival such as HP, GE, and Siemens, have made outward focus and change part of their modus operandi. Small and medium-sized enterprises (SMEs) are not often in positions favorable to this constant search, and they are the ones most in need of access to innovative talent. Thus a key component of MEP's future outreach programs is to show clients the necessity and the methods to look outward and access virtual knowledge networks beyond their locales to identify and access complementary resources and innovation stimulation.

Thus, with regard to clusters providing support for SMEs, we are in a transitional mode. Certainly local resources and knowledge within established social networks may still provide some sustenance for SMEs. However, there is a danger in a cluster becoming too introverted, not helped by jurisdictional driven funding. In the future, companies must adapt to being members of one or more extended virtual networks and the geographical imperative will wilt.

We do not recommend further government support for cluster foundation. Our research did not find membership of a cluster to be important in SME innovation success whatsoever.

However our recommendations to MEP in this report address the need for tools for SMEs to access external knowledge and expertise and thereby de-emphasizing the local constructs of geographical constraints.

6. 3 Chaebol and Keiretsu

These two related corporate models were studied briefly to determine whether there were any principles to be learned and transferred to U.S. SMEs.

Chaebol first arose in South Korea in the 1920s and 1930s when the country was under Japanese colonial rule. Japan planned Korea's economic development to feed its own markets and set up a series of companies which were privately owned and run, but strictly controlled by the central government through credit, approval of trading licenses, and a host of other measures. Paradoxically, Korea developed this system for itself once it had managed to win independence. This was due largely to President Park Chung Hee, who was head of state from 1961 until his assassination in 1979. Park was a great admirer of the Japanese and even fought for them in Manchuria as a junior officer. The major features of the chaebol are:

- They are conglomerates of many companies clustered around one holding company. The parent company is usually controlled by one family. In 1988, the 40 top chaebol comprised a total of 671 separate companies.

- The companies hold shares in each other.

- They are highly concentrated. South Korea must be easily the most prosperous industrial country to have such a concentration of the economy: the top four "superchaebol" have sales which account for somewhere between 40 and 45 percent of South Korea's Gross National Product. This is much higher than Japan.

Korean chaebol differ from most Japanese keiretsu in the following ways:

- Whereas keiretsu are also centered on one large financial institution or bank, such as Mitsubishi, in Korea, chaebols do not have their own financial institutions**.** This has traditionally made them much more dependent on government approval, especially since South Korea's banks were nationalized until the mid 1970s and industrial firms were prohibited from owning large shares in them even when they were privatized.

- Chaebol tend to spread across industries**,** unlike many keiretsu in Japan, which usually integrate vertically in the same industry.

- Chaebol are more centralized than keiretsu**.** Like the American and European conglomerates of old, they have strong central staffs whereas many keiretsu in Japan have no central staffs at all. So where the Japanese conglomerates operate more by informal networking, their Korean counterparts have formal structures and centralized control.

- Chaebol are much more family-based than keiretsu**.** This could be partly because they are newer institutions which have yet to pass out of the founder's hands in many cases, or there could be deep cultural differences between Korea and Japan which make Koreans far more family oriented (like the Chinese) and Japanese more oriented to wider social groups. The result is that even though they have grown to vast proportions, most chaebol continue to be overwhelmingly family concerns. While there is an emerging class of middle managers, one study in the late 1970s found that 12 percent of all top executives in chaebol are closely related to the founders.

We do not see any attributes of chaebol or keiretsu that are suitable for transfer to SMEs for the following reasons:

- Economists agree that the Korean economic crisis largely stemmed from arbitrary management decisions and risk taking by chaebol managers who were unaccountable to anyone. For example, during the Asian crisis, Hyundai chose to buy several heavily indebted companies.

- Opaqueness in management and accounting.

- They may be fine for a $500B economy but not for a $13 trillion economy of the U.S.
- Family ownership leads to succession crisis as sons fight over control for the chaebol.
- The mere size of the chaebol (the revenue of the biggest four account for 45% of the GDP of South Korea) lead to interference with the political reforms thereby interfering with the functioning of the economy.
- Reckless investing and borrowing – exposed with the financial crisis of 1997 wherein currency devalued by 80% in less than 45 days.
- There is no evidence that chaebol or keiretsu are any better at spurring innovation.
- The U.S. anti-trust legislation prevents such structures assembling.
- The models do not efficiently channel funding to innovation as, for example, the U.S. Venture Capital sector.
- The structures do not easily access the total intellectual capital within their organizations.
- There is a trend of our most keiretsu–like companies such as Ford and GM to devolve their member corporations.

Indeed, in Korea, Japan, and in the less concentrated yet similar entwined bank/corporate relationships that exist in Germany, we see gradual dissolution of these structures as too unwieldy and open to compete effectively in the innovation age.

7. Recommendations for the MEP Program.

If U.S.-based SMEs are going to continue to be an essential part of the growth engine of the U.S. economy, they must learn to compete by innovating, and not focusing on cost cutting. Innovation for most of these companies usually connotes “new products”. Yet, as we have seen, as we move from the knowledge era to one where innovation is a key driver, the form of innovation is very different from just product development. It is the application of holistic creativity in all aspects of a business.

Skills in effecting these new innovation processes are in short supply. Our “siloed” educational structures in many ways suppress rather than promote innovation. In order to address this skill shortage in a short time, we need to create “scalable tools” that promote self-help and leverage resources already in place. We do not have the time to wait for our existing educational systems to provide the next generation with the appropriate skills. On this basis, we have four recommendations for MEP that meet these requirements.

7.1 Provide Outreach Programs that Emphasize New Innovation Models

The research and cases within this report should be shared with MEP outreach professionals. In turn they should be encouraged to advise their clients to:

- understand the value of complementary partners to fill in the missing components of their business model. Partners should be sought from anywhere, and innovative collaborative structures explored.
- examine and implement methods for establishing closeness to customers.
- understand both the explicit and *implicit* needs of customers to provide a total service rather than merely a product.
- use IT as an inherent and embedded enhancer of business models that provided barriers for competitors.
- critique conventional business models and examine how they might be enhanced by incorporating the above points.
- begin to establish a more "holistic" innovation culture by emphasizing the ten attributes described in the report. These should be introduced by example by the top management of the companies.

7.2 Develop a "Train the Trainer" Course on Innovation Using Hybrid Problem-Based Learning

Innovation can only be learned by doing, not by reading books or being taught in a traditional classroom environment. Such new "experiential" methods are referred to as "problem-based learning, or PBL" in which the teacher's role converts to being a mentor, and students solve problems that they may create for themselves. Unfortunately, until recently, PBL has been even more resource intensive than conventional teaching.

Recognizing these limitations, the Smeal College at PSU, helped by funding from the Kauffman Foundation, has created a "generic platform" for PBL innovation learning which greatly removes the mentor load in course material generation, mentoring, and course management. This system has been piloted at PSU with great success.

We propose that the investment in this groundwork be used as a basis to create a new on-line learning course, perhaps with a short residence time, to "train" the MEP regional outreach professionals on how to coach their clients and help them in developing an environment for continuous innovation. Many of the cases and findings of the current task orders could provide inputs to the learning materials together with rich-media, text and case content already created by Penn State. Penn State can also support the learning platform, which removes the majority of management overhead in creating such executive education experiences.

Once the MEP members had experienced first-hand how innovation can be learned and executed on a routine basis, giving them confidence to take the concepts to their clients, the learning platform can be enhanced and made available as an every day tool for SME managers to gradually learn how to innovate, design new business models, create partnerships, manage IP, etc.- all the skills for 21st century SME innovation.

Access to the current PSU program can be arranged for those expressing *bona fide* interest in this initiative.

7.3 Undertake Casework with MBA Programs

Another way to access extra resources is for the MEP offices to work closely with regional universities that practice experiential learning within their MBA programs. We suggest that MEP create a set of guidelines for problem-based innovation cases. These would be used to help faculty, students and SME management teams to understand the procedures, the expectations and outputs from the relationship. In addition, an analysis framework would be provided that is built upon our findings so that the teams would understand that innovation in its broader definition is required from the teams.

Teams of students with a mix of skills would be assigned to the SME, undertake some field and secondary analyses and then explore various innovative plans including technology acquisition, new business models, partnership options, etc. culminating in a presentation to the senior executives of the SME.

We have undertaken several of these activities at PSU. There are advantages to all stakeholders:

- MEP would enhance its resources at little or no cost
- Students would have interesting cases to develop and work on
- SMEs would access new resources and thinking without any cost
- Students may find interesting employment opportunities
- Faculty would have constant new materials with which to challenge their students.

7.4 Develop an Innovation Portal for U.S. SMEs

As we have seen, clusters are naturally occurring phenomena, the results of environmental and economic factors that are difficult to cultivate. As telecommunications infrastructure and the diffusion and security of the Internet improve collaborative capabilities, geography becomes less and less a requirement for partnering and ensuing innovation.

We have also seen that successful innovating SMEs must search for opportunities well beyond their locale, and embrace the formation of partnerships of many forms to access complementary resources. To accelerate and aid long distance innovation and collaboration, we propose exploring the concept of an “innovation portal” executed on a structured, flexible web site that enables SMEs to explore innovative concepts in a non-threatening way with their peers, wherever they may be. Note, this is NOT a “transaction” site where specific products or services

are offered and bought; it is built on the premise that an SME may not know initially exactly what they are seeking, and the opportunity may only become defined as one or more participants begin to exchange ideas and concepts.

The proposed participants having access to the site are:

- **SMEs** that will post their core competencies and the fields in which they are looking to explore new opportunities.

- **Universities** as providers of experts and technologies.

Subsequently, other participants may be allowed to participate.

The portal will have at least the following capabilities and content:

- Listing area (level one) where a "seeking" SME can post in general terms what its special skills are and in which general areas it is seeking cooperation.

- Other SMEs and universities will be able to respond in somewhat more specific terms, (but still not divulging any confidential information) regarding what they may have to offer that they see as complementary to the seeking SME.

- A secure space into which the seeker can invite one or more of the respondents for more detailed "discussions" within a "level two exploratory chat-room".

- The site will guide the participants on how IP should be handled and provide boiler-plate agreements that the parties can use as models if they wish.

- When the seeker and respondents have mutually decided they wish to get into more detailed explorations, they will agree to enter into a secure "level three innovation section. (An example of such an innovation environment can be seen at www.Imaginatik.com). Such a software application allows participants to innovate as a team, while the software monitors and clearly establishes individual inventorship.

- The participants can then decide whether and how they want to enter into more substantial contracts for mutual benefit perhaps along the lines described in the PBR case study (see Appendix 9).

Such a portal would provide participating SMEs with a way to reach out to complementary enterprises while retaining secrecy, not jeopardizing intellectual property while exposing themselves to a broader range of potential partners. In addition, as innovations often arise when two or more unrelated concepts intersect, such a portal would greatly increase the serendipitous nature of innovation.

Appendix 7 describes some related work being undertaken by a consortium of universities, including Penn State.

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Appendix 1

Task Order #5
Review of Innovation Practices
in Small Manufacturing Companies

Statement of Work

Innovation is widely believed to be a source of future wealth creation in the U.S. and other countries. MEP's Manufacturing Futures Group seeks to understand how small manufacturers, both domestic and foreign, identify, develop, acquire, and implement innovations in their businesses.

> **We will direct the study in stages that correspond with the four sequential stages of innovation defined in the task order. We will begin by developing a terminology that will enable communication both within the project and in ongoing dialogues with MEP so that the concepts are clear and useful for further analysis and policymaking.**

First we will identify a set of small and medium sized manufacturers (approximately 500 employees) that innovate and how much their innovations are related to profitability (through revenue enhancement or cost reduction) and whether they result in short-term or sustainable competitiveness. The search of literature and databases will be guided by a firm's number of patents, R&D expenses/sales, percent of employees with advanced degrees in science or engineering, proximity to science bases, and level of workforce training and education. Based on such data, we will create a taxonomy defining the major types of successful manufacturing innovating firms.

Examples of types of innovating firms may include: the German Mittelstand Model, which is almost entirely driven by technological innovation focused into deeply vertical market sectors; the Italian Cluster Model based on mutually beneficial help networks to create innovative business models; the top-down driven Japanese/Korean Kereitsu/Chaebol model; as well as the US-prevalent "classical" model of local manufacturers applying productivity innovations to targeted domestic markets and concurrently accessing international markets through independent distributorships.

> **We will assess which, if any of these models are likely to prevail in the future, and postulate other models of firm innovation that might be more successful.**

We will study whether these innovations create or eliminate jobs in the aggregate. To assess the degree of innovation, we also will match domestic and foreign firms by sector, under the

assumption that innovation base rates and modes of innovation vary by sector. For example, do firms in the electrical/electronic, chemical, machinery, food, and fabricated metals industries innovate differently?

Within this "firm" taxonomy we will develop a second taxonomy of types of innovation that are particularly applicable to small and medium sized firms. For example, we can differentiate between degrees of innovation, e.g., entirely new manufacturing process, improvement of an existing manufacturing process, or first to market with a manufacturing idea long in the public domain. Each may involve different identification mechanisms, acquisition methods, implementation modes and timeframes. Also, the academic literature offers many different models of innovation types that can serve as the basis for one dimension of a taxonomy, e.g., incremental versus radical, competence-enhancing versus competence-destroying, sustaining versus disruptive. Another dimension will consider whether an innovation is within specialized functions, products or practices, e.g., six sigma, lean manufacturing; and/or driven by technological innovations, organizational creativity, or unique business models. This taxonomy also will be guided by the need to create a terminology that is directed at the MEP population.

After developing taxonomies, we will analyze how small manufacturers identify innovations. Do they generate them internally, or acquire via vendors, lead users, alliances, etc.? Who within the firm identifies innovations and how and from what sources? Against what criteria are innovations evaluated for adoption?

Practical experience and reported cases indicate that identification is not usually a barrier to innovation. However adoption and implementation are fraught with barriers. Thus we will seek cases where best practices have been exercised in the adoption process, as we believe that case illustrations are the most appropriate way to examine how the best innovative firms execute their plans. Are innovations adopted whole or in part, with or without modifications, and, if modified, then in what way? How is the "not-invented-here" syndrome overcome? How is intellectual property managed in a partnership?

Of specific relevance is the role of facilitators of adoption and/or implementation. We will examine such issues as: how do organizational structure, culture (e.g., toleration of failure and risk taking), incentives or rewards facilitate or inhibit innovation? Does fit with current business strategy, business model, and customer-base facilitate or inhibit innovation?

Work tasks:

1. Prepare firm and innovation taxonomies for discussion/ evaluation of innovation processes and practices, and schedule review with MFG staff.
2. Collect and analyze appropriate information on how small manufacturers innovate (related to manufacturing) in U.S. and overseas. We will seek information from MEP databases, as well as from published articles and cases studies, and from interviews with appropriate personnel from domestic and foreign manufacturing firms with exceptional records of innovation
3. Prepare three case histories to illustrate best practices of firm innovation in small and medium sized companies. Indicate which types of firms and innovations are currently and in

the future most likely to be sustainable. Postulate new firm models for the U.S. that might offer greater success.

4. Investigate the use of indicators such as number of patents, R&D expenses/sales, etc. to determine which sectors and firms within them are most likely to succeed.
5. Provide at least 3 presentations at NIST/MEP to discuss issues, impacts, and factors of importance.
6. Provide concise, written summaries of information contained in presentations from item 3 above.

Appendix 2

Current Debate
on Innovation, Competitiveness, and Offshoring

During this project, as we were seeking themes and directions to follow in our research, we decided to review some of the literature regarding "innovation as a solution to continued competitiveness" to provide a more balanced view of the issues prior to interviewing executives. We anticipated that there may be some emotional responses given the current high profile of these topics in the media and in political discourse and that we should be armed with both sides of the arguments in order to extract a more balanced response from interviewees.

Because "offshoring" is a more accessible term than innovation for undertaking media research, we used this as a surrogate for "need for innovation practices". In reviewing the current media there are views ranging across the spectrum from "offshoring is a grand continuation of an economic evolution begun centuries ago", to "it is a pestilence seeking to economically enfeeble the West".

In general, industry opinion leaders are all in favor of the process, citing analogous movements from the past. Some have caveats and conditions such as the delicate balance among offshoring, education, and job creation, but these are the same concerns of similar historical movements: from farm to manufacturing, from manufacturing to electronic systems and software design.

Carly Fiorina, CEO of Hewlett-Packard, in a recent letter to the Wall Street Journal (2004), expressed a typical corporate executive view. "Innovate. Protectionism is not the answer. To stay competitive, American business, in conjunction with American government, must invest in education and the building of new industries to replace the jobs lost to offshoring. This alone can maintain America's leadership in the global economy."

The political response is sensitive to those no longer employed and concerned over the creation of replacement jobs; this is the chief issue to address. Without higher wage replacement jobs, the domestic market will falter and become increasingly dominated by inexpensive imports. It must be the result of a concerted effort by business and government to reinvest savings realized by offshoring in our economy to ensure continued success.

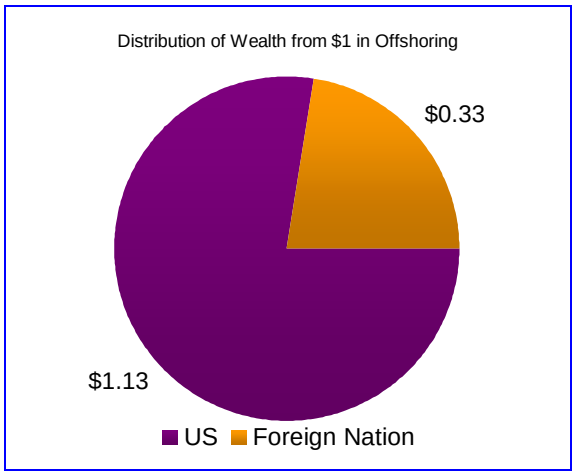
Management consulting firms generally take the position that offshoring is good for the economy; but we must recognize that consultants' opinions can be suspicious as they are seeking fees from clients that are looking for business solutions. Notwithstanding, a number of the leading consulting firms have attempted to analyze the problem and here are some of the results.

McKinsey demonstrates the returns of offshoring, not only for the companies involved but for their economies as well. Studies conducted by the McKinsey Global Institute (MGI) claim that every $1 spent relocating work generates between $1.45 and $1.47, $1.13 of which is captured

by the U.S. economy (78% of value created), the remaining $.33 by the receiving country (22%). See Figure 1 below.

Forrester Research predicts the loss of 3.3 million jobs to offshoring by 2015. MGI claims that this equates to value created through reduced costs, new revenues from developing markets, repatriated earnings by U.S.-owned enterprises, and redeployed labor as U.S. workers find new jobs. To mitigate the impact of joblessness during the transition (the time between offshoring and labor redeployment), "targeted insurance products" will provide wages for an acceptable period of time. They further argue that the ends—the value created—absolutely justify the means and benefit *everyone*.

Figure 1: Wealth Distribution from Offshoring According to McKinsey



According to the Institute for International Economics offshoring reduces IT Costs and creates higher skilled jobs. The first wave of offshoring enhanced the affordability and diffusion of technology hardware, which increased the productivity of American business. The second wave will do the same for software, further lowering the total cost of information systems, making more functional computing available to more businesses, especially small and medium-sized. This interpretation is important as it provides clue to one of the aspects of innovation that we are studying, namely how the innovative application of advanced IT can provide sustainable competitiveness in wealth creating enterprises.

The 10-30% reduction in IT cost attributable to offshoring from 1995-2002 and the associated increase in productivity impacted GDP growth .3% per year for the same period. Software spend growth is nearly double that of hardware (12.5% vs. 6.7% for 1993-2001). Increases in affordability of infrastructure and software contribute to the need for IT personnel. The Bureau of Labor Statistics projects that job growth in IT will be more than three times the economy at large between now and 2010.

Jobs ripe for offshoring will be replaced by jobs requiring increased skills sets with higher wages. Skill-building, born of a partnership between public and private sectors for education,

will ensure this achievement. The links among globalization, IT investment, education, and job creation are tenuous and interdependent.
Another class of thought and opinion leaders resides in the various trade organizations that represent U.S. corporations. Here is a selection of opinions made to a House Committee investigating the issue of outsourcing:

Information Technology Association of America (ITAA) Position: "Stay the course. Despite the inconvenience and loss of jobs to offshoring, protectionist policies discourage investment and innovation. Instead, companies and the government of this country should be devoted to increase R&D to build new jobs in this country".

Institute of Electrical & Electronics Engineers (IEEE) Position: "Addressing the claims made by McKinsey and the like, more attention must be paid to the defense of offshoring. If indeed values are created and ultimately new jobs for displaced workers in the U.S., more attention must be paid to exactly how those displaced workers will find new employment. Continued success of this country rests in leading the next generation of technologies, such as nanotechnology, and any investment in education to ensure leadership will be in vain unless there are jobs".

American Textile Manufacturers Institute (ATMI) Position: "Our government's failure to stop unfair and illegal trade practices by China and other Asian textile producers have forced and will continue to force U.S. textile companies to fire people, close plants, file for bankruptcy, or disappear altogether".

House Small Business Committee Chair Don Mansullo (R-IL) Position: "Productivity metrics as a result of offshoring are artificially inflated. U.S. firms who were making '100 widgets with 20 American employees' and now making '100 widgets with 10 employees' because half of their work is offshore. Offshoring taken to an extreme and limiting available jobs in this country also limits the disposable income Americans will have to purchase products made by the companies benefiting most from offshoring".

The META Group tempers the outsourcing trend by listing ten major risks that firms confront when following an offshoring strategy.

- Costs savings not realized immediately due to many hidden costs and a learning curve.
- IP and Data Security.Only companies with very high process discipline should be candidates.
- Business Knowledge is now housed elsewhere.
- Failure – contingency plans are required in case projects fail.
- Scope Creep.
- Government Oversight/Regulation.
- Cultural Issues.
- Turnover of key personnel.
- Knowledge transfer between geographical distanced operations takes longer, costs more.

The macro-economist William Baumol, in his recent book "The Free-market Innovation Machine", makes the argument that the forces of "creative destruction" raised by Schumpeter in the 1930's are continually overcome by nimble competitors innovating to grab customers. In a developed open-market economy, once the rule of law is established, innovation IS THE ONLY MECHANISM THAT CAN SUSTAIN AND GROW WEALTH. Baumol boldly argues that without innovation, the U.S. standard of living would be orders of magnitude below what we enjoy today. Innovation always has been and will now be the answer for the continuation of wealth creation.

A recent report by Robert D. Atkinson from the Progressive Policy Institute reviews the various interpretations of offshoring in a macroeconomic framework and the advantages and disadvantages of different policy initiatives. Atkinson's policy recommendations are stated thus: "the right response is to enhance our nation's ability to specialize in innovative, high-valued-added work, get tough about practices by other countries that distort free trade, and boost aid to workers and communities hurt by global competition".

Summarizing these views, we quote from a recent "personal view" in Wired.com: "A century ago, 40% of Americans were farmers. Each successive trend to move the bottom rung off the ladder has arguably increased the standard of living overall. Overall is an important word, however. The metrics are typically GDP and GDP/Capita, which do not capture the individual hardships of those displaced by the change. Analogies with the supposed threat of the computer thirty years ago also carry the same implications: it didn't hurt the workforce overall, but it did force retooling and increased education".

Again, we are challenged by a shift in how and where value is created and we have to put the systems in place, infrastructure, education, financial, etc. that will provide the support to generate the next round of economic growth. Irrespective of political bent, there is a strong consensus that innovative practices are key to the future health of the U.S. economy.

Source:
Fiorina, C. (2004**)** "Be Creative, Not Protectionist" *Wall Street Journal*, New York: February 13, A12

Appendix 3

Summary of Simons' Research on Mittelstand Companies

The Hidden Champions: Who Are They?

"We strongly prefer to remain hidden." This, in fact, is a major problem in researching these companies – they do not want to be uncovered and are extremely secretive.

Criteria for a Hidden Champion:

1) Number one or two in a world market or number one in the European market in terms of market share; if market share is unknown, a company must be a leader relative to its strongest competitors.
2) Not more than $1 billion in sales revenue (except for a few; 4.4% of the sample companies exceed this limit).
3) Low public visibility and awareness.

Mean Market Shares of the Hidden Champions:

	Market Share	**Share of Largest Competitor**
World	30.2%	**19.4%**
Europe	36.7%	**20.8%**
Germany	**44.4%**	**21.8%**

Age Structure of the Hidden Champions:

Age	**> 150**	**75-150**	**50-75**	**25-50**	**< 25**
Year Founded	Before 1845	1845-1919	1920-1944	1945-1970	After 1970
% of Hidden Champions	7.6%	23.5%	11.8%	40.3%	16.8%

Selected Statistical Characteristics of the Hidden Champions:

These companies exhibit solid growth, balanced product life cycles, >50% exports and are privately held:

Revenues	$130 million
Growth	1989-1994 6.5% per annum 1985-1989 16.2% per annum
Product Life Cycle Stage	2.7% introductory 28.2% growth 67.3% mature 1.8% in decline
Number of Employees	735
Export Share	51.4%
Exports	$66.5 million
Ownership	76.5%, closely held/family owned 21.1%, concern owned (of those, 59% foreign) 2.4%, public
Age of Enterprise	Mean: 67 years Median: 47 years

The Goal of the hidden champions is market leadership:

"Our goal is to become number one".

Hidden Champions' Criteria of Market Leadership:

Largest in Sales Revenue	72.6%
Largest in Sales Units	46.6%
Technological Leader	36.2%
Product Line Leader	6.9%
Other Criteria (e.g., quality, service, worldwide presence)	14.7%

The Market:

"A big splash in a small pond!"

World Markets Served by the Hidden Champions:

Size of World Market	**<$67 million**	**$67 million - $334 million**	**$334 million - $1.67 billion**	**>$1.67 billion**
% of Hidden Champions	23.6%	20.8%	26.4%	29.2%

Focus and Concentration – typical quotes from interviews:

- "We are highly specialized"
- "We concentrate on what we can"
- "Niche!"
- "We are deep, not wide"
- "We stick to our knitting"
- "No diversification"

Appendix 4

The Warsaw, Indiana Cluster

History

These notes result from conversations between Tolga Sakman, a team member, and Ms. Joy McCarthy of the Warsaw Chamber of Commerce, who gave a brief history behind the formation of the orthopedic devices cluster in Warsaw, IN region. Additional details were obtained from public sources on the companies.

In 1895, Mr. Revra DePuy, starts a splint manufacturing business, on the promise of a fiber splint to replace the wooden barrel staves then used to set fractures.

In 1905, Mr. Justin Zimmer is hired as DePuy Manufacturing's first sales representative.

In 1921, Revra DePuy dies. He has no sons or daughters, so his wife Winifred takes over the business.

Justin Zimmer comes up with the idea of manufacturing an aluminum splint. Winifred does not like the idea. Zimmer tries to purchase DePuy, but does not succeed. In 1927, Zimmer starts his own business across town to manufacture aluminum splints.

For the next half a century or so, Zimmer and Depuy grow independent of (and competing with) each other. They both make multiple acquisitions and are acquired multiple times. Their names and main locations remain the same despite all these corporate governance changes.

In 1977, four engineers then working for Zimmer get an SBA loan guarantee and start their own business in town. The new company is Biomet, now the third largest orthopedic device manufacturer in the cluster.

Over the years, small and large manufacturing and servicing partners have emerged around the town. One player that was attracted to Warsaw to tap the talent is Medtronic of Minneapolis. This company opened up a wholly-owned manufacturing facility there.

Today, the orthopedic devices manufacturing cluster in Warsaw, IN is estimated to feed 8,000 residents of the region (employees + their families), out of a total population of 74,000. The total workforce is estimated to be 36,000 people.

The Warsaw Cluster Today

The Warsaw cluster is located in the Kosciusko County of Indiana. The main area of expertise is the manufacturing of orthopedic devices. The Battelle Institute report that was commissioned by The Indiana Health Industry Forum gives the following information on the economy of Kosciusko County:

In 1998, Kosciusko County was the home of 116 private sector health industry establishments, employing more than 6,100 workers. With an average annual wage of greater than $52,000 per employee (167 percent of the regional private sector average), the health industry generated nearly $1.3 billion in output and supported a total of 11,600 jobs across the county economy. Overall, health industries in Kosciusko County account for more than 20 percent of regional employment, making it the largest single industry sector of the local economy.

Medical supplies and equipment manufacturing is the primary strength of Kosciusko County's health sector, in particular the manufacturing of surgical appliances and supplies, or orthopedics. Indeed, Kosciusko County, Indiana, is acknowledged to be the nation's leader in orthopedics manufacturing. This industry employed nearly 3,500 county workers in 1998, or 57 percent of the entire health sector, and is largely responsible for the four percent annual rise in real health industry wages experienced since 1989. The average wage paid in the industry topped $71,000 in 1998.

Surgical appliances and supplies manufacturing is 130 times more concentrated in Kosciusko County than across the United States. Locally, the industry grew only two percent in terms of employment between 1989 and 1998, however, despite national trends toward double-digit growth. Several hundred employees work within the surgical and medical instruments manufacturing field, establishing a concentration 15 times greater than the national average (i.e. approximately 15 times more workers than would be expected simply in accordance with the population of Kosciusko County).

Firms within this classification supply both the local orthopedics manufacturers and other customers around the country and world. The supplier chain serving the original equipment manufacturers is strong within the county, with many firms providing everything from "tackle boxes" to tools and other instruments. In short, Kosciusko County has an orthopedic manufacturing cluster unequaled in the rest of the world.

Other Kosciusko County health specializations include doctors' offices, personal care facilities, and hospitals and laboratories, serving the extended region beyond as well as within the county boundaries. Average wages in these industries have risen in real terms since 1989, but generally either more slowly or at rates only slightly in excess of those for the state of Indiana and the nation as a whole. Employment growth has been due to supportive local competitive positions as well as national-level growth trends.

Strengths, Weaknesses, Opportunities, and Threats Impacting the Warsaw Cluster

Kosciusko County has a valuable economic advantage to use as a foundation for its future: a true cluster in biomedical manufacturing. Kosciusko County is many times more concentrated in this particular health industry than any other location in the United States. In addition, there are several other industry strengths that give the regional economy a measure of variety and robustness. Residents and the local government look favorably on business in the region and are generally responsive to industry concerns and needs.

The community itself also presents advantages for business as well as quality of life. A superior system of public education accompanies the strong work ethic that reflects the region's agrarian roots. The cost of living, while somewhat heightened by the prosperity of the region, remains low compared to metropolitan regions around the nation. Along with its beautiful lakes for swimming, boating, fishing, and other recreational activities, life in Kosciusko County offers appealing qualities including low crime, minimal traffic congestion, and small town charm.

There are weaknesses that act against the strengths of Kosciusko County, several arising from the clustering of biomedical manufacturing in the region. The extreme concentration of biomedical manufacturing, together with the limited education and training programs attuned to the biomedical industry in the region, has produced a shortage of qualified technicians and manufacturing workers. As a result, competition among the biomedical firms and their suppliers for quality employees is fierce. It is difficult to attract professional and managerial staff to the region from other areas of the country, and the out-migration of much of the community's youth after high school graduation exacerbates the situation. The major biomedical firms have long been in direct competition with each other, and generally remain averse to communication even on non-competitive issues of mutual concern. The delivery of telecommunications access also requires improvement, particularly in the area of wireless technology.

Several outside factors tend to pose threats to the region's current competitive position as well. Biomedical firms that began as spin-offs may desert Kosciusko County as they are acquired by larger national or multi-national companies, or find regions or nations offering more favorable research and development capabilities or a larger qualified workforce. The biomedical industry as a whole will face a changing sales base with the generations following the Baby Boom, and the prospect of new materials and technologies such as biopolymers and tissue regeneration may radically alter the industry over the next two decades or longer. Technological advancements and workforce shortages threaten other Kosciusko County industries as well, including printing and agriculture.

REFERENCE

Sustaining Kosciusko County's Health and Biomedical Industry for the 21st Century, Technology Partnership Practice of Battelle Memorial Institute, February 2001.

Appendix 5

Golf Equipment Cluster
Carlsbad, California

This cluster, in comparison with the Warsaw cluster above, is relatively new. There are several reasons why this very focused cluster of manufacturing companies resides in Carlsbad.

First, is the serendipity that the first entrepreneurs, Karsten Solheim, and later Eli Callaway lived in Carlsbad. It could just as easily been Wichita, Kansas Second, the local social capital within the aerospace sector that had the design and machining skills suitable for high quality, exotic metal products, and finally the enormous growth in the golf equipment market over the last 40+ years. This growth has enabled several small companies to form, grow and be acquired by larger firms in a relatively short period.

Companies involved:

- CobraGolf (subsidiary of Acushnet Company (subsidiary of Fortune Brands (FO)
- Karsten Manufacturing Corporation (privately held)
- TaylorMade-adidas Golf (subsidiary or division)
- Callaway Golf Company (ELY)

Cobra Golf
Acushnet Company
1812 Aston Avenue
Carlsbad, CA 92008
http://www.cobragolf.com/

Key points:

- The Acushnet Company, home of Titleist, Foot Joy and **Cobra Golf**, is a recognized leader in the golf industry and committed to providing both serious and recreational golfers alike with products and services of superior performance and quality. By combining technology with innovative design, the company claims to provide its customers with a competitive advantage not found with other manufacturers.

- A subsidiary of Fortune Brands, Acushnet is a leading maker of golf balls, clubs, shoes, gloves, and other golfing equipment and accessories. Its Titleist brand of golf balls is the #1 seller in the US. Its Foot joy golf shoes also are #1 nationwide. The company also makes value-priced Pinnacle golf balls and Cobra-brand golf clubs. Acushnet's products are sold to

golf pro shops, sporting goods stores, and to mass merchants throughout the US, and also in Canada, South Africa, and in parts of Europe and Asia.

- Fortune Brands (Parent company to Cobra Golf)

Major Brands	Major Product Liners	Market Leadership
Titleist	Golf balls	#1 golf balls worldwide
Foot joy	Golf clubs	#2 golf clubs in the U.S.
Cobra	Golf shoes	#1 golf shoes worldwide
Pinnacle	Golf gloves	#1 golf gloves worldwide
Dry joys	Golf outerwear	#1 golf outerwear in the U.S.

Key points:

- TaylorMade-adidas Golf is striving to be the best after acting as a catalyst in the golf equipment industry. The #2 golf club maker (after Callaway Golf) produces metal drivers and irons (300 Series, R500 Series), putters (Rossa), and balls (Distance Plus, Maxfli, TP Tour) sold worldwide. Other products include bags, apparel, and accessories as well as products designed just for women and kids. It sponsors players on the PGA (Ernie Els, Retief Goosen), Senior PGA (Gary McCord), European PGA, and LPGA (Se Ri Pak) tours. Gary Adams founded Taylor Made in 1979 after discovering that balls struck by metal drivers travel farther than those struck by traditional woods. Taylor Made became part of adidas-Salomon in 1998.

- TaylorMade-adidas Golf, one of the largest golf club manufacturers in the world, is a subsidiary of adidas-Salomon A.G. When Taylor Made, Salomon and adidas joined force in 1998 it brought together some of the most innovative companies in their fields.

- TaylorMade-adidas Golf has led the golf industry's technological evolution since being founded in 1979.

Revenue (2002):	$741.00 M
Revenue Growth (1 yr):	53.50%
Employees (2002):	1,078
Employee Growth (1 yr):	**11.40%**

Appendix 6

Additional Research and Experimentation on Virtual Clusters in Italy and Canada

During our research we uncovered a recent publication entitled *DIGITAL INNOVATION: Innovation Processes in Virtual Clusters and Digital Regions* edited by Giuseppina Passiante, Valerio Elia & Tommaso Massari (University of Lecce, Italy). Published Sept 2003 ISBN 1-86094-352-7. Below are notes on the content.

The book discusses the results of an empirical analysis of the new phenomenon of virtual clusters (VCs) and highlights the dynamics of these emerging innovation networks in the digital economy. There is currently no conventional theory of social networks that can be applied.

Nevertheless there is an overview of the most significant theoretical approaches to innovation networks, and their rethinking in the digital economy scenario. Following a neo-Schumpeterian approach, a particular focus is on the opportunity to integrate the economic benefits coming from the geographical proximity, with the advantages related to the "organizational proximity" allowed by the IT networks.

The e-Selanto project is described in which the concepts of establishing a virtual cluster application to enhance an Italian neglected region. Some general implications of the project for theory and practice are also discussed. The architecture and the master plan of two initiatives within the e-Salento project, concerning the agribusiness and tourism sectors are described.

The book also describes:

- A model of leadership, to guide innovation in an organization competing in the digital economy, including both firms and regions.
- Issues concerned with VC growth and regions' economic development processes that are common to both the regional studies and the innovation management literature; the book represents an important empirically grounded contribution to them. Furthermore, several scholars argue that new development models are emerging for firms and regions. There is a lack of published work that provides empirical grounding and/or analytical models of firms' and regions' development processes in the Net Economy.

An interesting experiment is being run in rural Canada to test the application of virtual networking. Key points in the study are:

- Implementation of a new “SuperNet" has the potential to enable the creation of virtual industry clusters (Porter, 1998). Recent research on high tech clusters shows that not all of the Porter conditions need be satisfied for success (e.g. Phillips, 2002).
- Thus, the prospects for virtual clustering at distance are becoming attractive. When 95% of Alberta’s rural communities are linked by a high-speed telecommunications backbone, it may be possible to counter the clustering disadvantages that now exist.
- This work will study the e-business impact of SuperNet on rural businesses by conducting in-depth interviews with leaders in internet communication identified during studies of wireless, GPS, and multimedia clusters in Western Canada (ISRN-MCRI) to formulate the identifiable opportunities and techniques for use of video conferencing as a tool for transmission of the tacit knowledge that is exchanged in clusters (Langford, Tyree, and Peace, 2002)
- Constructing scenarios (or models) of how small businesses might use broadband access
- Conducting interviews with Alberta businesses about how to use broadband Internet access to conduct business more effectively and efficiently
- Developing an understanding of how to help rural small businesses use that access in their businesses
- Examining how broadband access to the Internet might allow for the creation of virtual industry clusters -- the working together of several businesses to support each other in their work.
- The study is a natural quasi-experiment in a field setting.
- The experimental or treatment group is the set of Albertan rural communities that will be connected to the SuperNet in the Winter of 2002/early 2003 period. The experimental population is all the small businesses that exist in those communities.
- The control group is the set of Albertan rural communities that will be connected to the SuperNet in the year 2004.

Principal Investigators were Richard Field, Douglas Cumming, Cooper Langford.

Appendix 7

European E-Hubs Consortium
Supporting Virtual Clusters

Program Coordinator: Godfried AUGENBROE;Georgia Institute of Technology, ARCH 0155 Atlanta GA 30332, USA: Tel: +1 -404-894-1686, Fax: +1 -404-894-1629, Email: fried.augenbroe@arch.gatech.edu

Origin: The European e-HUBs consortium[1] was awarded funding from the European Commission's IST program in 2002 to develop a web hosted platform for the planning of e-Engineering projects. The focus is on partnerships that are remote, time-critical, volatile and limited to dedicated engineering services. The project aims at a set of web hosted services that enable such projects to be planned efficiently through a so-called e-Hub.

Objective: the new e-Hub should offer collaborative project planning (PP) services that focus on collaborative, tactical decision making that goes into the formation, work planning, contracting and trust building on both sides of an e-engineering partnership .

Approach: The focus is on projects that are performed in so-called small "project windows", i.e. partnerships that are executed within a short time frame. Large product development companies recognize that global partnerships are critical to their future success. Rather than betting on the "extended enterprise" formula, companies express the desire to engage in on-the-fly partnerships. Ad-hoc partnering in project specific dynamic settings provides the agility that long term strategic alliance based partnering cannot guarantee. It is this realization that has companies looking for support to initiate and plan partnerships that are remote, time-critical and volatile.

The launch of the R&D project in 2002 was predicated on the belief that these partnerships necessitate a new generation of collaborative project planning (PP) methodologies and services. Although there are elements in this approach that resemble "outsourcing" practices, the two types of business partnerships are in fact very different. First of all, e-Engineering is not driven by the need to "ship work" from one organization to the other. Rather, its main purpose is to bring in expertise which is needed for a new product development if that expertise is not part of the core domain of the developer or organization. Another contrast is that there is no need to form strategic long term "service level agreements" as is current standard practice in outsourcing agreements. Rather, the contract is project specific, governed by the tactical needs of the project at hand. e-Engineering partners must be able to "fuse" their processes and they need to do so rapidly, remotely and securely, limiting project failure risks to the minimum. This obviously requires adequate tools that enable partners to reach agreements about project requirements, work arrangements, process mediation etc., swiftly and transparently.

Business perspective: A new business entity will host a Project Planning platform that enables partners to make the tactical preparations of an engineering project. The PP service rests on existing substrates that deliver mainstream functionality of project collaboration spaces. E-Hubs will start -off by providing only PP functions but will soon start becoming a full Project Preparation and Planning (PPP) provider. This will occur when the market starts requesting additional PPP services, which will be offered both through the web hosted collaboration platform as well as through add-on services. The add-on services will consist of advice offered by affiliated human experts, e.g. in the form of consultancy services channeled through the storefront of the e-Hub, or could be offered as franchised or referral services by already existing B2B partners that could affiliate with an e-Hub. The hybrid mix of web hosted and human consultancy will over time be enriched by training, education and marketing services, primarily directed at SMEs**.** Four main business drivers of the e-Hub have emerged from an analysis of the current landscape of collaborative engineering:

- Efficient integration of engineering services on an ad-hoc basis into engineering projects is of strategic importance for the productivity and competitiveness of engineering design consortia.
- Good project preparation and planning is a key element for the effectiveness of dispersed collaborative engineering teams thus adding to the business value and ROI on investments in current collaborative engineering platforms.
- The delivery of generic project planning functionality paves the way for a whole range of other services that enhance the productivity and competitiveness of companies engaged in new product development. It should be noted that e-Hubs are not targeted as catalysts of the over exposed Virtual Cluster.
- Enterprise nirvana. In fact, e-Hubs offer a viable alternative with greater flexibility and short response time to changing circumstances.

Technology: collaborative PP is viewed by the e-Hub as a managed process that transparently generates a set of comprehensive planning documents. They may contain both structured models and unstructured documents. The added value of the e-Hub is that the generation process is collaborative in nature and logically ordered, driven by structured content exchange. Both aspects are embodied in a formal Project Planning Model (PPM) that companies develop and agree on at the strategic and international trade level. They represent the business intelligence of "how companies want to engage in remote partnerships". The PPM is not one single model but a collection of models. Each of these models consists of a PP process model that incorporates the coordination logic of how the project planners negotiate and reach a resolution on one of the aspects that need to be tactically agreed. Each of the workflow models operates on one or more content templates. A content template is an ordered set of fields with specific meaning. The WF model controls who has read or write access to which field. All parts of the PPM are grouped in "packages", each of which may contain a set of (sub) process models. Each process model is defined as a workflow model that adheres to the WfMC standard. In the project planning platform in the e-Hub the workflow models are enacted, initiated by the project planners. Depending on who is the owner of the workflow, different planners will have the right to launch the enactment of a workflow.

Results: The project will end in July 2004. An e-Hub prototype is currently being evaluated in workshops throughout Europe, whereas interviews are conducted with thought leaders and decision makers to elicit opinions on the viability of the developed e-Hub concept and prototype.

1 The e-Hubs Consortium consists of: TU Delft (NL), RWTH (GE), Design Solutions (NL), European Dynamics (GR), CKA (BE), GeoDeco (IT), Loughborough University (UK) with affiliated partners ITESM/IECOS (Mexico) and NUMA (Brazil), Georgia Tech (USA) and Penn State (USA)

Appendix 8

Taprogge GmbH
Company T

A visit to the web-site (http://www.taprogge.de/en/) shows the intense technological content, attention to detail, and quality typical of a Mittelstand company. This appendix contains three sections. The first provides details on the company taken from public sources. The second provides insight into the company through a personal interview with Detlef Taprogge, the CEO and owner. The third is entries to the taxonomy.

Taprogge is the worldwide market leader in the field of cooling water systems. The company promotes itself as "No. 1 for both technology and service, continuously developing its technology to maintain that position for the exclusive benefit of its customers".

Company Background:

For more than 50 years, Taprogge has been operating in the sector of optimization of water circuits, particularly in power stations, seawater desalination plants, refrigeration and industrial plants. In this special field the company is the international market leader using its inventions in process technology and plant engineering.

Company Philosophy:

To fully support its customers in pre-installation design, installation and after market service.

Company History:

It all began 50 years ago. For Josef Taprogge, the head of the power station at Essen-Kupferdreh, dealing with problems pertaining to fouling of the condenser tubes and the resulting capacity losses of the turbine was a daily ritual. However, he came up with an innovation whereby these tubes would be cleaned by circulating sponge rubber balls that are a little larger in diameter than the tube itself. What is more remarkable though is what Josef Taprogge made of this idea. With his enthusiasm and hard work, he worked on eradicating the "teething problems" of his new product. Mr. Göstenkors, an employee then and later director of Gersteinwerk power station – one of Taprogge's first clients, recounts that Josef Taprogge spent many nights at Gersteinwerk – in addition to his assignment at his own power station – in order to solve these problems.

But in all probability, these successes would not have come about in the absence of brother – Ludwig Taprogge. The technical matters to be solved were too time-consuming for Josef Taprogge to be able to provide adequate attention to the organizational and commercial aspects of the business. However, thanks to Ludwig Taprogge, the young company was put on the right track from the start. First-class personnel and an international orientation contributed to the initial success. Very soon, agencies were established in the Netherlands and in England, and in less than five years the first subsidiary was founded in the United States of America. Today the number of Taprogge's wholly-owned subsidiaries stands at 11, and it has agencies in more than 60 countries.

Ludwig Taprogge's son, Detlef Taprogge, (see interview summary below) has continued as CEO of the company. Under his guidance new products were developed, new markets were opened up, and a production plant was set up in China. He prepared the company for the future, and while continuing to do so, ensures that the efforts of his uncle and his father do not go in vain. At the same time, he stands for the original values and ideals of the firm, thereby creating stability and continuity.

Time Line:

1949: Josef Taprogge invents and patents the tube cleaning system ("TAPROGGE System")
1953: Taprogge Corporation is founded in Wetter ad Ruhr, Germany
1968: The first generation of large cooling water debris filters based on turbulence technology is launched
1983: The first filter generation based on pressure-relieved backwash technology ("PR-BW technology") is launched
1987: The pressure-relieved backwash technology is further developed into the high-performance filter
1993: The first condenser monitoring system ("CMS") is invented
2003: Comprehensive solutions for the pre-treatment of reverse osmosis plants are developed and introduced

Technology:

Taprogge cleaning balls: The optimal efficiency of the Taprogge System is entirely dependent on the cleaning ball. One of the essential requirements is that the balls are distributed uniformly in the water and the same should be equivalent to the uniform distribution of the balls through the tubes to be cleaned. Similar to a sponge in a bathtub the cleaning balls would swim on the surface of the water until they are full of water. This means squeezing them under water, which eliminates the air, and filling them with water. A good "watering ability" is therefore necessary to achieve a good ball distribution.

But the core problem is to get the water into a sponge rubber cleaning ball whose vulcanizing process produces a closed cell structure! The solution invented and patented by the company is to crack the cell walls, in this way making them open, porous and thus permeable to water without destroying the structure of the balls. Cracking is done in the production process prior to the last step – the optical final inspection – in a dual-stage cracking mechanism. The balls are

pressed through a gap between two rolls working in opposite direction. For every ball (with varying diameters) there is a specific gap width.

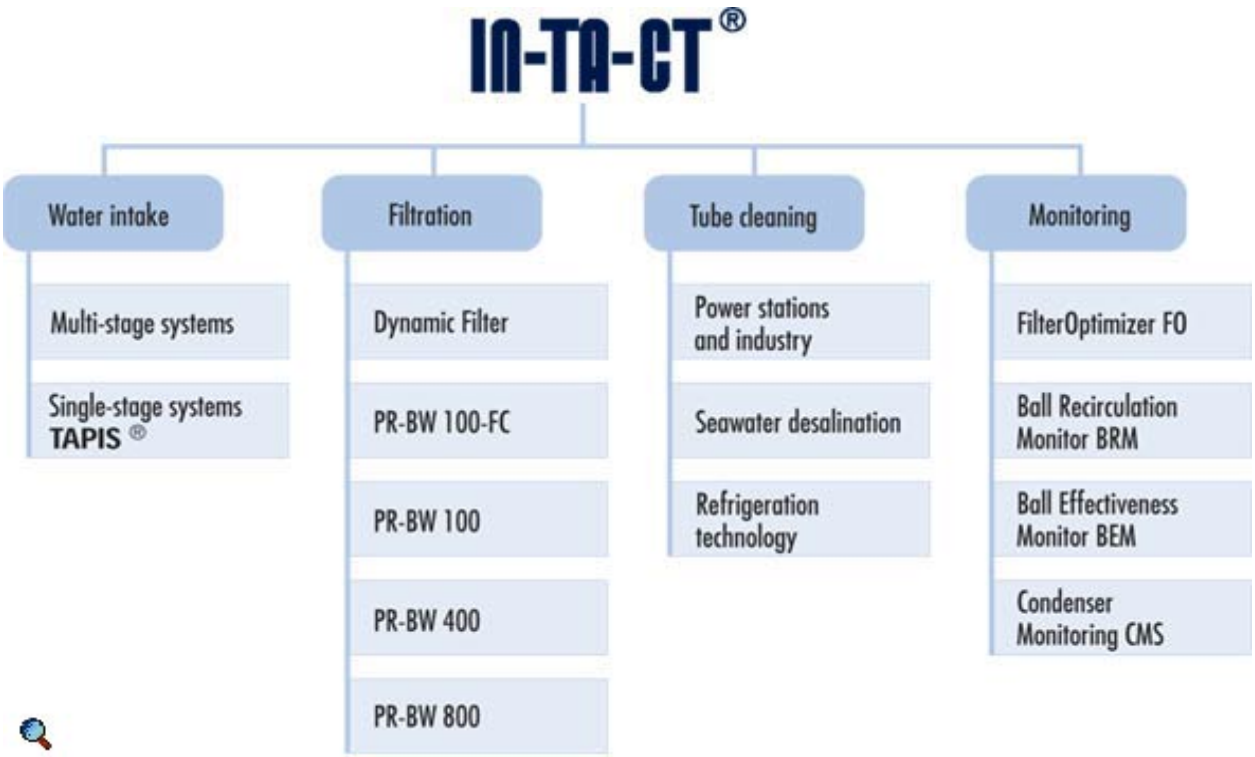
But how do you get a ball of say 32 mm diameter through a 3.0 mm gap? "Well – not everything is revealed…" says Detlef Taprogge (*authors' note - indicating that trade secrets are part of the company's IP management practice).*

Remote Monitoring: In order to monitor Taprogge systems, an extra module is integrated into the controls of the Taprogge debris filters and tube cleaning systems. By modem, the respective system is connected to the Taprogge Remote Monitoring Centre. A telephone connection is all that the operator has to provide. A remote monitoring system is also available as a retrofit kit.

Most importantly, this IN-TA-S® module provides the customer with the competence of the Taprogge personnel without actually having to pay for their physical presence. (*Authors' note – in addition to reducing operating costs, this provides "informational intimacy" between the customers and Taprogge)*

Products:

- IN-TA-CT® (Integrated TAPROGGE Concept) provides complete assistance for the planning and purchase of its systems:



Advantages of IN-TA-CT® (Integrated TAPROGGE Concept):

- Planning carried out by Taprogge would result in the highly effective IN-TA-CT® modules contributing to more intelligent layouts of the mechanical cleaning chain in cooling water systems which in turn would reduce capital expenditure for the prospective client.
- IN-TA-CT® is made by Taprogge - which means that it comes from a single source. Reduced administration, low handling cost and reduced processing time are the consequent benefits.
- IN-TA-CT® provides new process safety by guaranteeing the scope of the integral system. Traditional interface problems are avoided.
- As an IN-TA-CT® user you have an automatic back-up of the quality features and an unrestricted access to IN-TA-S®.

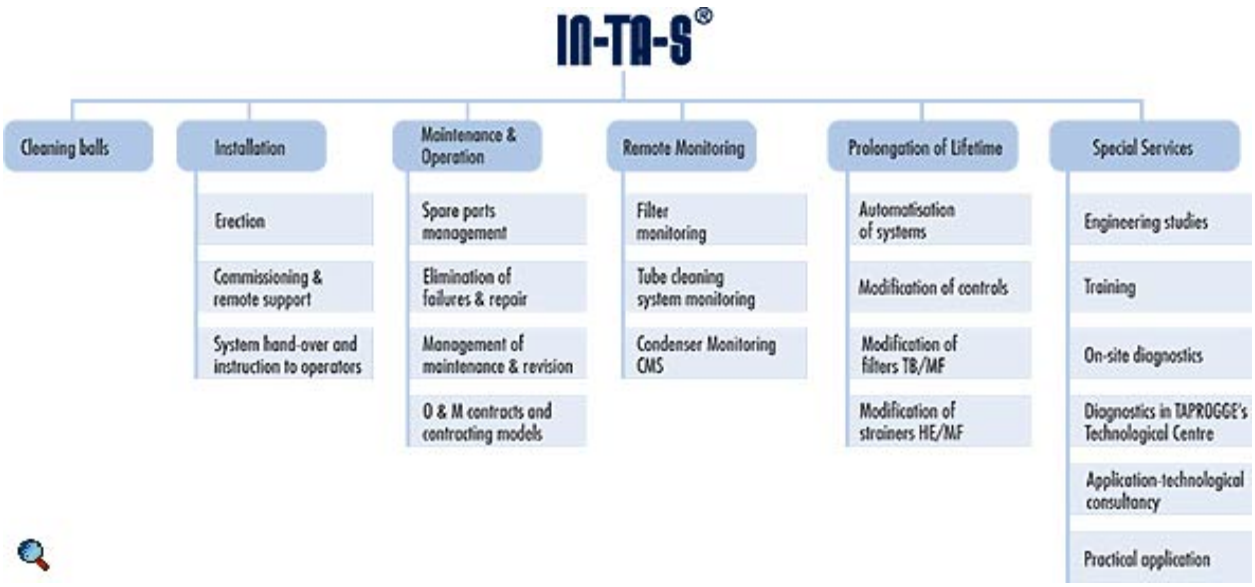
INTACT – Monitoring - The Filter Optimizer (FO) Being an optional add-on device, the FO ideally complements every Debris Filter. Using intelligent software, the patented device self-learns and automatically optimizes the filter backwash timing. Payback is generally less than one year.

Ball Effectiveness Monitor (BEM) - The BEM serves as an optional add-on device to the TAPROGGE System automatically measuring the effectiveness of the circulating cleaning balls. It enables the operator to check the state of the cleaning balls in circulation – at any time and without further effort – with a necessary ball exchange being signaled at the same time ensuring the System remains optimized – without need for manual intervention.

Ball Recirculation Monitor (BRM) - The BRM serves as an optional add-on device to the TAPROGGE System and automatically monitors the quantity of balls. The circulation of the pre-set ball charge is a precondition for an optimal cleaning result. Automatic monitoring by BRM offers enhanced comfort to the end user – manual checks are no longer necessary.

Condenser Monitoring System (CMS) - The CMS is a patented sophisticated, modular measuring technology. It not only serves for monitoring the ball recirculation and ball effectiveness for tube cleaning, but can determine the velocity and flow of the cooling water, as well as the heat transfer coefficient, even of individual cooling tubes, quickly and accurately. The operator is therefore, for the first time, provided with an early warning on-line system that signals changes in condenser performance.

- IN-TA-S® assists operators in a comprehensive and reliable way through the lifetime of their systems, covering not only installation, operation and maintenance but also permanent optimization and monitoring, including large-scale upgrades for a lifetime usage of the IN-TA-CT® modules.



Advantages of IN-TA-S® (Integrated TAPROGGE Services):

- Taprogge technology is process technology. With the purchase of a system the prospective client first receives the tool enabling it to operate a plant more efficiently. However, the increase in the efficiency and consequently its commercial benefit depends on the operational mode that is optimal for the relevant application. As a user of Taprogge technology the client is entitled to make use of IN-TA-S® and receive on-site competence and expertise (*Note – software content in products)*
- For the optimal adjustment of the systems and the improvement of the client's performance IN-TA-S® accesses a proprietary data bank containing information on more than 5,000 Taprogge applications (*Note – use of acquired data as added-value and competitive advantage)*
- By the modular structure of the individual IN-TA-S® services the client can choose the scope of its work to match its specific requirements (*Note: customization feature)*
- Taprogge offers the client local availability. The client can simply rely on IN-TA-S® centers in 10 regions of the world, dual sources from Taprogge's two production centers, as well as its IN-TA-S® remote center (*Note: real-time service)*

Applications:

- *IN-TA-CT® in Power Stations with Once-Through Cooling*: In places where water is sufficiently available, once-through cooling is the most economic form of cooling. According to this principle, surface water is extracted from the sea, river, lake or canal, pumped to the turbine condensers (main cooling water circuit) and to the coolers of the auxiliary circuit, and subsequently transported back to its origin. *IN-TA-CT® in Power Stations with Closed Circuit Cooling*: Where there is insufficient natural water source available, recirculative cooling is recommended. With the recirculative cooling, cooling water is extracted from the basin of a cooling tower and delivered through the cooling circuit by a pump. The water heated up in the

condenser is then cooled in the cooling tower. The water losses caused by evaporation and desalting, are compensated by treated make-up water.

- *IN-TA-CT® in Seawater Desalination according to the MSF Principle*: The major part of the drinking water of the world produced from seawater is generated according to the MSF principle (Multi-Stage-Flash Evaporation). Salt water is taken from the sea and, in evaporator stages connected one after the other, is separated into distilled water and highly concentrated brine.

- *IN-TA-CT® in Membrane Plants*: In recent years, membrane-technical processes have made spectacular inroads into the vast fields of water technology. In addition to reverse osmosis (RO), established for many years, membrane technology applies above all to the processes of micro, ultra, and nano filtration (MF / UF / NF). Major technical applications, in particular those where natural water serves as the water source, are, above all, seawater desalination, municipal drinking water supplies and the production of water of high purity for technical purposes, for instance the production of boiler feed water.

- *IN-TA-CT® in Industrial Water Circuits*: Be it in petrochemical, chemical, steel, cement, or paper industries, in refuse incineration plants and major heat pumps, or in numerous other industrial applications, IN-TA-CT® has gained a firm footing in all of those sectors.

- *IN-TA-CT® in Refrigeration Plants*: The major application of refrigeration technology is for air conditioning systems. In particular in countries with high average temperatures and high humidity they constitute an essential requirement for the creation of a comfortable living space which is why they are indispensable for office buildings, hotels, hospitals, shopping centers, and airports. But refrigeration is also required for technical purposes, for instance in cold storage houses and in the electrotechnical and textile industries.

Quality:

Taprogge products are tested in an in-house technological center for technical perfection and maximum safety. Specifically Taprogge tests to the following certifications (among others):

- performance as per DIN EN ISO 9001:2000
- safety of design by fulfilling the requirements of the European Pressure Equipment Directive 97/23/EC (up to Module A1)
- approval KTA 1401 for nuclear systems
- certification as specialized welding workshop of the top level DIN EN 729-2
- certification as per SCC (management system for safety, health and environmental protection) for our after sales service section

Partnership:

Taprogge solves difficult problems involving membrane-technological processes in partnership with inge AG, (www.inge.ag) a manufacturer of innovative UF (ultra filtration) technology membranes and modules for the processing of drinking water and waste water treatment. Taprogge invested in inge AG as a minority shareholder on June 10, 2002.

Statistics:

Plant area:	More than 62,000 sq. metres
Staff:	Approximately 350 worldwide
Capital Stock:	10 Million Euro
Annual Turnover:	*Around** 50 Million Euro ($55MM)
Subsidiaries:	In 11 countries
International Agencies:	In more than 60 countries of the world
** Authors' note: Taprogge GmbH is a privately held company, hence it is not possible to get accurate and in-depth financial information.*	

Summary of an interview with Herr Detleff Taprogge, Geshaeftsfuehrer (CEO) of Taprogge GmbH. February 6, 2004 with Dr. Anthony Warren.

Background: This company is a typical "Mittelstand" Company based in Germany. The company was founded by Detlef's father who developed a novel system for cleaning heat exchangers while working at a large electrical utility in Germany. Upon the successful use, Mr. Taprogge Sr. was allowed to leave in order to commercialize the technology in a privately held company.

Today Taprogge GmbH is run by the son, Detlef. Detlef has an engineering degree in Germany and an MBA from Dartmouth College in the US.

The company's revenues are kept secret, but are in the range of $50-$100M at least. Despite that fact that the company designs, tests, manufactures its equipment and spares in a high labor cost area, it carries no debt except for short-term working capital, has 90% of its revenues outside Germany and has a dominant (>75%) market share in its chosen product and service areas. One third of the employees are non-German.

International distribution and service is carried out through 10 wholly-owned subsidiaries in the major economies and a further 60 distributorships in other countries. The company is highly successful in Asia and has successfully penetrated the power industry in China where it has also established a manufacturing plant.

History and Strategy: The company has a well thought through strategy regarding its business model migration. It has developed through the following phases:

Phase 1: selling heat exchanger and boiler cleaning systems using its unique "sponge ball" technology to the power generation industry, initially in Germany and, as it saturated the home market, moving in a planned way into overseas markets. At this phase this was a one product company. Development initially was taking the same product into more markets especially internationally.

Phase 2: combining service into the product. The company will design, install, monitor and service equipment on a service contract. More recently, the company has introduced condition monitoring into its products to ensure shorter downtimes and also to maintain ongoing relationships with its customers – see below for more on this.

Phase 3: by listening to its customers, and positioning itself as the water treatment specialist, it solves their problems as a basis for entering new markets. In this way the company moved from its focus on cleaning systems into filtration and now filtration revenues have surpassed its original business of tube cleaning. A major sector that it has tackled is filtration in de-salination plants. In order to penetrate this market, Taprogge purchased a small company with leading membrane technology and are always looking for such acquisitions that provide technology to open up new markets ONCE THEY HAVE BEEN IDENTIFIED AND RESEARCHED. The company does not enter any market where there are strong entrenched competitors. They turn down far more opportunities that come to them than they follow up. Thus the strategy is well-defined and extremely focused.

Phase 4. They are now moving both upstream and downstream in the water treatment sector by becoming a systems integrator of proprietary treatment modules that enable them to put together a system to meet any industrial requirements from semiconductor plant to hospitals, power plants to high energy intensive manufacturing. Thus they are moving towards being the total solution in industrial water management from intake to output using "plug compatible" modules rather than selling components. In particular they believe that most micro-fouling problems can now be solved using this approach.

So from product to product/service, to service provider to total water problem outsourcing in very targeted markets internationally has been a logical strategy for the company.

Management of Technology and Intellectual Property: The company uses a well defined strategy:

a) Most R&D is carried out internally. It still has work done at two German Universities (Dortmund and Aachen). However, it uses these for very specific solving of technical problems and do not let them get close to their core IP. In fact they are moving away from using the universities for several reasons:

- It is difficult to control confidentiality
- It is difficult to determine precise inventorship and hence patent status
- The universities are getting greedy and now "want a piece of the action" as well as funding of the research. This has gone too far according to Detlef.

- However, there are "technology fairs" annually in Germany where the universities and research institutes show what they are working on, and Detlef sends attendees to many of these to keep up to date on what is going on in relevant fields.
- Also membership of certain associations can give access to sources of technical knowledge and developments, and universities are usually members of these too.

b) The industry sectors that it serves are very risk averse and Taprogge must develop new systems to half-scale before most customers will risk placing an order for a new, untried system component. This is a major cost item for the company; however, it greatly helps focus as it will not invest in pilots unless it is clear that it can sell many products AT HIGH MARGINS WHERE THERE IS NO OR LITTLE COMPETITION. Also doing in-house research and pilot plant reduces time to market.

c) The company has over 400 issued patents and uses these to stake out its field. However it focuses patents on hardware and engineering and DOES NOT patent processes that it believes would give competitors some advantage if they were published in patents. For example, it does not patent its processes for making the many different types of sponge balls. These are made in a separate facility and only those with a "need-to-know" are allowed access and knowledge. The reasons for this are explained to all staff to avoid trust issues growing and damaging the corporate culture. Note that "patents are only as valuable as your willingness and capability to enforce them". Taprogge has a reputation of quickly and strongly enforcing its patent rights. Also Taprogge is in a relatively slow changing market and therefore it needs long-term technology protection. "Patent strategy is a daily discussion point in our company".

d) The company's most valuable asset is the complex database that it has developed covering all operating parameters of every installation. This is now enhanced by its on-line monitoring systems that give it real-time access to customers' systems. These data enable Taprogge to a) predict the behavior of a system in most if not all locations and environments ("water is not just water"), b) design new products, systems and services more effectively, c) provide fast turn-around service or even on-line help which reduces service time and costs. This strategy is particularly important when the product is customized.

Customer Relationships: As mentioned above, the company prides itself on reputation and reliability. It now embodies customer contact on a regular basis by using remote monitoring which gives a basis for pre-emptive actions and regular interaction with all customers either from the local office or from the German HQ. The importance of this cannot be over-emphasized. Two major advantages thereby accrue – better service at lower cost and the ability to detect problems early. Customers initiated most of the Taprogge's new products by coming to the company with an unrelated water problem, and knowing that it will do its utmost to solve the problem. In this way the company has built the reputation as the "problem-solvers" in the sector and this capability is promoted.

Further advantages are to promote "customer lock-in" and dependence as well as being able to provide HQ knowledge and capability at remote sites.

Human Resources Issues: The company tries to promote long-term employment and does not have any variable salary components. The policy is to see the employees through bad times as well as good. This is, of course, more normal in Germany where an employer has to pay employees whether they keep them on or not. However, Detlef believes that this policy enables him to retain people and to keep the intellectual capital within the company. Also privately-owned companies, if well managed, can provide continuity of management over a long time which promotes loyalty reflected in hard work and pride in quality.

He believes that the push for quarterly earnings would not have allowed him to build a company like this, as he would not have invested so much in R&D and in pilot facilities.

He is concerned about the quality of high school education both in Germany and in the U.S. He still feels however, that the U.S. often fails to get the basics taught in high schools such as math and language skills, basic physics etc. On the other hand, he feels that university special education is better in the U.S. and is particularly impressed with our executive education. (Note he has an MBA from Dartmouth) .

Summary: Taprogge GmbH is a privately held company that dominates its field of endeavor internationally while remaining private and maintaining a strong balance sheet. Keys to the success:

- "do the right things well" – stick to basics
- focus, focus, focus – do not chase opportunities that are outside the long term strategy and do not go into markets where margins will be squeezed
- only enter new markets that fit your strategy and you can maintain high margins
- have a clear policy for IP management that fits the corporate strategy
- actively keep close to your customers and use them as a source for new product and markets.
- promote innovation in the organization – communicate with staff and build trust
- remain privately owned for a long-term view
- innovate in technology, markets and business models
- seek technology externally only as appropriate as a supplement but maintain control through substantial internal R&D
- be willing to take measured risks.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	High	**Medium**	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-sharing Programs	Yes	**N. A.**	No
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Low	Medium
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	Medium	**Low**
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Mix	**Service / Manufacturing**	Service	Manufacturing
14	Competitive Advantage	Technology / Innovation	Service	**Product Quality**
15	Partner Relationships	High	Medium	**Low**
	Innovation Type	**Radical**		Incremental
	Firm Type	Entrant		**Incumbent**

Rationale

1) Intellectual Property: **High**
This inference has been arrived at after reviewing the technology and the services that are on offer at Taprogge especially the *Cleaning Sponge Balls* technology. The *Cleaning Sponge Balls* technology is certainly a highly creative piece of work wherein a 32 mm diameter ball is made to pass through a 3.0 mm gap. Furthermore, Taprogge maintains a data bank that contains information on more than 5,000 Taprogge applications. Also, Taprogge via its IN-TA-CT® modules contributes to more intelligent layouts of the mechanical cleaning chain in cooling water systems which reduces capital expenditure for the prospective client. In short, innovative plant engineering is driven by Taprogge's high level of expertise in the field.

2) Innovative IT Applications: **Medium**
The software content for Taprogge could be categorized as medium for the following reasons:

The Filter Optimizer (FO):
An optional add-on device, the FO ideally complements every TAPROGGE Debris Filter. Due to its intelligent software, the patented device is self-learning and automatically optimizes the point of time for filter backwash.

IN-TA-S® (Integrated TAPROGGE Services):
For the optimal adjustment of the systems and the improvement of the client's performance IN-TA-S® can rely on a data bank that is unprecedented the world over and contains information on more than 5,000 Taprogge applications.

Remote Monitoring:
In order to monitor Taprogge systems, an extra module is integrated into the controls of the Taprogge debris filters and tube cleaning systems. By modem the respective system is connected to the Taprogge Remote Monitoring Center.

3) Ownership: **Private (Family owned)**

4) Age Structure (in years): **>50 years**
Taprogge was founded in 1953

5) Employee Turnover: **Low**
Though there is no concrete data to support the above assertion, good labor relations is one of the core values of the Mittelstand.

6) Profit-sharing programs: **N. A.**
It should be noted however, that about 50% of the Mittelstand companies offer profit-sharing programs and many provide clubs and organize activities for employees and their families. Taprogge has a policy of retaining staff in lean times as well as good times.

7) Closeness to Customer: **High**
That Taprogge's interaction with its customer is high is evident from the fact that it has continuously been able to identify the problems of its customers and solve them through its technological innovation. The repeat business that its subsidiaries are getting clearly is testimony to the fact that Taprogge's closeness to its customer is high and that it is meeting the needs of its customers well. In addition, Taprogge uses its on-line monitoring service to remain "electronically tethered" to its customers.

8) Market Focus: **High**
Taprogge focuses on the provision of optimized water circuits particularly cooling water circuits. However, market focus does not imply industry focus too. Taprogge provides optimized water circuits to – power stations, seawater desalination plants, refrigeration

and industrial plants. So, the inference that the market focus of Taprogge is high stems from the fact that the market it caters to is just one – one that involves water circuits because that's where Taprogge can add value by optimizing the same through deep technical knowledge.

9) Geographical Focus: **International**
Taprogge exports the majority of its products and systems. It currently has 10 subsidiaries and agencies in more than 60 countries.

10) Market Entry Risk: **Low**
Taprogge has been operating in the sector of optimization of water circuits, particularly in power stations, seawater desalination plants, refrigeration and industrial plants. As long as there are power stations, seawater desalination plants, refrigeration and industrial plants and the need to optimize their water circuits, Taprogge is always going to be in business. Taprogge is the worldwide market leader in the field of optimization of systems for cooling water. It is number one for both technology and service, and it continuously develops its technology to maintain that position for the exclusive benefit of its customers. Hence, the competitive risk is low. Furthermore, Taprogge has already developed an ocean of intellectual property pertaining to its business of optimizing water circuits and is very highly specialized in its field and all this requires huge investments in terms of time and money. This proves a clear deterrent to anyone wanting to challenge Taprogge's supremacy and leadership in the field. When it comes to optimization of water circuits, Taprogge is far ahead of the curve.

11) Marketing Aggressiveness: **Medium**
The marketing aggressiveness can be put as medium as Taprogge does not have to go out of its way to market its IN-TA-CT® and IN-TA-S® modules. These modules with their high technological innovation would be able to attract customers on its own. Furthermore, these modules with their high technical intensity have undoubtedly become the world standard.

12) Technology Integration: **High**
Technological focus is judged to be high because Taprogge pours all its resources into creation of technology that would further optimize water circuits – via better cleaning systems and debris filters and more intelligent capital layouts as also the provision of better services via its IN-TA-S® model viz. the Remote Monitoring System. Taprogge has introduced five distinct filtration systems for its IN-TA-CT® modules (Dynamic Filter, PR-BW 100, PR-BW 100-FC, PR-BW 400, PR-BW 800) for different levels of volume flow. Taprogge introduced TAPIS®, a single stage pre-screening system, which is an important milestone in the progress of effective and environmentally compatible pre-screening systems. Taprogge also has the *Cleaning Sponge Balls* technology, which is certainly a highly creative piece of work wherein a 32 mm diameter ball is made to pass through a 3.0 mm gap. By means of these sponge rubber balls that are oversized in relation to the tubes to be cleaned, circulate through the tubes, fouling is removed which results in a permanently good heat transfer. Furthermore, Taprogge maintains a data bank

that contains information on more than 5,000 Taprogge applications. The technical intensity can be seen at the company's web-site

13) Service / Manufacturing Focus: **Service / Manufacturing**
Taprogge manufactures single (TAPIS®) and multi-stage systems for water extraction, filtration systems (Dynamic Filter, PR-BW 100, PR-BW 100-FC, PR-BW 400, PR-BW 800) and cleaning sponge balls. IN-TA-S® assists operators in a comprehensive and reliable way during the whole lifetime of their systems, covering not only installation, operation and maintenance but also permanent optimization and monitoring, including large-scale upgrades for lifetime extension of the IN-TA-CT® modules. Taprogge also uses condition monitoring to provide real-time and preventive maintenance responses.

14) Competitive Advantage: **Technology / Innovation**

Due to reasons already stated before, it is very clear that technological innovation and customer service provides dual competitive advantage to Taprogge. In addition, typical of a Mittelstand company, Taprogge maintains the highest quality standards.

15) Partner Relationships: **Low**
Taprogge is an archetypal Mittelstand company – focused, controlled, secretive, global, dominant in its chosen markets with weak competitors, clear IP strategy, continually improving its technology base, mainly through incremental innovation, while migrating the business model to a hybrid manufacturing/service format. The company is very successful even operating in a high labor cost market with severe regulatory constraints while maintaining a strong balance sheet.

Innovation Type: **Radical**

Firm Type: **Incumbent**

The lessons to be learned for the U.S.-based SMEs are:

- slow but sure
- clearly defined strategy
- acquiring new technology but only for very defined needs
- staying close to the customer actively
- providing impeccable service and reliability
- managing IP strategically
- having an HR plan that is able to retain key persons
- staying in control of your own destiny and "flying under the radar"
- continually innovating mostly in small steps.

As Detlef Taprogge stated: "I do not know what all the fuss is about Mittelstand Companies. I received my management training in the U.S., which I think is the best in the world, and then just used the tools that I learned coupled with commonsense to take the company to this point without taking a large risk. Why is this considered difficult?"

He is however, a holistic thinker, just as comfortable with a CAD drawing as a balance sheet or a sales call.

Sources:

http://www.taprogge.de/en/
http://www.inge.ag/en/inge/portrait.html
Taprogge Newsletter(s)

Appendix 9

PBR
Company P

We chose PBR to study as part of this project for several reasons. It is headquartered in Victoria, Australia, it is publicly-owned and it competes successfully in the automotive supply sector worldwide including the U.S. Strictly speaking, it is not an SME being part of a larger conglomerate, although the stand-alone division's sales are close to the SME threshold. However, we felt that the company could provide valuable input, itself being a rather small entity in a tough market segment. We wanted to learn how an Australian company could compete effectively on U.S. soil against entrenched domestic competitors. More details on the company are available at http://www.pbr.com.au.

We start with a description of the company, followed by excerpts from our interview with the Chief Technology Officer that provides key insights into the company's successful execution of continuous innovation within a highly competitive industry.

Company Background

PBR International, the Pacifica Group's automotive subsidiary, is a manufacturer of brake and clutch products to OEMs in Australia, North America, Malaysia and Thailand, and to replacement markets in 45 countries. Around 70% of OEM sales are generated in North America.

Headquartered in Australia, PBR International operates manufacturing facilities in Australia, Malaysia, Thailand and the USA, as well as a sales office in New Zealand and a technical center in Detroit (USA). It also licenses its technologies to manufacturers in Japan and Korea.

PBR International is based in Melbourne, Australia, and has been in the automotive industry for more than 70 years. Throughout this time, PBR has set world-class standards for brake products and application technology, and has become a key supplier to leading vehicle and vehicle system manufacturers around the world. It uses state-of-the-art CAD/CAM/CAE technologies to design its innovative products.

Recent Product Innovations

- The *Auriga* brake is covered by broad international patents. The new single-shoe *Auriga* Brake is the most significant breakthrough in service brake design in 30 years. It is targeted at the OEM customers. PBR's testing of the *Auriga* indicates potential for shorter

stopping distances, reduced risk of rear wheel lock up and a more even front-to-rear, pad to lining wear ratio. The *Auriga*'s design also incorporates an extended-life lining geometry for potentially lower running costs and less frequent maintenance.

- Aluminum and cast iron disc brake calipers (worldwide patents) – PBR's slimline aluminum brake calipers combine lightweight, low drag design with excellent aesthetics to improve the braking performance and look of almost any vehicle on the road.

- *Banksia* parking brakes (worldwide patent) – PBR has revolutionized the braking industry with its *Banksia* parking brake, a duo-servo unit utilizing a single, continuous rolled sheet metal shoe. This simple but highly effective design is another breakthrough in the automotive industry.

Plants

PBR has five manufacturing facilities throughout the world:

- The Melbourne, Australia facility manufactures full braking systems for passenger vehicle customers.
- The U.S.-based facilities in Knoxville, Tennessee, and Columbia, South Carolina, produce calipers and brake products for sports cars, medium-sized passenger cars, and large and light trucks.
- The company's Asian facilities, in Malaysia and Thailand, supply brake products for worldwide markets.

Sales

PBR International: 2001: $451 million.

Employees

Approximately 1,600 employees in all, 850 of which are based at the headquarters in Melbourne. Of the remaining 750 employees, 650 are in the United States and 100 are in Asia.

Key Customers

- Bosch
- Delphi
- American Axle & Manufacturing
- OEM’s
    - Ford
    - Holden
    - Mitsubishi
    - Toyota
    - GM
    - Ford Motor Co.
    - Delphi

- Proton in Malaysia
- Ford-Mazda in Thailand
- Daewoo in Korea

Around 60% of General Motors vehicles in North America are fitted with PBR brakes!

Competitive Advantages

- Dependability through innovation is what PBR does better than its competitors. It continually finds better and more innovative ways in everything they do, from pure research through design and engineering, to manufacturing processes, packaging and distribution.
- While PBR's engineering and product design innovations are well known, an innovative approach to manufacturing is just as important in providing optimum value to its customers. PBR's manufacturing utilizes state-of-the-art technology that enables the integrity and performance of every component to be validated.
- To maximize the benefits of IT technologies and remain an industry leader in this field, PBR has recently restructured its IT department. The result has been the formation of an IT strategy incorporating new technology to improve customer requirements management, reduced costs and increased profitability. The e-Commerce technologies, especially those in the global automotive industry, have greatly improved PBR's business-to-business e-Commerce between PBR facilities, customers and suppliers.

Quality

- First brake company in the world to achieve QS 9000
- All existing sites certified to ISO 9001 / QS9000 edition 3
- PBR Australia Q1 certified.
- PBR Knoxville Q1 certified
- Working towards TS16949

Commitment to Customers/Quality

To remind itself every day of its customer's concerns, a daily e-mail is sent to all sites that describes every customer feedback that it receives. No matter how small, these concerns are documented and fully investigated. All associates who have access to e-mail are urged to read these messages and think about how they can “Protect the Customer”.

Corporate Strategy

PBR has focused on increasing its international presence and around 65% of its automotive sales are now generated outside Australia. North America has been a particular focus for PBR's expansion in a bid to diversify its North American customer base.

Joint Ventures and Partnerships

- In May 2002 PBR and SKF agreed to jointly develop an electric version of PBR's Banksia parking brake. The alliance brings together SKF's expertise in automotive mechatronics with PBR's know-how in park-brake solutions. With parking brake-by-wire technology the driver will be able to actuate the parking brake using a switch in the car.
- In June 1999, Delphi exercised its right to acquire a 49% equity stake in PBR's Knoxville plant. PBR retained the remaining 51% stake in the facility. Demand for calipers from the new plant during its initial months of operation was greater than originally anticipated, leading to a rapid increase to full production and exceptionally strong sales.
- PBR has had a strategic alliance with brakes manufacturer Brembo SpA of Italy since 1998.

Investments

Following the success of the Knoxville plant that was opened in October 1998, PBR began construction of its second U.S. production site in late 1999. In March 2001 PBR opened its Columbia, South Carolina (USA) plant. PBR employs around 200 people in this US$90M facility, which manufactures aluminum brake calipers and Banksia shoe parking brakes.

To accommodate the increasing demand for aluminum castings for brake calipers, PBR installed a four-station carousel at its Melbourne casting plant in early 2000. The newly commissioned cell eliminates exposure to molten metal and repetitive materials handling, and deals with traditional safety issues and crush points. The cell also increased output from 900 to 1,900 units per day. The technology developed for this project is also being used in the Columbia, South Carolina (USA) plant.

Contracts

- In March 2001 PBR received orders to supply foundation brake systems to Toyota in Australia. The brake systems comprise front and rear calipers, disc rotors and Banksia parking brakes. The orders are valued at $10mm (USD), per annum at full production. The systems are manufactured at PBR's plant in Victoria (Australia) for installation on Toyota Camry and Avalon models.
- In September 2001 PBR secured a five-year contract to supply brake products, including aluminum calipers and parking brake technology, to Bosch's Chassis Division in North America. The calipers will be produced at PBR's Columbia facility, which will undergo a $40M (USD) upgrade to accommodate the contract. The deal will increase PBR's presence in North America and increase its exposure to a variety of U.S.-based OEMs.

New Product Development

During 2001 PBR/Pacifica group consolidated its R&D activities within a new division, Pacifica Group Technologies (PGT).

In March 2000 PBR launched a prototype of a totally new rear brake, which has already attracted attention from automotive manufacturers in North America, Japan and Korea. Designed and developed by PBR, the new brake is aimed at major international markets as a replacement for rear drum brakes. The brake, named the Auriga, offers a simple, effective and hard-wearing alternative to other replacement models. Through product design and innovative manufacturing processes, PBR has reduced the number of parts in the drum brake by half.

Outlook

PBR intends to seek further expansion through offshore alliances, as joint-ventures between vehicle manufacturers flow through to the components industry. PBR's international reach offers the company opportunities to provide products for global platforms. Its success in winning a caliper and park brake contract to supply Bosch in North America is a promising development as first tier suppliers such as Bosch are playing a growing role in selecting and working with brake system component suppliers.

Awards & Achievements

PBR has been recognized with several awards for its global excellence in quality and for consistently delivering on time and in correct quantities. For example, the company has been a recipient of the Victorian Government Certificate of Manufacturing Excellence, the Ford Motor Company Silver World Excellence Award, and the Toyota Motor Corporation Australia Silver Supplier Award. The company's most prestigious recognition, however, was its 2002 induction into the Victorian Government's Manufacturing Hall of Fame. This honor recognized PBR for consistently providing outstanding manufacturing performance over an extended period.

Excerpts from Interview with CTO/Chief Engineer of PBR

Background: PBR is a public Australian HQ'd company doing about $650M in 2003 mainly in brake calipers. Key technology is aluminum casting for brakes, a field in which PBR believes it is a world leader. PBR entered the US market for Australian manufactured goods initially through a JV with Delphi and now manufactures here in a wholly-owned plant in SC. Employs 2000 people and makes gross margins and EBIT well above the industry norms.

Key factors for success are:

- Staying focused on what we do best
- Close client relationships
- Ensuring that we always stay ahead in technology by seeking the best in the world from partners
- Remaining nimble so that we can undertake product development much faster than

our competitors. Large companies just take too long and are cumbersome in product development.

Rapid Product Development: in order to succeed in rapid product development we must be:

- Fast and right first time
- Access key complementary competencies as we cannot expect to go it alone
- Create a corporate culture that embraces partnerships.

To execute on this plan, PBR has developed methods to rapidly assemble partners, cooperate effectively and share benefits. PBR's Joint Development Agreements (JDA's) have several unique features that support this strategy.

- The contracts are well-structured and simple to understand
- They do not try to define the final outcome initially but allow gracious migration to move to supply agreements, or even fully operational jointly owned companies.
- The difficult issue of IP ownership is dealt with up-front. Generally, any IP that is generated in the partnership is jointly owned and cannot be withdrawn by any partner even if they choose not to proceed to a contractual status beyond the development stage.

PBR understands that setting up these partnerships is key to its future success. They reduce product development life cycles time, retain focus on core competencies and make efficient use of resources. Building skills to uncover, create and manage several concurrent partnerships is key for continuing success. Thus PBR considers that its key business model is to implement non-sequential product development structures using complementary partners across supply chains and technologies. Providing responsive product development service to customers is an important attribute for an innovative company.

Corporate Culture: Human resources become a problem after reaching about 1000 employees – we lose the family, inclusive culture that is important for continual innovation. Therefore PBR has decided that it is preferable to have multiple locations. PBR has instituted a bonus plan to retain key staff.

Knowledge Management: Know-how must be held and retrieved in computer format to create corporate learning retention and recently the company has invested heavily in an IT infrastructure to retain and retrieve accumulated corporate knowledge.

Public Ownership: Being public is problematic as it creates a "vicious circle of expectations". After a major innovation, the margins will be elevated, and then the share market expects this to be held high which is not possible until the next major innovation gets to market. Thus in this interim period as margins decrease, PBR has to reduce staffing costs to maintain earnings Thus key resources may leave and strip the company of the ability to regenerate through innovation back to higher margins. Thus public ownership forces running a very thin organization that may be unable to sustain innovation over the longer haul.. This can lead to take over, further depressing innovation as costs need to be further cut to justify the purchase price and the

downward vicious cycle continues. This may be one of the contributing factors why larger companies just cannot innovate so quickly.

There are other models in the automotive sector where extreme focus and excellence in quality with little product innovation can maintain high margins and competitiveness, e.g. Agrati and Fontana, both privately owned fastener manufacturers in Northern Italy.

External searching: PBR has technical specialists that are tasked to spend one day a week to look at external technologies and developments. PBR is developing relationships with Australian universities as sources of new technology. PBR benchmarks its own manufacturing processes against the best regularly in search for best practices and excellence.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	**High**	Medium	Low
3	Ownership	Private (Non-Family Owned)	Private (Family Owned)	**Public**
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	**N.A.**	Low
6	Profit-sharing programs	Yes	**N.A.**	No
7	Closeness to Customer	High	**Medium**	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Focus	Service / Manufacturing	Service	**Manufacturing**
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	**High**		Low
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale

1) Intellectual Property: **High**
PBR's key technology is aluminum casting for brakes. PBR currently has 10 United States patents to its name.

2) Innovative IT Applications: **High**
Know-how is held and retrieved in computer format to create corporate learning retention.

3) Ownership: **Public**

PBR is a public Australian headquartered company.

4) Age Structure (in years): **> 50**
PBR has been in business for more than 70 years.

5) Employee Turnover: **N. A.**
It employs about 2,000 people.

6) Profit-sharing Programs: **N. A.**

7) Closeness to Customer: **Medium**
Providing responsive product development service to customers is an important attribute of PBR.

8) Market Focus: **High**
PBR does about $650M in mainly calipers. Its key technology is aluminum casting for brakes.

9) Geographical Focus: **International**
PBR imports from Australia into the U.S. through a JV with Delphi and now manufactures here in wholly owned plant in South Carolina.

10) Market Entry Risk: **Medium**
PBR manufactures calipers and so it is going to be in business as long as people buy motorcycles, cars, and trucks. It is focused, nimble, maintains strong relationships with its clients, and stays ahead in technology.

11) Marketing Aggressiveness: **Medium**

12) Technological Integration: **High**
PBR has technical specialists that are tasked 1 day a week to look at external technologies and developments. PBR is developing relationships with Australian Universities as sources of new technology. PBR has technical specialists that are tasked 1 day a week to look at external technologies and developments.

13) Service / Manufacturing Focus: **Manufacturing**
PBR mainly manufactures calipers. PBR imports from Australia into U.S. through a JV with Delphi and now manufactures here in wholly owned plant in South Carolina.

14) Competitive Advantage: **Product Quality, Technology / Innovation**
PBR benchmarks its own manufacturing processes against the best regularly in search for best practices and excellence. Key business model – non-sequential product development structures using complementary partners in supply chain and technology. Furthermore, providing responsive product development service to customers is an important attribute of PBR.

15) Partner Relationships: **High**

Innovation Type: **Incremental**

PBR benchmarks its own manufacturing processes against the best regularly in search for best practices and excellence. Key business model – non-sequential product development structures using complementary partners in supply chain and technology. Furthermore, providing responsive product development service to customers is an important attribute of PBR. Also, it has technical specialists that are tasked 1 day a week to look at external technologies and developments. PBR is developing relationships with Australian Universities as sources of new technology.

Firm Type: **Incumbent**

Appendix 10

Company B

Company B requested anonymity.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Low	**Medium**
2	Market Focus	**High**	Low	**Medium**
3	Technological Focus	**High**	Low	**Medium**
4	Geographical Focus	Regional	Domestic	International
5	Service / Manufacturing Focus	Service	Service / Manufacturing	Manufacturing
6	Software Content	**High**	Low	**Medium**
7	Member of Cluster (Italian, Japanese, etc.)			
8	Ownership	Private (Non-Family Owned)	Private (Family Owned)	Public
9	Technical Intensity	**High**	Low	**Medium**
10	Age of Enterprise (years)	< 25	25-50	> 50
11	Competitive Advantage	**Product Quality**	**Technology / Innovation**	**Service**
12	Employee Turnover	High	Low	**Medium**
13	Profit-sharing programs	Yes	No	-
14	Market Risk	High	**Low**	**Medium**
15	Competitive Risk	High	Low	Medium
16	Interaction with / Closeness to Customer	High	Low	Medium
17	Marketing Professionalism	High	Low	**Medium**
18	**Innovation**	**Disruptive**		Continuous Improvement

Rationale

1) Intellectual Property: **High**
Company B protects key IP with patents, as well as some key processes, rest is kept trade secret. Company B currently has 25 United States patents to its name.

2) Market Focus: **High**
Company B focuses on making high end and high volume brake products for motorcycles, cars, and trucks in Italy, Poland, China, US. It is the largest manufacturer of rotors in the world – 34 million annually. It is now moving into EM brakes and has created a separate company to compete with original hydraulic systems.

3) Technological Focus: **High**
Company B has technical specialists that are tasked 1 day a week to look at external technologies and developments. It works with partners, e.g. SKF, Motorola etc.

4) Geographical Focus: **International**
Company B is a quasi public Italian company making high end and high volume brake products for motorcycles, cars, and trucks in Italy, Poland, China, US.

5) Service / Manufacturing Focus: **Manufacturing**
Company B manufactures high end and high volume brake products for motorcycles, cars, and trucks. It is the largest manufacturer of rotors in the world – 34 million annually. It is now moving into EM brakes and has created a separate company to compete with original hydraulic systems.

6) Software Content: **High**
Know-how is held and retrieved in computer format to create corporate learning retention.

7) Member of Cluster: **None**
Company B does not consider that it depends on a supporting cluster although it is within the Milano hinterland of automotive suppliers that operate in a tight network. It does not collaborate except for a tacit agreement not to poach key staff.

8) Ownership: **Public**
Company B is a quasi public Italian company. However, it is buying back stock.

9) Technical Intensity: **High**
Company B has technical specialists that are tasked 1 day a week to look at external technologies and developments.

10) Age Structure (in years): **25-50**
Company B was founded in 1961.

11) Competitive Advantage: **Product Quality, Technology / Innovation**
Company B benchmarks its own manufacturing processes against the best regularly in search for best practices and excellence. Key business model – non-sequential product development structures using complementary partners in supply chain and technology. Furthermore, providing responsive product development service to customers is an important attribute of Company B.

12) Employee Turnover: **N. A.**
It employs about 3,000 people.

13) Profit-sharing programs: **N. A.**

14) Market Risk: **Low**
In business as long as people buy motorcycles, cars, and trucks.

15) Competitive Risk: **Medium**
It is nimble, focused, risk taking, opportunistic, and creator of high performance image and brand in spite of being the largest manufacturer of rotors in the world – 34 million annually.

16) Interaction with / Closeness to Customer: **Medium**
Providing responsive product development service to customers is an important attribute of Company B.

17) Marketing Professionalism: **N. A.**

Innovation: **Continuous Improvement**
Company B benchmarks its own manufacturing processes against the best regularly in search for best practices and excellence. Key business model – non-sequential product development structures using complementary partners in supply chain and technology. Furthermore, providing responsive product development service to customers is an important attribute of Company B. Also, it has technical specialists that are tasked 1 day a week to look at external technologies and developments. It works with partners, e.g. SKF, Motorola etc.

Appendix 11

ChemStation
Company C

Background

ChemStation was founded in 1983 by George Homan. It offers custom formulated, environmentally friendly industrial cleaning and process chemicals, which are delivered to refillable containers and placed free of charge at customer facilities.

ChemStation believes that its system is one part science and two parts organization. ChemStation custom blends formulas for its customers. It caters to a wide variety of industries and applications that range from washing down a fleet, to a factory, store or restaurant.

ChemStation has a bulk delivery system and a national network. A free container is placed where the customer needs it and is then maintained by trained ChemStation attendants. ChemStation eliminates receiving, storing, handling, disposing and reordering chores.

Company Philosophy

ChemStation's philosophy is to try to find the best answer for each customer and to continue to look for improvement opportunities. It is this "work with" partnership that enables ChemStation to provide its customers with customized solutions based in individual needs.

Salient features of the ChemStation Service

ChemStation provide complete cleaning solutions to its customers. It claims that its solutions are efficient as they are custom blended to meet the specific needs of the customer. There is no time wasted in ordering, receiving, handling or disposal of the containers since they are located at the customer's facilities. This enables the customer to have the products when and where they are needed. This is made possible by a just in time delivery which is achieved by a computerized inventory management system. ChemStation has managed to localize manufacturing to provide strong support and quick response to its customers needs. Furthermore mass customization is undertaken to maximize customer advantages.

ChemStation works out be an economical solution for its customers because there are no hidden costs for ordering, receiving, storing and handling. Since ChemStation offers free delivery there are no freight costs involved. ChemStation trained attendants undertake maintenance of the service, which ensures no product loss from improper dilution and consistent performance. Since the containers are not disposed there is no loss of products with containers being discarded.

ChemStation is also extremely environmentally conscious. They use state of the art techniques to formulate water based, biodegradable and safe detergents. All its products comply with EPA regulations. It also assists in waste-stream management. Its rigorous analytical processes allow them to exceed virtually all environmental standards.

Franchisee Network

ChemStation has used its franchisee network very effectively to get tremendous reach within the U.S. market. The first franchise was given in 1985 and since then 48 franchises have been awarded. Today there are 50 units operating in the US of which only two are company owned.

Areas of Application

Some of the major users of The ChemStation Solution are:

- Poultry Processing
- Meat Processing
- Seafood Processing
- Vehicle Care
- Parts Cleaning
- Metal Phosphatizing
- Odor Control
- Degassing
- Forest Products Industry
- Food Sanitation
- Bakery Solutions

Associations

ChemStation has strategically chosen to be a member of some associations so that it can take better care of its customers' needs. ChemStation is a member of the following associations:

- International Sanitary Supply Association
- US Poultry and Egg Association
- National Tank Truck Carriers
- International Association for Food Protection
- The Dairy Practices Council
- Portable Sanitation Association
- Solid Waste Association of North America

Source: www.chemstation.com

Interview

The interview was conducted with George Homan, owner and founder, on March 23, 2004.

Q. How do you keep up with technological change that relates to developing, producing or delivering your products and services?

A. Water based solutions is the current trend. However, there is constant industry gossip of enzymes being the latest and newest cleaning technology and the future of cleaning. ChemStation just simply tries to put 2 and 2 together and see if something can come out of it. The labs and the tech force at the labs are aware of these developments. ChemStation has its own sources too to keep it up-to-date with the latest developments. However, talking with customers and knowing their problems and their difficulties is the main manner in which they come up with innovative cleaning solutions.

Q. Do you conduct any of your own research?

A. ChemStation has a tech service lab. And the tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers.

All the development currently takes place internally. However, lately they have hired a chemical consultant from the Department of Energy who has quite a lot of experience in dealing with Universities and tapping the huge intellectual property that lies in them. So ChemStation is looking to tap into the immense wealth of knowledge at the Universities.

They hold 2 patents. The machine and the process, both are patented. However, the patents, though they hold well in Canada, do not protect them overseas. They have not filed for international patents.

Q. How do you learn about outside technology developments?

A. ChemStation has its own sources also to keep it up-to-date with the latest developments. However, talking with customers and knowing their problems and their difficulties is the main manner in which they come up with innovative cleaning solutions.

Q. Where and how do you capture and store technology knowledge until you need it?

A. ChemStation has devised its own software package. The franchisees are also provided with the same. Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into this package and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein.

Q. How do you learn about your customers' needs and priorities?

A. ChemStation has a tech service lab. And the tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers.

Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into the software package which has been devised at ChemStation and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein.

Q. Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire?

A. Whatever problems are solved at the franchisee's outlet and the manner of the same is fed into the software package that has been devised at ChemStation and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein.

Q. How do you keep in-touch and up-to-date with any changes in your customers' needs or priorities?

A. ChemStation has a tech service lab. And the tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers.

Q. Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?

A. ChemStation has devised its own software package. The franchisees are also provided with the same. Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into this package and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein.

Q. What have you done recently (within last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?

A. They are growing at a fast clip. In fact, George Homan likes recessions (don't take him to news over that). This is so because it as at the time of recessions that his company grows fastest as at such a time of crisis, people / companies are constantly looking at ways of cutting costs and they even start looking at waste and try to find out ways to save money. Otherwise, even those people who do the day-to-day cleaning are not aware of what they use to clean the objects / floor and they don't even care.

Q. Do you take any special measures or precautions to assure that competitors can't use any of the knowledge that you acquire about your technologies or customers and

imitate your products or services? These measures or precautions may include patents or informal policies and practices, or they could arise naturally because of the way you make products or conduct business with customers.

A. Different clients face different cleaning problems. And as ChemStation solves these diverse cleaning problems, they become owners of this intellectual property. And this knowledge – no competitor has it, no one else in the market has it. Once they had a problem in Harley Davidson with their shock absorbers manufacturing division and they had to use one solution for one line and another solution for the sister line which was adjacent to it. Such know-how then becomes a part of their data bank. Due to this, the customers also tend to get locked in. Customers essentially pay for materials that they use, however mentally they think that they are paying for the services that the get from ChemStation.

They hold two patents. The machine and the process, both are patented. However, the patents, though they hold well in Canada, do not protect them overseas. They have not filed for international patents.

Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into the software package which has been devised at ChemStation and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein.

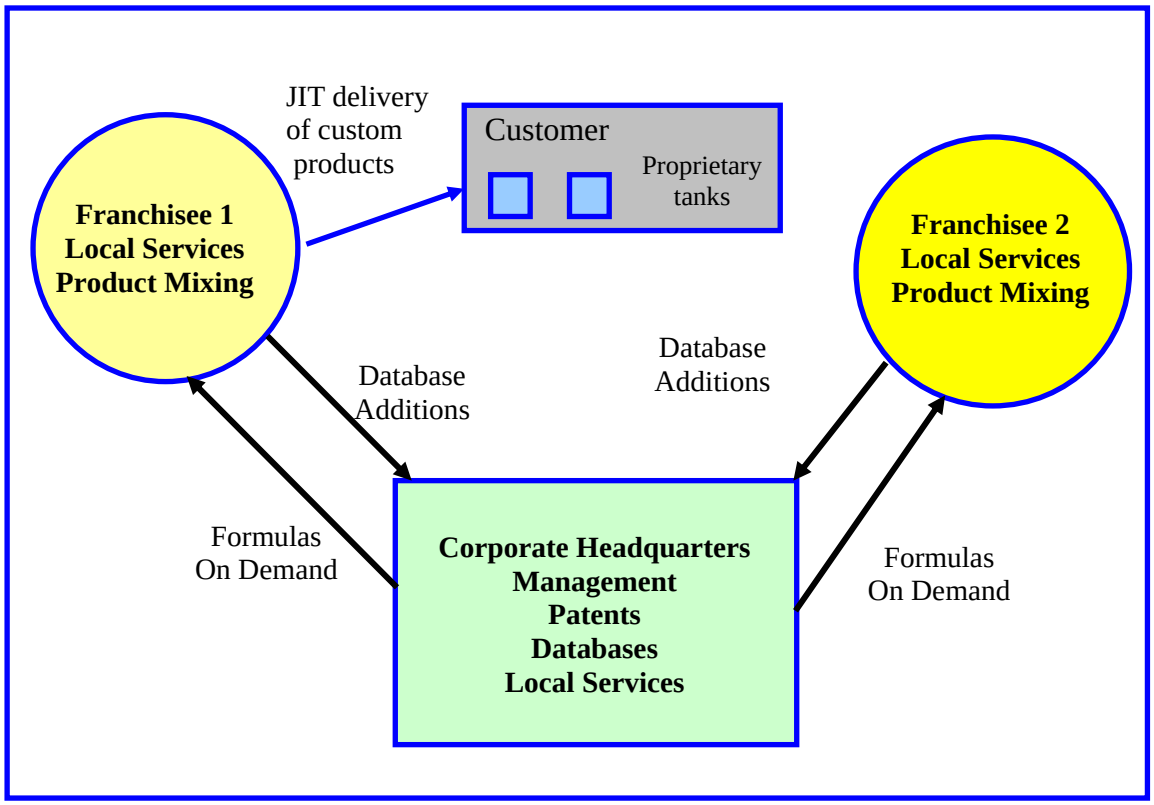
Q. Do any of your answers to the previous question apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these policies and practices? Have they had their intended consequences?

A. The incentive provided to employees is that if they stick along with ChemStation long enough, they will be rewarded well. They are sold out on the fact that this is a winning business formula.

Q. How do you stay current with developments that relate to your innovations? Who gathers such information?

A. Water based solutions is the current trend. However, there is constant industry gossip of enzymes being the latest and newest cleaning technology and the future of cleaning. ChemStation just simply tries to put two and two together and see if something can come out of it. The labs and the tech force at the labs are aware of these developments. ChemStation has its own sources too to keep it up-to-date with the latest developments. However, talking with customers and knowing their problems and their difficulties is the main manner in which they come up with innovative cleaning solutions.

ChemStation's Unique Business Model



Key Points:

- Central database retains all accumulated knowledge of formulas and applications. This is NOT available except on a case by case basis to franchisee, and, even then, in a coded format.
- Corporation holds rights to patent on unique dispensing equipment.
- Growth is funded by franchise fees – upfront is $1M.
- Franchisees can be bought back as cash flow grows.
- Franchisees are contractually bound to contribute new cleaning solutions from their region into central database for use by all franchisees and the parent.
- Company guarantees consistency and quality everywhere through common database and systems.
- Customers get local customized service quickly through access to corporate knowledge base.
- U.S. market size is $300M, company has grown from zero to 20% market share in less than ten years.
- Power of database prevents "mom and pop" business competing for high added value complex cleaning problems.
- Consolidation of local cleaning creates economic power in purchasing materials.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	High	**Medium**	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-sharing programs	Yes	N.A.	**No**
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	International	Regional	**Domestic**
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	High	**Medium**	Low
13	Service / Manufacturing Mix	**Service / Manufacturing**	Service	Manufacturing
14	Competitive Advantage	Technology / Innovation	Service	**Product Quality**
15	Partner Relationships	**High**	Medium	Low
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale:

1) Intellectual Property: **High**

Different clients face different cleaning problems. And as ChemStation solves these diverse cleaning problems, they become owners of this intellectual property. And this knowledge – no competitor has it, no one else in the market has it. Such know-how then becomes a part of their data bank. Due to this, the customers also tend to get locked in. They hold 2 patents. The machine and the process, both are patented. However, the patents, though they hold well in Canada, do not protect them overseas. They have not filed for international patents.

2) Innovative IT Applications: **Medium**

ChemStation has devised its own software package. The franchisees are also provided with the same. Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into this package and the same now becomes an integral part of the ChemStation database. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein. In some cases, there are remote sensors that are placed inside of the drums and via the internet or the telephone, ChemStation can decipher what is the level of the detergent in the liquid and can do the re-filling jig. It should however be noted that though the remote sensor technology is sexy, it is at the same time costly as well and it may cost anywhere between $500 and $1000 per drum. And so the remote sensor technology is used only on a need to use basis.

3) Ownership: **Private (Family Owned)**
George Homan, the owner of ChemStation owns 100% of the company (there are no other shareholders).

4) Age Structure (in years): **Younger than 25**
ChemStation was founded in the year 1985 at the peak of the recession of the 80's.

5) Employee Turnover: **Low**
In the case of the sales force, the employee turnover is high. However, in all other areas the turnover is low.

6) Profit-sharing programs: **No**
The incentive provided to employees is that if they stick along with ChemStation long enough, they will be rewarded well. They are sold on the fact that this is a winning business formula. It is a commissioned based incentive (commissions form about 15 – 20% of revenues).

7) Closeness to Customer: **High**
The tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers.

8) Market Focus: **High**
ChemStation is a service offering custom formulated, environmentally friendly industrial cleaning and process chemicals, delivered to refillable containers placed free of charge at customer facilities. In short, it focuses on providing cleaning detergents, chemicals to a variety of customers ranging from Universities to coal mines.

9) Geographical Focus: **Domestic**
ChemStation has $50-60M in revenues, all from domestic operations – currently it has 50 locations in the US. However, they are looking to expand in Germany and France as that market is more sensitive to disposing of things. The society is more aware and conscious to such things. And ChemStation holds the key here as in its case no disposing (drums) is required. (It should be noted that ChemStation is not into managing waste streams yet). ChemStation is looking for a JV partner in Europe rather than franchising as a European company having a vested interest in the business would help them grow faster and better.

10) Market Entry Risk: **Medium**
As long as people adhere to the principle of cleanliness, ChemStation is going to be in business. Though ChemStation is the only one offering the kind of service that it does in the world, it does have competition from the mom and pop businesses that would be willing to offer similar service at a cheaper price (however, the disadvantage is that they cannot offer the service on a country-wide basis and can operate only locally).

11) Marketing Aggressiveness: **Medium**

The marketing aggressiveness and its success are directly tied to and dependent on the ability of entrepreneurs who are willing to be a franchisee of ChemStation and increase its outreach.

12) Technological Integration: **Medium**
Whatever problems are solved at the franchisee's outlet and the manner of the same are fed into ChemStation's software package and the same now becomes an integral part of the ChemStation database. The sharing of such information by the franchisees with the HQ is mandated by a written agreement between ChemStation and its franchisees. The database is the key asset for ChemStation and they have the necessary software and framework in place to interpret the results therein. ChemStation has a tech service lab. And the tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers. However, this tech lab does not need huge investments in terms of R&D and they do not *seem* to be working on chemicals or detergents which would be revolutionary in nature.

13) Service / Manufacturing Mix: **Service / Manufacturing**
ChemStation are involved in custom manufactured and rotationally molded of linear, low density polyethylene plastic. At the same time, however, their system is the solution. ChemStation's refillable delivery system and patented manufacturing allows them to custom blend products for your specific needs. You will never have another drum disposal and handling problem. ChemStation is committed to keeping drums out of landfills. Customers essentially pay for materials that they use, however mentally they think that they are paying for the services that the get from ChemStation. They hold 2 patents. The machine and the process, both are patented.

14) Competitive Advantage: **Product Quality**
The main hassle for the customer is the handling of drums. Once ChemStation takes care of that, the customer wants to make sure that the detergent also does the cleaning well. And so service initially lures the customer, but it is backed up by product quality, i.e., the quality of the detergent / chemical and its ability to cleaning the object well.

15) Partner Relationships: **High**

Innovation Type: **Incremental**
ChemStation has a tech service lab. And the tech folks at the lab are constantly talking to the customers, to the franchisees, and hence leading to continuous improvements to the solutions and also coming up with new solutions to cater to the different cleaning requirements of different customers. All the development currently takes place internally. However, lately they have hired a chemical consultant from the Department of Energy who has quite a lot of experience in dealing with Universities and tapping the huge intellectual property that lies in them. So ChemStation is looking to tap into the immense wealth of knowledge at the universities.

Firm Type: **Incumbent**

Appendix 12

DeAngelo Brothers,Inc./DBI Enterprises

Company D

In 1978, brothers Neal and Paul DeAngelo founded a company on the basic principal of making sure the customer's expectation of service and results were not only met but also exceeded. Today, DBI Services Corporation has been built on that original belief, making sure it never puts itself in a position where this commitment to customer service is compromised, and never forgetting the basic principal of its foundation.

Vision Statement:
To build a global, diversified commercial and industrial service company

Core Values:

- Customer service
- Employee development
- Growth
- Flexibility
- Pride
- Profit

Products and Services

DBI provides a diversity of industrial/commercial service solutions including vegetation, road and cleaning management. Company provides these services to federal, state and local governments, departments of transportation, railroads, utilities and large industries throughout the United States and Canada.

Top 6 U.S.customers: Union Pacific Railroad, CSX Railroad, Wal-Mart, Norfolk Southern Railroad, Virginia DOT, PennDOT

Top 5 Canadian customers: Canadian Pacific Railway, Canadian Forces Base – Petawawa, Ministry of Transportation - London area, Cape Breton Central Nova Scotia Railway, Embridge pipelines

Competitive strategy:

- Diversity of services
- Regional office locations
- Company dynamics
- Quality work force
- Advanced technology

Growth strategy:

- Expand current contracts with existing customers
- Offer other service lines to existing customers
- Diversify by adding additional business units
- Serve additional customers out of existing locations
- Strategic partnerships, alliances, joint ventures
- Geographic expansion
- Strategic acquisitions

Top 10 growth opportunities

- Complete asset management contracts
- Road management business unit
- Acquisitions
- Canadian expansion
- Railroad crossing programs
- Cleaning management business unit
- Invasive species
- Aquatics nationally
- IVM nationally
- Chemical sales

In addition to the Asset Management division, DBI is broken into the following seven divisions--

- Railroad (RR)
- Industrial Vegetation Management (IVM)
- Departments of Transportation (DOT)
- Utility Right-of-Way (ROW)
- Aquatic (AQ)
- Chemical Sales (CS)
- Cleaning Management (CM)

Railroad (RR):
Serving all Class 1, Regional, Shortline and Commuter Railroads

In this segment, DBI is the industry leader in providing railroads with vegetation management solutions throughout North America. It has over 30 years of experience working with class 1, short line and commuter railroads developing Integrated Vegetation Management (IVM)

programs. The company offers various services such as crossing clearing and maintenance programs, branch line, main line and yard track programs, brush control programs, noxious or invasive weed species programs, mechanical weed and brush programs.

Related factors:

- The weather is the main reason for volatility in this line of business.
- Union Pacific and CSX Railroad are two of the biggest customers of DBI in this line of business.
- The contract generally runs for up to 5 years.
- This is a $60M market and DBI has about 40% of the market at $25M.
- Union Pacific alone has 26,000 railroad crossings in over 30 states.
- The privatization of the Mexican railroads also offers opportunity for international expansion.
- The switching cost for the customer is high. So this in turn is an advantage for the service providers such as DBI.
- Safety is of paramount importance and consequently is a major issue too.
- Railroad crossing programs falls in the list of top 5 growth opportunities.

Industrial Vegetation Management (IVM):
Serving large industries, including oil terminals, manufacturing facilities and other industrial sites

DBI has provided heavy industry with vegetation management solutions throughout North America for over twenty-five years. Whether working on electric, petroleum, natural gas or small industrial sites, DBI's Integrated Vegetation Management Services have met the needs of their clients by helping eliminate undesirable vegetation and reducing their overall cost for site maintenance. Ultimately, DBI strives to provide the customer with the most cost effective and environmentally sound program for customer's specific site situations. Within this segment DBI provides services in bareground vegetation management, and plant growth management.

Related factors:

- There are many small players in the market.
- The profit margin is low.
- The cost of entry is very low, however like in the Railroad Division, safety is an issue here.
- IVM also figures in the list of top 10 growth opportunities for DBI (Exhibit 4), primarily with being able to sell national accounts.

Departments of Transportation (DOT):
Serving state, county, city and other local municipal departments of transportation

DBI is the top service provider of Integrated Vegetation Management programs to State Departments of Transportation as well as county, city, and local departments of public works. As the largest provider in North America, DBI is able to provide the specialized equipment and licensed personnel to meet customers' budgeted needs.

Related factors:

- GIS / GPS gives DBI competitive advantage as there are only one or two companies offering such service.
- Virginia DOT and Penn DOT are two of DBI's biggest customers in the US.

Utility Right of Way (ROW):
Serving all types of utility company's right-of-ways.

Utility Rights-of-Way (ROW) usually involve the clearing of corridors of vegetation because tall trees or shrubs growing under or too close to utility lines often create problems. Branches, which break during wind or ice storms can knock down lines, create dangerous situations, and disrupt service. DBI customers are not only the electric power utility companies but also petroleum and natural gas companies.

Related factors:

- This is the biggest market, however no supplier is able to be profitable because of the bidding practices of the utility companies.
- There are a number of competitors in the market.
- The barriers to entry are very low so local suppliers enter very easily.

Aquatic (AQ):
Serving water management districts, golf courses and homeowner associations

In year 1999, DBI acquired Aquagenix, Inc., which provides aquatic and industrial vegetation management services to governmental and commercial customers. Aquagenix's services include control of aquatic weeds, algae and exotic plants, brush and noxious tree control, wetland planting and restoration, installation of fountains and aeration systems and the stocking of fish for game and plant and insect control. The company's services helps to control floods, maintain health, beauty, quality and natural balance of life in aquatic and terrestrial environments. The customers of the company are golf courses, country clubs, real estate owners and developers, homeowners and condominium associations, apartment complexes and various governments, municipalities and state authorities.

Related factors:

- DBI's national presence is the biggest competitive advantage. Post acquisition, Aquagenix has increased its national presence. Recently the company has started working with big store chains such as Wal*Mart with maintaining their retention and detention ponds.

Chemical Sales (CS): Distributors of chemicals and supplies to the vegetation management industry

DBI purchases chemicals from big chemical companies such as DuPont, Dow and BASF. It also supplies the same chemicals to smaller companies. In addition it also supplies equipment and small tools to local companies active in the vegetation management business.

Cleaning Management (CM):Providing low and high pressure industrial cleaning services

The Cleaning Management Division provides services in roadway and parking lot sweeping, graffiti removal, bridge cleaning, tunnel washing, and low and high pressure cleaning. It's high margin, new area of business. DBI leverages its existing customer relationship to get new contracts. Company has developed new techniques and methods with the graffiti removal process.

Asset Management

DBI provides highway asset management solutions to government transportation agencies and authorities. Asset Management is one of the key strengths of DBI, which pulls together and includes all the services offered by the company. In last 25 years, the company has invented many innovative processes, technologies and equipment. Every year DBI conducts many research and development projects in both laboratory and in-field testing. The company also has research partnerships with some universities, which keeps its services at the forefront of emerging technologies.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	**High**	Medium	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-sharing programs	**Yes**	-	No
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Focus	**Service / Manufacturing**	Service	Manufacturing
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	Medium	**Low**
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale

1) Intellectual Property: **High**
They have almost all their intellectual property in the form of trade secrets. DBI is one of only two companies in the industry with GIS / GPS capability. Asset management is one of the key strengths of DBI. In last 25 years, the company has invented many innovative processes, technologies and equipments. Every year DBI conducts many research and development projects in both laboratory and in-field testing. The company also has research partnership with some universities like Purdue, which keeps its services at the forefront of emerging technologies.

2) Innovative IT Applications: **High**
As afore-mentioned, they have the technology and the software to pinpoint the exact location of the weed on and under the railway tracks and to destroy the same with the right quantity and mixture of pesticide.

3) Ownership: **Private (Family Owned)**
The DeAngelo brothers, Neal and Paul are joint and equal owners of the business.

4) Age Structure (in years): **25-50**
DBI was founded in 1978.

5) Employee Turnover: **Low**
DBI has a very low employee turnover as they adequately compensate their staff.

6) Profit-sharing programs: **Yes**

7) Closeness to Customer: **High**
Brothers Neal and Paul DeAngelo founded their company on the basic principal of making sure the customer's expectation of service and results were not only met but also exceeded. And so they have maintained proximity to customers and their needs ever since and consequently today, DBI Services Corporation is making sure it never puts itself in a position where this commitment to customer service is compromised, and never forgetting the basic principal of its foundation. Customer Service I one of the core values of DBI.

8) Market Focus: **High**
They are in the business of providing vegetation management to railroads, industrial areas, State Departments of Transportation, county, city, and local departments of public works, electric power utility companies, petroleum, natural gas companies, and also aquatic vegetation management services to governmental and commercial customers. In short, they are in the business of providing vegetation management.

9) Geographical Focus: **International**
They do business in Canada and Mexico and are looking for a JV partner in Europe.

10) Market Entry Risk: **Medium**
There are a number of competitors in a couple of their businesses like Industrial Vegetation Management and Utility Right of Way and here the cost of entry is also low. On the other hand, Railroad Management, which constitutes 42% of their turnover, the switching cost for the customer is very high and there are fewer competitors. Furthermore, in businesses like Aquatic Management, their national presence is the biggest competitive advantage and recently the company has started working with big store chains such as Wal-Mart in retention and detention of their water system. Also, in businesses like DoT, they are one of only two companies with GIS / GPS capabilities. In short, overall their competitive risk is low to medium.

11) Marketing Aggressiveness: **Medium**

12) Technology Integration: **High**
They use sensors to detect the weeds on railway tracks and have the technology that can pinpoint the precise location of the weed and destroy it. Furthermore, they are one of only two companies with GIS / GPS capabilities. They have trucks that can run on roads as well as the railway tracks which they have manufactured in-house, they have injectors on these trucks which while running on the railway tracks can pinpoint the exact location of the weed and destroy it. These and other property, which are firmly guarded and kept as trade secrets, clearly suggest that DBI is a company with a high technical intensity.

13) Service / Manufacturing Mix: **Service**
They do manufacture the most essential equipments that they need in their railroad vegetation management themselves. However, what they provide is their service whereby they use the equipment manufactured in-house to manage the vegetation on the railroads, industrial areas, etc.

14) Competitive Advantage: **Technology / Innovation, Service**
Their technology gives them a competitive edge and they enhance it even further by offering their clientele a great service and value with the help of their technology. DBI is one of only two companies in the industry offering GIS / GPS services and the same once again gives them competitive advantage due to their technological prowess.

15) Partnership Relationships: **Low**

Innovation Type: **Incremental**
Firm Type: **Incumbent**

Sources
Interview with Neal DeAngelo
www.dbiservices.com

Appendix 13

Lutron Electronics Company, Inc.

Company E

Company Background

Lutron Electronics Company, Inc. was founded by Joel and Ruth Spira in 1961. Lutron's first product was called a "dimmer switch" and represented the world's first solid-state electronic device used to dim lights in a home, replacing bulky rheostats and autotransformers that were inefficient and unattractive. Although Lutron has grown substantially over the past several decades, the company still maintains the feel and personal closeness of a smaller firm, and to this day still operates under the guidance of the company's 5 Principles.

Today, over 40 years later, Lutron is still devoted to controlling lighting. Its focus on product innovations, technology, quality, and customer service has made Lutron the undisputed leader worldwide in the area of lighting controls. IT offers more than 10,000 products to satisfy virtually any residential or commercial project. Lutron products adjust the intensity of virtually every kind of light, and they remain to this day the only company that provides an integrated solution for controlling both natural daylight as well as electrical lighting.

Lutron has a global sales and service network. Its European headquarters is in London and its Asian headquarters in Tokyo. Lutron has sales and service offices located throughout Europe, the Middle east and Asia.

Lutron's position as the leading manufacturer of lighting controls worldwide, the breadth and depth of its product offerings, and commitment to servicing customers worldwide has resulted in an average growth of approximately 20% annually. This growth has in turn allowed the company to continue to invest in recruiting and retaining the best people who can help Lutron service their customers. Continuous growth has also fueled Lutron’s ability to constantly develop new technologies and new manufacturing processes that in turn drive the creation of new or better products and services.

Products

Lutron has developed a range of products for all types of lighting controls. Its product offerings consist of four main categories that are residential products, commercial products, shading solutions and mixed use. Below are the details of the products under each of the categories.

Residential Products

- Light dimmers

- Fan speed controls
- Switches
- Wall plates and accessories
- Spacer systems which allows the user to create and recall lighting scenes
- Grafik Eye Systems, which allows the user to switch from one lighting combination to another by just one press of a button. It allows the customer to create different lighting scenes within any space by controlling lighting zones
- Radio RA Home Dimming System, which allows the customer to control both the interior and exterior lighting of the house from anywhere including the car. This allows the customer to switch on the lights of the house from their car as they approach it
- HomeWorks® is a complete lighting solution for a house

Commercial Products

- Light dimmers
- Fan speed controls
- Switches
- Wall plates and accessories
- Spacer System
- Radio Touch which is wireless remote lighting control ideal for conference halls, lecture rooms and training rooms
- Grafik Eye Systems
- Digital microWATT which is a solution that integrates with building management systems. These systems are used to improve employee comfort, reduce energy costs and improve safety within an organization.
- Ballast which are the fluorescent dimming systems offered by Lutron
- perSONNA which is Lutrons wireless control for fluorescent lighting

Shading Solutions

- Sivoia QED® (Quiet Electronic Drive) which are remote controlled roller shades, roman shades and drapery systems. The Sivoia QED® is suitable for shades up to 225 sq. ft.
- AC Systems which are remote controlled shades for larger applications such as window walls and atriums
- Fabrics – Lutron offers fabrics for the shades that it produces. They offer several colors and printed designs. Lutron offers a range of “green” fabrics which are free of PVC

Mixed Use

- The mixed use solution offers two or more of the above mentioned products or solution together

Interview with Joel Spira, Chairman and Founder of Lutron, April 14, 2004

Q. How do you keep up with technological change that relates to developing, producing or delivering your products and services?

A. Attending technical conferences; reading publications; hiring people with technical, scientific

background; hiring full-time employees who are PhD's etc.

Q. Do you conduct any of your own research?
A. It's all internal – all product development work, all product research work is internal.

Q. How do you learn about outside technology developments?
A. It is a cultural thing. The company's tech-gatekeeper passed away – the same was a setback. But dependence cannot be placed on any one person, there are others too.

Q. Where and how do you capture and store technology knowledge until you need it?
A. Have an instrument for doing it called "the human brain".

Q. How do you learn about your customers' needs and priorities?
A. Everybody in the company is a marketer. However, in case of problems especially in case of new products, the R&D people take center-stage.

Q. Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?
A. Lutron has a shadow company that has been set-up to look at new products and major projects outside of day-to-day operations. Every project involves personnel from manufacturing, marketing, engineering etc.

Q. Do you take any special measures or precautions to assure that competitors can't use any of the knowledge that you acquire about your technologies or customers and imitate your products or services? These measures or precautions may include patents or informal policies and practices, or they could arise naturally because of the way you make products or conduct business with customers.
A. Lutron has 220 United States patents to its name. Furthermore, Lutron also uses trade secrets at times as and when required. The sales people do not have in-depth information about the mechanism of the products they sell for various reasons and Mr. Spira states that the sales people do understand and respect the same. Also, there have been no lay-offs in Lutron since it was founded more than 40 years back.
As far as competitors are concerned, everybody in the company keeps a close watch on them. Though Lutron doesn't look at every new patent that is filed in the lighting sector, it does perform a complete patent-database search before it files for a patent to look for similarities between its *prospective* patent and the related patents already filed.

Q. Is there a traceable pattern among your innovations in the last five years? That is, how do you proceed from one major product innovation to the next? For example, your product innovations could be based on common technology or combinations of technologies, related product offerings, or similar types of customers served. Is any basis more prevalent than another?
A. When it comes to new technology, it is either possible that Lutron may have the capability in-house to be able to capitalize on the new technology. However, if it does not have in-house capabilities, it goes outside to find out them in the form of individual experts in the

respective category. Mechanical, electronic and software are the company's core competencies. In short, Lutron has technical core-competencies. Also, development is driven essentially by commercial need. It has one or more consultants in every field – marketing, software, general business, mechanical engineering, electronics (digital, sensors, power electronics, etc.) – as any one consultant does not have the whole story. Lutron continually uses consultants – in fact every day consultants are utilized by some or the other unit of the company.

Q. Exports:

A. About 10-30% of Lutron's revenues come from exports. Though it had a notion that about 50% of its revenues would come from exports, this did not happen as its domestic sales grew at a much faster pace than its exports.

Q. Motivation:

A. Mr. Joel Spira is from the school of thought that a good individual basically is driven by the enjoyment and the challenge that his job offers him. And then he needs to be adequately financially compensated for his work because in the event of that not happening, he will take that same enthusiasm and abilities to some other place where he is properly compensated. All the promotions to higher positions happen from within. Employees are developed and trained and they know that the company is investing time and money on them to prepare them for higher responsibilities in the future.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	**High**	Medium	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	**Public**
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-sharing programs	Yes	**N.A.**	No
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Mix	Service / Manufacturing	Service	**Manufacturing**
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	Medium	**Low**
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale:

1) Intellectual Property: **High**
Lutron has 220 United States patents to its name. In fact, the founder / chairman Mr. Joel Spira himself holds 89 U.S. patents, with innovations based on a variety of technologies, including: physics of gas discharge lamps, fluorescent and incandescent lighting, linear-slide dimming and – most recently – a microprocessor-controlled window shading system.

2) Innovative IT Applications: **High**
Mechanical, electronic and **software** are their core competencies. They have one or more consultants in every field – marketing, **software**, general business, mechanical engineering, electronics (digital, sensors, power electronics, etc.) – as any 1 consultant does not have the whole story. Lutron continually uses consultants – in fact every day consultants are utilized y some or the other unit of the company.

3) Ownership: **Private (Family Owned)**

4) Age Structure (in years): **25 – 50**
It was founded in 1961.

5) Employee Turnover: **Low**
There have been NO LAYOFFS since the company was found in 1961.

6) Profit-sharing Programs: **N.A.**
The employees are adequately financially compensated (clearly suggested by the fact that there have been no layoffs in the history of Lutron). But the company did not provide any information pertaining to profit-sharing programs.

7) Closeness to Customer: **High**
Everybody in the company is a marketer. In fact, development too is driven essentially by commercial need.

8) Market Focus: **High**
The company is highly focused and is in the market of providing control for visual environment. In fact they have always grown via R&D and the only company they have ever acquired is a company involved with window shades and they did the same as their newest product is window shades controlled electronically. Here lights, bulbs and window shades are jointly controlled electronically and one of their first few customers is the Carnegie Mellon University.

9) Geographical Focus: **International**
About 10-30% of their revenues come from exports. Numerous sales and service offices are located throughout the US, Canada, and Mexico. Other sales and service offices located throughout Europe (Berlin, Madrid, Paris), the Middle East, and Asia (Hong Kong, Singapore, Tokyo).

10) Market Entry Risk: **Medium**
With rising consumer expectations from lighting products, visual environment has become indispensable. Though they are not the biggest in the industry, they are the leaders in their respective field and in what they do.

11) Marketing Aggressiveness: **Medium**
Everybody in the company is a marketer

12) Technological Integration: **High**
Lutron's entire R&D is focused towards enhancing visual environment. Their huge patent holding, extensive use of consultants in various business units, R&D focus on visual environment, clearly suggest their high technical intensity.

13) Service / Manufacturing Mix: **Manufacturing**
Lutron Electronics Co., Inc. is the world's leading designer and manufacturer of lighting controls and architectural lighting control systems for residential, commercial, industrial and institutional applications. Manufacturing facilities are located in the Lehigh Valley, Puerto Rico and St. Kitts in the Caribbean.

14) Competitive Advantage: **Technology / Innovation**
Lutron has 220 United States patents to its name. In fact, the founder / chairman Mr. Joel Spira himself holds 89 U.S. patents. Lutron's entire R&D is focused towards enhancing visual environment. All the above clearly suggest a technological / innovative advantage for the company.

15) Partner Relationships: **Low**

Innovation Type: **Incremental**
Significant earnings are poured every year into R&D to continually improve products (and also launch new ones) so as to enable Lutron to maintain its leadership position in its field.

Firm Type: **Incumbent**

Sources
Interview with Joel Spira, Chairman/Founder, April 14, 2004
http://lutron.com/lutron/

Appendix 14

Summit Industries, Inc.

Company F

Summit produces equipment for three major businesses; chiropractor, veterinarian, and clinical/medical (under name of Amrad). Veterinarian market represents one-third of sales, chiropractic is one-fourth, clinical medical is one-third (non-hospital), and 10% is parts and replacements that are equally distributed among the three main businesses. All equipment is film-based radiographic technology, which is gradually being replaced by MRI and CAT. Sales are $20 million annually, but only $650,000 is foreign (half in Europe, half the rest of the world). Summit started in 1984 with the vet market. Until then, vets and chiropractors used second-hand hospital equipment. That's all that was available. The idea was to develop a machine especially designed for vets, e.g., animals need to be held on a table. Features and machine design evolved to meet the needs of vets. The founder, Jim Walsh, came from a competing radiographic company.

The interview was conducted with Ken Petrella, COO and Joe Flies, VP of Manufacturing, December 18, 2003.

Q. How do you keep up with technological change that relates to developing, producing or delivering your products and services?

A. This business is considered low tech. X-ray technology is 100 years old. The only recent technology shift has been to digital receptors, which is a substitute for film and converts analog images to digital signals. Summit's machines cost from $20,000 to 70,000. The addition of the simplest digital receptor would add 50% to 250% to the cost. Summit's machines remain at the low end. Most human applications are now mainly digital, but vet machines are low volume. Vet machines take 50-60 pictures per week, human machines take 50-60 per hour. Film-based X-ray equipment is for lower volume applications. The market for such machines is $100-120 million worldwide. Summit's equipment is compatible with digital receptors. They can be added via standard interface. They don't provide it, but customers could add it. The film chamber is designed to fit digital receptors within old film receptors cavity. Third parties sell such receptors.

Summit has a different strategy for each market. The strategy for vet X-Ray market is differentiation. Summit leads in feature introduction and has 60% market share. In chiropractor market, the strategy is "me-too", with some differentiation. Summit is a latecomer to this segment, and the differentiation strategy is not as well developed. In the clinical and medical market, it's a price strategy. Summit uses the same channels as others do but at 5-10% lower price. It differentiates the vet market by designing machines specifically for vets. Competitors have copied some of its machine's features, e.g. space

(close to wall), vet can stand at the machine, able to operate machine if both hands are busy or encumbered by lead apron (e.g., slides and hip switches, not buttons to push). Competitors in the U.S. are American, but in Europe one competitor is Spanish, which has a modest presence ($2 million) in sales in the vet, chiropractic, and clinical- medical markets. They make low end equipment in Europe. Summit has an American competitor that is 50% larger and located in Chicago. They serve the same markets. The difference is that the competitor has a larger clinical medical market, but is the same size in vet and chiropractic markets. Summit's presence in clinical-medical market is new in the last 5-6 years.

Subassembly and components are outsourced to local Chicago firms, with the exception of film processors (Germany). Beginning in the first quarter of 2004, they will assemble the entire product in the Chicago facility. Now they are assembling only film processors.

Competitors are in the same three markets because of similarity of dealer channels. Dealers may be different, but they function similarly. They tend to be small, specialized installation contractors that provide monthly services to customers. Film processors need to be serviced every month. Equipment requires constant cleaning (e.g., toxic chemicals). Every month a service person arrives with fresh chemistry and film, cleans the processors. Summit doesn't sell anything directly to end-users (vets, chiropractors). Vet and chiropractor markets are more similar to each other than to the clinical medical market. Digital is a long-term threat to the dealers. They might become competent on the digital side, but maybe 10% can manage the training.

There will always be a place for film-based machines. Summit focuses on enhanced features such as automatic picture taking, shorter exposure time, and intensity. It is a leader in this area. Personnel with the lowest pay grades often take the pictures. Thus, the more automatic the picture taking, the higher the success with a quality image.

Q. Do you conduct any of your own research?

A. Summit designs the machines, adds features. It doesn't do its own R&D. It's basic physics. It doesn't rely on patents. The technology is the same for all competitors. Its competitive advantage is in productivity. The CEO is interested in adequate but not maximum profits. The CEO sees a major role for Summit as improving the social fabric of the community (city). He'll never go to the suburbs. He prefers to hire inner city low-income people. Twenty different countries are represented in the work force.

Q. How do you learn about outside technology developments?

A. Summit participates in many trade conferences. They watch for technology changes. On the manufacturing side, Joe Flies and his people watch for new technology, processes, assembly techniques, materials, etc.

Q. Where and how do you capture and store technology knowledge until you need it?

A. Knowledge management is not very sophisticated, basically pen and paper and file folders. Management teams meet periodically to discuss markets and competition. They also conduct meetings to which dealers are invited. Sometimes meetings are conducted by telephone.

Q. How do you learn about your customers' needs and priorities?

A. Learn about the end-customer via trade shows. Attend 10-12 trade conferences a year. Some are national, others are regional. Vets attend trade shows. Sales and marketing people attend these and bring back ideas.

Q. Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire? How do you keep in-touch and up-to-date with any changes in your customers' needs or priorities? Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?

A. Trade shows are informal. Visit booths of equipment manufacturers, and chat about interest in equipment. Also they appraise themselves and dealers in each market segment. Try to stay in close touch with dealers. In the vet market, there are 300-400 vets who specialize in radiology. Summit has a close relationship with about 24 of them. They ask them to visit, participate in forums. They also learn about their needs from key dealers and users. Differentiation is based on spending a lot of time and energy with customers, and making it easy for dealers to do business with Summit.

Q. What have you done recently (within last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?

A. The focus recently has been on manufacturing productivity and quality. Customers had once questioned whether their practices were up-to-date. They responded by developing a quality culture in the last twenty months. They also plan to expand the market with new services and other products to the vet market. They believe that the vet market will grow faster in dollar volume than the other segments in the next 3-5 years. What other products do vets require? Surgical tables are not much different from X-ray tables. There also is a growing market for vet dental X-ray equipment. These new products will go through new channels. Mobile equipment is needed for larger animals, but Summit hasn't chosen to enter this market. It's a different industry. They won't be offering more clinical/medical products, but refining distribution to this market. It's a channel driven market. Clinical-medical segment is new for Summit, so the cadre of dealers here is more modest. Need to strengthen this. The distribution channels for vets/chiropractors are similar, but clinical/medical is somewhat different.

Q. Do you take any special measures or precautions to assure that competitors can't use any of the knowledge that you acquire about your technologies or customers and imitate your products or services? These measures or precautions may include patents or informal policies and practices, or they could arise naturally because of the way you make products or conduct business with customers.

A. See brief comment in question #2.

Q. Did you design and develop your current organization structure, policies and practices with any conscious and consistent values or objectives in mind? If so, what were these values or objectives? Do any of your answers to the previous question apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these policies and practices? Have they had their intended consequences?

A. Summit was once highly vertically integrated. They are now primarily an assembly company. They have reduced in-house fabrication, and now concentrate on core competencies in assembly. They view themselves as "boundary-less" internally. They operate mostly with cross-functional teams. Assembly is done is cells. Last year, they launched training for hourly people on company time in ESL (English as a second language), blueprint reading, and basic math. The training is conducted by nearby Truman College. Employees get a raise when they complete each course. The CEO's vision is for employees to get vocational and life skills. There has been no voluntary turnover in 18 months. All supervisors go through 12 courses of supervisory and management training. Teams include suppliers (supplier partnering program), and the number of suppliers is being reduced. Customer focused/driven. Metrics include on-time delivery, number of units produced, but requirements are primarily based on customer service. Product quality and price is a given in this market. Outstanding service is what makes the difference. There is enough capacity to cover the entire market if everyone else left the market.

The organization is built around developing the core group. There is a career path strategy in the hourly ranks that starts with general laborer, to assembler, certified assembler, master assembler. Pay is based on knowledge, not on seniority. All workers are tested on QA and have to pass tests in order to get pay increases. There currently are two master assemblers and eight or nine certified assemblers. There are potentially more that haven't been certified yet. In three years, most of the work force will be master assemblers. A certified assembler is skilled in one product, a master assembler is skilled in many product lines. Two months ago, approximately 70 people from manufacturing and engineering were broken into nine product improvement teams. They look at individual products and focus on how to improve quality, processes, and the company. They meet every week. They are learning different tools, learning all parts of the business. For example, one team worked with a packaging vendor to reduce packaging from 7-9 cartons down to one. This is a major cost reduction. These are not capital-intensive initiatives. Most involve just re-laying out work-flow. Support from the COO is important to success.

Big companies don't have a clue about the meaning of vendor partnering/involvement. Summit's vendors are included in product design and process improvement. There are formalized engineering change request meetings every week. A recent proposed change involved converting from plate to stainless steel rails. All changes need top-level approval. All product managers are involved in changes. Everyone spends time on the floor, and works closely with manufacturing to problem-solve on time-to-market, cost, and user friendliness.

There is one production manager, and four team leaders (mechanical, electrical, shipping, and warehousing). There is no gain sharing or profit sharing, but they discuss this periodically. There is a holiday bonus. It's a tradition of the founder. There is a fairly structured suggestion program. Get an award for just making a suggestion. If it is accepted, then there is another monetary reward. Have an annual review. Open communication is pushed. Failure stories are encouraged and rewarded. For example, what happened during the week that could have been prevented or quickly fixed.

INNOVATION TAXONOMY

	Category	**Factor(s)**		
1	Intellectual Property	High	Medium	**Low**
2	Innovative IT Applications	High	Medium	**Low**
3	Ownership	Private (Family Owned)	**Private (Non-Family Owned)**	Public
4	Age Structure (in years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-Sharing programs	Yes	**N.A.**	No
7	Closeness to Customer	High	**Medium**	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	International	Regional	**Domestic**
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	High	Medium	**Low**
13	Service / Manufacturing Mix	**Service / Manufacturing**	Service	Manufacturing
14	Competitive Advantage	Technology / Innovation	Service	**Product Quality**
15	Partner Relationships	**High**	Medium	Low
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale:

1) Intellectual Property: **Low**
   During the interview with the COO Ken Petrella and the VP of manufacturing Joe Flies, when asked about technological changes in their products, they say that their industry is considered "low tech" and Summit machines "remain at the low end". They also said they do not rely in patents.

2) Innovative IT Applications: **Low**
   Summit have described that most of their capturing and storing of technological knowledge is using pen and paper and hence their innovative IT applications is low.

3) Ownership: **Private, Non-Family Owned**

4) Age Structure (in years): **Younger than 25**
Summit was founded in the year 1984.

5) Employee Turnover: **Low**
The employee turnover in Summit is low. This is achieved by providing training to the employees. The CEO's vision is for the employees to get vocational and life skills. The employees are provided training so that they can grow within the organization.

Profit-sharing programs: **Not answered.**

6) Closeness to Customer: **Medium**
For understanding its customer needs Summit sales personnel attend 10 – 12 trade shows each year. The sales personnel come back with ideas for the products. They also stay in close touch with dealers to understand customer requirements. For the veterinarian products Summit has a close relationship with 24 vets and use their feedback to develop products.

7) Market Focus: **High**
The market focus has been identified as high. Summit is extremely focused with its product range and manufacture only X-Ray equipment. However these are used for different applications.

8) Geographical Focus: **Domestic**
Though Summit does have an International presence, only about US$ 650,000 in revenue out if US$ 20 MM ie. About 3% come from International sales.

9) Market Entry Risk: **Medium**
The market risk is medium as there will always be a requirement for X-Ray machines, however being such a commoditized industry it may not seem very attractive to a new entrant.

10) Marketing Aggressiveness: **Medium**
Summit does not seem to be marketing its products directly to most of its customers. However, it uses its dealers network to market its product, hence we can classify it marketing aggressiveness as medium.

11) Technology Integration: **Low**
Summit have said that their business is low tech and hence they have very little technological integration in their products. They compete on productivity and price.

12) Service / Manufacturing Mix: **Service / Manufacturing**
Summit manufacture and supply their machines to the customer through their dealers. Though Summit does not do it themselves, there is a service element which is taken care of by their dealers. Summits dealers are responsible for providing its customers seervices like cleaning and servicing of film processors.

13) Competitive Advantage: **Product Quality**
The main reason for Summits success is that they are able to manufacture high quality products at lower prices. They are able to do so by maintaining productivity levels which are higher than that of their competitors.

15) Partner Relationships: **High**
Summit is very reliant on its partners for its success. It does not undertake its own R&D and relies on suppliers for parts. Even on the sales and service front Summit are very heavily reliant on their dealers. Moreover, Summit depends on its dealers to get feedback from their customers and design new products. Hence, Summit is very high on its partner relationship.

Innovation Type: **Incremental**

Firm Type: **Incumbent**

Appendix 15

Company G

Company G requested anonymity. The interview was conducted with its CEO.

Q. **How do you keep up with technological change that relates to developing, producing or delivering your products and services?**

A. We certainly keep up with technical literature relating to the fields we work within. Most of innovation is internally driven—an accumulation of knowledge challenged by thought provoking questioning of why do it that way and why not do differently, then investigation.

Q. Do you conduct any of your own research?

A. We have spent high percentages of our earnings on research and development with up to 15% of our staff fully engaged in the future.

Q. How do you learn about outside technology developments?

A. Much of what we learn is internally and market driven information, we do not have a system or plan in place to comb literature or others innovation. We do depend on vendors to creatively provide solutions to some of our barriers to developments with ready off-the-shelf technologies.

Q. Where and how do you capture and store technology knowledge until you need it?

A. No systematic company storehouse is in use; we handle by internal communications and sharing of information. Departmentally and by executive's information is retained for future exploit or continued development with a strict focus. Some use Outlook, some use Act and some use Adapt to manage contacts.

Q. How do you learn about your customers' needs and priorities?

A. Many times we have taken risks and anticipate their needs before they even realize them. Innovating a solution that seems fine today but will be questioned (even if it is us who initiates the questioning) in the future.

Q. Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire?

A. Generally we will test and retest if appropriate, for a solid base to move forward on. All of the information is building blocks to the next steps of a technology breakthrough. Many technologies are somewhat simplistic so some steps can be moved through rapidly until a barrier develops.

Q. How do you keep in-touch and up-to-date with any changes in your customers' needs or priorities?

A. Executives, Marketing, Sales, Engineering, and Development meet regularly and all are involved in running the business. There truly is not massive separation of responsibilities.

Q. Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?

A. Techniques are concerted efforts of rapid full dissemination of information to potentially concerned departments that might store, use or contribute additional information.

Q. What have you done recently (within last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?

A. All of the above, and across the board.

Q. Do you take any special measures or precautions to assure that competitors can't use any of the knowledge that you acquire about your technologies or customers and imitate your products or services? These measures or precautions may include patents or informal policies and practices, or they could arise naturally because of the way you make products or conduct business with customers.

A. Patents, formal trade secret policies conventions, nondisclosure & secrecy agreements with vendors or during market studies and testing.

Q. Did you design and develop your current organization structure, policies and practices with any conscious and consistent values or objectives in mind? If so, what were these values or objectives?

A. There was somewhat of a logical development through habits and practices and they are getting documented because this has become our culture. This structure was based on my conscious and consistent values, to get to results and efficiently utilize work product.

Q. Do any of your answers to the previous question apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these policies and practices? Have they had their intended consequences?

A. As we have grown, experimentation related to getting higher performance and output from our human resources has occurred with mixed results. The overall atmosphere related to a small entrepreneurial company has provided adequate motivation (people feel part of a team/family). We have eliminated poor performers because there is no room for a non-performer in this environment.

Q. Is there a traceable pattern among your innovations in the last five years? That is, how do you proceed from one major product innovation to the next? For example, your product innovations could be based on common technology or combinations of technologies, related product offerings, or similar types of customers served. Is any basis more prevalent than another?

A. I think our innovations are driven by needs we determine to exist and opportunities that make themselves available. I fully believe if we were in a different market or field we would still excel.

Q. How do you stay current with developments that relate to your innovations?
A. We regularly monitor new patent applications that relate, we work and walk tradeshows, we communicate with customers and vendors.

Q. Who gathers such information?
A. Everyone in our team from receptionist to CEO.

Q. Is any special training or experience required in order to understand these developments?
A. Sometimes – exposure and experience in general term as compared to specialization gives us peripheral vision rater then focused. Obviously there is a time to focus; universities and research labs are full of technology looking for homes or commercialization because of a lack of a true useful vision.

Q. What types of contacts were made in the past two years? How or where did they occur?
A. The entire spectrum of contacts have been made and developed, this is a continual process. Some contacts get old and dry up as new contacts become productive and fruitful.

Q. How many of these contacts occurred during this time period, e.g., less than 5, between 5 and 10, more than 10?
A. Way more than 10.

Q. Were these contacts made specifically for the purpose of staying current with developments or were they chance encounters?
A. We need help from a variety of sources, we seek and pursue contacts and do our best to manage them professionally.

<u>Other points made in the telephonic interview</u>:

People – Team & CEO
The CEO was enrolled in Industrial Engineering but left it midway. He has also studied Environmental Science. Furthermore, at age seventeen he worked on x ray machines. So he strongly believes that he is a generalist.

Versatility is the key when it comes to hiring people. The CEO is looking for more of a generalist, one with drive, in short, practical creative engineers. He believes that he is the driver, a generalist by his own opinion. The hiring policy is hire low – fire fast. There is also a low staff turnover in the company. Motivation comes from family / team atmosphere.

Growth
The CEO believes Company G is an incubator. Then there are spin offs like X, and a spin off of Y is in the making). Then, managers are sought to handle the spin offs. However, the initial experience with externally hired managers has not been very good as the turnover has been high and the ones turned over have been managers from big companies. So now, more entrepreneurial sorts of managers are sought.

Company G is looking for a licensee partner in Europe and Asia that is willing to shell out an initial investment of at least $10MM. The market for binders is 1.3B binders in Europe, and about $2.3B worth of binders in the U.S. alone. The Company G technology is radical in nature.

R&D
Enormous amount of earnings are spent on R&D.

Financials
Revenues currently stand at $23MM.
15% of total revenues come from exports.
20% of total revenues come from X.
Employee strength is around 140 in Columbus, Ohio alone.
Money is made per package.

Innovation
First innovative product is the sleeve. 1.6B such sleeves are made world over.
Innovation is internally driven. There is an anticipation of the demands of the customer.
Focus is on decreasing costs and increasing efficiency of products. They keep adding products to the existing mix on the basis of perceived needs of consumers.

Exit Strategy
Once revenues reach $50-100M, it comes into the radar of $6B companies.

Problems
- Lack of people to manage the spin offs.
- CEO is spread too thin.
- He is running out of manpower.
- There is a transgressing of patents.
- Money is made per package.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	High	**Medium**	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-Sharing programs	**Yes**	N.A.	No
7	Closeness to Customer	High	**Medium**	Low
8	Market Focus	High	**Medium**	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	**Medium**	Low
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Mix	**Service / Manufacturing**	Service	Manufacturing
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	**Medium**	Low
	Innovation Type	**Radical**		Incremental
	Firm Type	Entrant		Incumbent

Rationale:

14) Intellectual Property: **High**

Company G has come up with inventions such as the safety sleeve, etc. All these innovations have been described in the brief report above. All of these are highly innovative and radical in nature. There are patents filed not only in the U.S. but also overseas for these innovations. There are six patents that have been filed with the USPTO alone.

15) Innovative IT Applications: **Medium**

Company G's innovative IT applications have been identified as medium as its radical innovative products utilize relatively moderate levels of software support /content.

16) Ownership: **Private (Family Owned)**

The CEO and his family are the majority owners of the business.

17) Age Structure (in years): **Younger than 25**

Company G was founded in the year 1988.

18) Employee Turnover: **Low**

The CEO believes in hiring low and firing fast. So, once an employee is absorbed into the company, he is in for the long haul and the staff turnover from then on is virtually zero.

19) Profit-sharing programs: **Yes**
Yes, there are profit-sharing programs.

20) Closeness to Customer: **Medium**
Company G keeps adding products to the existing mix on the basis of perceived needs of consumers. Hence, the interaction with customers has been conferred to be medium.

21) Market Focus: **Medium**
The market focus has been identified as medium. Although each of its major innovations caters to relatively different markets, all of the products in some or the other way are related to the storage device market.

22) Geographical Focus: **International**
15% of revenues of Company G's come from exports. However, the company is actively seeking to explore the European market even more as the potential for expansion is enormous and thereby seeking probably a Joint Venture partnership in Europe and Asia.

23) Market Entry Risk: **Medium**
The market risk is low as there is always going to be a demand for Company G's products (unless hard copies are completely done away with) and safety sleeves for CD's. The company specializes in radical innovations, though there are substitutes. Hence, the market risk can be conferred to be medium.

24) Marketing Aggressiveness: **Medium**
Company G does not *seem* to be aggressively marketing its products. In fact, highly environmentally conscious countries like Germany and Japan are potentially huge markets for its products (because of their quality of being bio-degradable); however, exports form only 15% of the company's revenue-stream.

25) Technology Integration: **High**
Company G pours a major chunk of its earnings into R&D in order to come up with radical innovations. In fact, Product X was in the making 2-3 years and absorbed enormous earnings in the process. Hence the technological focus can be termed as high. Currently, two German companies involved in the business of manufacturing page protectors, have machines that produce 240 page protectors per minute via thermal/ultra-sonic methods which leads to somewhat deformed/distorted materials thus requiring thicker materials for the process. However, at the same cost of capital of the equipment as the companies in Germany, Company G produces 1,000 page protectors per minute. There is absolutely no metal piece involved in the manufacturing of this product and it is a 100% poly-propylene product, which gives it archival capabilities. The companiy's quality engineered, vinyl products and 100% recyclable U-1000 poly sleeves offer superior disc protection in a wide variety of products with virtually unlimited options. (Further reasons as to why the technical intensity of the company can be regarded as high can be found in the product details of its various products).

26) Service / Manufacturing Mix: **Service / Manufacturing**

Company G manufactures Product X, currently outsources manufacture of Product Y and has a service model for the safety sleeve wherein it gets into these companies (viz. Sony, Old RCA/Bertelsmann, Sanyo etc.), manufacturing takes place inside these companies/ customers. Company G pays for labor, handles logistics, pays for machine and handles it.

27) Competitive Advantage: **Technology / Innovation**
Due to reasons already stated before, it is extremely clear that the technological innovation that Company G provides to its customers gives it a competitive advantage.

15) Partner Relationships: **Medium**

Innovation Type: **Radical**

Firm Type: Entrant

Appendix 16

Company H

Company H requested anonymity.

Q. How do you keep up with the technological change that relates in developing, producing or delivering your products/services?

A. Company H focuses on its core competence. It has developed a platform for manufacturing and delivering its products. It has strived and is continuously trying to optimize the methods that it uses to develop and produce its products. If it finds that it is developing a product that does not fit into this platform with some minor modifications the product is dropped. It does not "chase" products. It will pursue only what seems to fit into a framework which is working very effectively. In some ways it says that it is striving for perfection in what it does and does not deviate from that path. All the employees at Company H are given a high degree of freedom and are allowed to spend time in trying to develop its new ideas. These people are encouraged and given time for pursuing what they believe are good ideas. However, it is made explicitly clear to them that if the product that they are trying to develop cannot be manufactured with minor modifications to the existing framework then the product will be scrapped. Company H encourages ideas but is extremely selective when it comes to employing extensive resources towards developing the idea into a product. It uses the Real – Win – Worth Principle. Is the idea "real", are we going to "win" and finally is it worth going for developing this product.

Q. Do you conduct any of your own research?

A. Yes, Company H spends a large amount of money on R&D. It is an important part of the company's policy and it believes that the growth of the firm lies largely with R&D. He said that he could not give the figures or the percentage amount of revenue that was invested back in R&D as that was information he cannot disclose.

Q. How do you learn about outside technology developments?

A. Company H has a division that employs people called "Product Specialists". These people are responsible for tracking market trends. It focuses not only on the products or similar products sold by Company H but also focus on trends in technology/manufacturing methods. Personnel at Company H attend and participate in a lot of tradeshows/exhibitions. It is at these exhibitions and tradeshows that it learns about new needs of its customers and also on new trends in technology. It keeps a close tab on market dynamics. Whenever required, it is willing to form strategic alliances. These alliances may be for manufacturing or for marketing and vary as per the requirements of the situation, e.g., a marketing association with P&G for the dental floss made by Company H. These alliances are usually not very long-term and are made only to meet a specific requirement. It is not like a collaboration where Company H will jointly develop a new product. Its alliances are purely on short-term need basis.

Q. Where and how do you capture and store technology knowledge until you need it?

A. Company H has two main sources of knowledge. One is the market and the other is in-house developed knowledge. It is aware that nearly every one of its competitors is aware of the knowledge that it gets from the market. Hence, it is interested in protecting the knowledge that is developed in-house. This is done in two manners:

   a. Patents and Trade Secrets – Company H has more that 1200 patents registered and it registers about 100 new patents every year. In addition to the patents it has several trade secrets. Some of these are patented; the others are just kept in-house. All the personnel employed in Company H go through regular awareness programs and initiatives to inform them and keep them abreast of knowledge they can divulge to others and what must remain a company secret. In addition, of course, all employees enter into a standard non-compete and confidentiality agreement with the company which is strongly enforced.
   b. Company H has an information system that is based on a "need to know". A person only has access to information that it needs to know. All other information is not easily accessible to them. This is another way that it is able to protect some of its trade secrets and not much information leaks form Company H. It was so secretive that until recently exact sales and revenue figures of Company H were not easily known to the public. Only the figures declared by the company were known.

Q. How do you learn about your customers' needs and priorities?

A. Company H shares very strong associations and relationships with its customers. It has very strong ties and works like partners. Company H gets involved with its customers at the product design and development stage itself and is willing to run the risk of investing time and money with a good customer for a project it is not sure will materialize. Marketing is the conduit for the flow of information between the customer and Company H. Quite often R&D personnel work on the marketing team that interacts with the customer on a regular basis to evaluate performance of existing products. In this role they are constantly scouting to identify new products that may be required by the customer. If these products fall within the framework that Company H operates under, they try to develop these products. The organization is very flat and networked and all the various departments interact a lot with each other and have cross-functional teams that allow ideas to get converted into successful products very quickly. No one in Company H needs his or her supervisor's permission to go into the field and explore at the customer's end. Each business unit acts like a profit center comprised of sales – manufacturing and technical and each business unit tries to maximize its profit. All the business units have a very high degree of autonomy.

Q. Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire?

A. It has a very strong information system that takes care of its "need to know" system. This information system also organizes the information and makes it available for the people for whom it would be useful.

   The personnel in the information technology are also used extensively for research and if someone is looking for some information he or she can contact the information technology

division who look for the information and email it to the person who requested it. This group is very efficient and rarely has anyone found better information than it has been able to produce. Management of Company H strongly believes that you should not try and do something that someone else can do better than you. You do what you can do the best.

Q. Do you use any special techniques or methods to tie together the technological and customer based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?

A. At Company H, there is a very strong emphasis on creating value for the customer. It believes that it is absolutely key to succeed in business. It is in constant touch with the client and is always jointly looking for ways to create value with its customers. Despite the fact that it is very conscious of creating value, cost is a very important aspect for it to consider. It will not pursue creation of value if it feels that it is too expensive and will not be beneficial for the company in the long run. Company H decides to make a product only if it believes that it shall make profits. There is a constant need vs. benefit analysis undertaken to decide whether it take up a project to enhance value for customers. Marketing and Development are key to the success of Company H in this endeavor and hence these two departments work very closely with each other.

Q. What have you done recently (within the last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?

A. Company H is in four areas of business, which are Electronics, Industrial Products, Medical Products and Fabrics. Of these industries, electronics and industrial products had been affected quite badly by the downturn in the economy. The other two industries, i.e., medical products and fabrics are quite recession proof and helped Company H tide over the last three years. In fact these two areas have shown sustained growth over the last three years. In order to deal with recessionary times Company H has tried to create a stable product portfolio that is diverse enough to tide them over economic fluctuations.

Company H did also implement some cost cutting programs. Company H is also very heavily reliant on automation to keep its manufacturing systems productive, efficient and to lower its manufacturing costs.

Q. Do you take any special measures or precautions to assure that competitor's can't use any of the knowledge that you acquire about your technologies or customers and imitate your products or services? These measures or precautions may include patents or informal policies and practices, or it could arise naturally because of the way you make products or conduct business?

A. Company H uses patents and trade secrets to try to ensure that the competition does not know what it is doing. As explained earlier, staff at Company H undergo awareness programs where they are educated as to how important it is for them to keep the trade secrets of the company. All the members of Company H are made aware of what information they can share with others and what information is classified and should not be shared with people outside the company. Also the "need to know" based information systems reduce the free

flow of confidential information and there are fewer chances of the information being leaked out into the public.

Company H recognizes that its products can be duplicated by others especially where it has trade secrets or when the patents for those products expire. In such situations there is not much that it can do to prevent others from making similar products to its own. It believes in retaining the market by developing a better product than the competitor. If it fails to retain a market it goes by the philosophy "be better next time".

If Company H learns that some other firm is trying to replicate its products, it just tries to enhance and develop a better product that will not allow the competitor to take away its market share. However, if it feels that it may be unable to hold onto its market share, then it gives up the business.

Q. Did you design and develop your current organizational structure, policies and practices with any conscious and consistent values or objectives in mind? If so, what were these values or objectives?

A. The founder was responsible for the current organization structure. He believed very strongly in one on one relationships and communications. He liked to know every one of his employees on a name basis and believed that if there was a problem he could speak with the person himself. That is the culture that has been adopted throughout the firm. Plant sizes are restricted to about 150-200 people so that all the employees know each other really well. If the operation starts to grow too big to be handled by the staff a new group is created. These new groups are made on a synergistic basis. It grows like cells by dividing and subdividing. In Company H it is called the amoebic practice. This is a continuous and ongoing process.

Q. Do any of your previous answers to the previous questions apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these policies and practices? Have it had its intended consequences.

A. Since manpower is the biggest asset and Company H has several trade secrets, employee retention is critical for them. Company H has a strong culture of fairness and freedom for employees. People are free to do their own thing as long as the work they are supposed to be doing does not suffer. This encourages employees to explore new avenues of business whenever they may have some free time. This is one of the biggest motivations for an employee to work and stay at Company H.

Compensation is decided to some extent by peer evaluation of performance (people evaluating performance could be either senior, at the same level or even junior to the person whose compensation is being evaluated.) This inculcates a culture of people helping each other within the organization.

The culture of Company H is the foundation for employee satisfaction and diversity is very important to the senior management. In Company H there are several associations with which employees can affiliate. There are ethnic/business networks for employees to join and take advantage off.

There are no budgets allocated in Company H. You can do whatever is needed and there are no bureaucratic set ups for getting the funds allocated to you.
There is a strong emphasis on training of employees. Training is an ongoing process and all employees take advantage of training opportunities. Company H believes that employee satisfaction is the key to employee retention.

INNOVATION TAXONOMY

	Category	**Factor(s)**		
1	Intellectual Property	**High**	Medium	Low
2	Innovative IT Applications	High	**Medium**	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age Structure (in years)	< 25	25-50	> 50
5	Employee Turnover	High	Medium	**Low**
6	Profit-Sharing programs	**Yes**	N.A.	No
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	**High**	Medium	Low
11	Marketing Aggressiveness	**High**	Medium	Low
12	Technology Integration	**High**	Medium	Low
13	Service / Manufacturing Mix	Service / Manufacturing	Service	**Manufacturing**
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	**Medium**	Low
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale:

28) Intellectual Property: **High**
Company H is very reliant on its intellectual property for maintaining its edge over its competition. They take protection of their IP very seriously and do so by means of patents and trade secrets. They have a need to know system because of which only information that is relevant to a person, disclosed to them.

29) Innovative IT Applications: **Medium**
While Company H does use its IT applications quite successfully, there is no evidence that it is one of the prime drivers to its success and hence we rank it as medium.

30) Ownership: **Private**
Company H was started as a private company and remains to be one till date.

31) Age Structure (in years): **25-50**
Company H was founded in the late 50's and hence falls within the bracket of 25-50 years.

32) Employee Turnover: **Low**
The employee turnover in Company H is very low. The main reason for this is that the employees have been kept very satisfied. Company H features regularly in Fortunes list of best companies to work for. Employees within Company H are given a lot of training and development opportunities. They are also given their own time to go and develop their ideas into businesses for the company if the management believes that the idea will be successful. It is very rare for someone to leave Company H.

33) Profit-sharing programs: **Yes**
Company H has developed a profit sharing program for its employees. This also adds to the employees having a stronger sense of belonging to the company and increases their loyalty towards it.

34) Closeness to Customer: **High**
Company H believes that being close to its customer is critical for its success. They are very involved in understanding the needs of their customer so that they can develop new products based on customer inputs.

35) Market Focus: **High**
The market focus has been identified as high. Company H have a view on the market and their customers whenever any decision is taken within the organization. Company H believe that their success lies in un-relentless market focus.

36) Geographical Focus: **International**
Company H have a strong international focus and have a presence in more than 20 countries. A large protion of their revenues are generated from these international markets.

37) Market Entry Risk: **Low**
Company H recognizes that it is very easy for a competitor to start manufacturing some of its products and compete with it. Hence the market entry risk is high. They overcome this problem by constantly innovating and getting rid of businesses where they will be one in a pack. They pursue and continue a business only if they are going to be a market leader.

38) Marketing Aggressiveness: **High**
Company H believe that marketing along with R&D are the main reasons for their success. They use their marketing division as their arms and legs into the customers organization. It is through marketing that they get inputs for the development of new products and hence their marketing focus has been ranked as high.

39) Technology Integration: **High**

One of the core strengths of Company H is their innovation and the integration of new technology in the development of their new products. Company H have often been the pioneers in developing new technologies and products.

40) Service / Manufacturing Mix: **Manufacturing**
Company H is predominantly a manufacturer of products. It makes and sells the products to its customers. There is no service element to Company H and neither is there any bundling of products and services, even though products may be developed based on customer inputs.

41) Competitive Advantage: **Technology/Innovation**
Company H derives its competitive advantage from technology and innovation. Company H has been at the forefront of development of new products by constant innovation and the use of new technology. Company H have been listed amongst the most innovative companies in the world for years.

15) Partner Relationships: **Medium**
Company H forms short term relationships with some other companies only to meet their specific requirements. These alliances are not made for long term joint product development, but only meet some need that Company H may have temporarily.

Innovation Type: **Incremental**

Firm Type: **Incumbent**

Appendix 17

Restek Corporation

Company R

Company Background
Paul Silvis, a chromatographer, formed Restek Corporation in October 1985. Initially, Paul and a handful of other employees occupied a few hundred square feet of space in a business incubator in State College, PA. In less than two decades, Restek has grown to build, and fill, a 70,000-square foot facility, serve tens of thousands of customers around the world, and support the families of nearly 200 employees. Restek's sales have grown every year since 1985.

Awards
Two years on the Inc. 500 list of fastest growing companies
Two years on the list of 100 Best Companies to Work For in Pennsylvania

Facts and Figures

Employees	Nearly 200
Patents since 1976	5

Key Persons

Paul Silvis	Head Coach (Founder, CEO, Owner)
Bryan Wolcott	Chief Financial Officer
Sabah Dabby	Chief Innovation Officer

Key Points

- **Employees** are treated as a company's most precious assets, individuality is encouraged, and focus is always on doing everything or changing anything in order to better serve our customers.
- **Use of metrics** - Total gross profit over the lifetime of a product divided by the R&D investment that went into the product - as explained to us by Sabah Dabby. For Restek, this factor is 5. This metric is a Restek product. It helps it to evaluate the payback period of their investments.
- **Identification of new products** - Sabah Dabby also told us that Restek qualifies a product as a new product only if it gives a gross profit of at least 8% more than the average gross profit of the company. This illustrates a clarity in thinking as various companies mistaken themselves with the notion that they are churning out 40% new products every year though the gross profit of the new products is equal to or sometimes even less than the average gross profit of the company before the introduction of those products.
- **Customer satisfaction is the driver** - "Satisfaction of and service to customers is what drives us" – This was the unanimous opinion of the whole group when I

asked them what motivates them. So simple but yet so effective - you serve your customers well and keep them happy...the company will automatically prosper.

- **Collaborations with Universities** – In spite of its proximity to Penn State, Restek has not been dealing with the Penn State University because of the bureaucratic hurdles that it has to go through – which has been a turn-off.
- **Intellectual Property** – Restek has 5 patents to its name.
- **Ownership**: Paul Silvis, the founder of the company is the majority owner of the company at this point in time. However, over the next five years, Paul is going to divest his share and Restek's employees are going to be the majority owners of the company.
- Restek is **privately-held** and plans to continue to be so.
- They work extremely closely with its customers and their needs.
- One of the advantages of Restek is the speed of its decision-making. Suppose, Restek is contemplating making an investment or buying a technology – the time frame for the decision is less than a week. In Restek, there are about a dozen key people each with their fortes and they come together and arrive at decisions very quickly, unlike big companies where it takes "eons" to arrive at a decision due to the bureaucratic hurdles.
- They do have profit-sharing programs too. As stated above – it is expected to be an employee owned firm in the next 5 years.
- The **employee turnover** is extremely **low**. The employees like what they are doing and like where they are.
- It was formed in 1985 and will complete **19 years** this October.
- **Product quality** and **service** are its core-competencies/competitive advantages.
- Paul Silvis is referred to as Head Coach and not as the CEO of the company.

Source(s)

Interview with Paul Silvis, Founder and Owner, Sabah Dabby, Chief Innovations Officer, and other key Restek people
http://www.restekcorp.com/
USPTO

INNOVATION TAXONOMY

	Category	Factor(s)		
1	Intellectual Property	High	**Medium**	Low
2	Innovative IT Applications	High	**Medium**	Low
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
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13	Service / Manufacturing Mix	Service / Manufacturing	Service	**Manufacturing**
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	**Medium**	Low
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Rationale:

42) Intellectual Property: **Medium**

Restek has 5 patents issued in its name since 1975, hence we have classified it as medium on the intellectual property factor.

Innovative IT Applications: **Medium**

43) Ownership: **Private (Family Owned)**

Paul Silvis, the founder is the majority owner of Restek. He is planning to reduce his ownership by giving employees partnership. He is however clear that the company will continue to remain privately held.

44) Age Structure (in years): **Younger than 25**

Restek was founded in the year 1985.

45) Employee Turnover: **Low**

The employee turnover in Restek is very low. The management believes that their employees are their biggest asset and hence take good care of them. Moreover the employees enjoy what they do and where they are, and hence employee turnover is low.

46) Profit-sharing programs: **Yes**

Restek has a profit sharing program with its employees. In fact the owner Paul Silvis would like to make it a largely employee owned company in the next 5 years.

47) Closeness to Customer: **Medium**
Restek work very closely with their customers to address their needs. Restek understand the importance of their customers and will bend their back backwards to satisfy their customers. They say that customer satisfaction is what drives them.

48) Market Focus: **High**
The market focus for Restek has been identified as high. Restek bases its product development on the needs and requirements of the market. They have an outward view towards the market when deciding their product range.

49) Geographical Focus: **International**
Restek clearly has an international focus. They have subsidiaries in Germany, France, UK and Ireland. In addition to these subsidiaries they have established a dealership network in more than 50 countries.

Market Entry Risk: **Medium**

Marketing Aggressiveness: **Medium**.

Technology Integration: **High**

50) Service / Manufacturing Mix: **Manufacturing**
Restek provide their customers with products. There has been no bundling of manufacturing of products and services.

51) Competitive Advantage: **Technology/Innovation**
The main reason for Resteks success has been itsconstant focus on technology and innovation. Restek pride them selves on their innovation and have been recipients of several awards. They state innovation of all aspects of their business is one of their keys to success.

15) Partner Relationships: **Medium**
Restek is located very close to Penn State University, but has virtually no relationship with it. The main reason being that Restek does not want to deal with the bureaucracy of the university. At the same time Restek has very strong relationships developed with its customers and hence we rank it medium on partner relationships.

Innovation Type: **Incremental**

Firm Type: **Incumbent**

Appendix 18

Lake Shore Cryotronics, Inc.

Company L

The interview was conducted with Karen Lint (Chief Operating Officer), Ed Maloof (Vice President of Engineering) and Dr. Philip Swinehart (Vice President of Research and Development).

Company Background/History

Lake Shore Cryotronics, Inc. is a privately held corporation that has been an international leader in the development of innovative measurement and control technologies since 1968. The company philosophy has been to continue to reinvest itself with a research and development budget that is 100 percent above the national average for instrumentation companies.

The company's growth has been primarily achieved by supplying the needs of scientists and researchers studying the physical properties of metals and ceramics at very low temperatures. Within the past decade, Lake Shore's staff of physicists, material scientists and engineers has expanded the line of cryogenic temperature sensors and instrumentation to include instrumentation and systems for studying magnetic properties of materials. The magnetic measurement product group includes a complete line of benchtop and handheld gaussmeters and Hall probes, vibrating sample magnetometers, electromagnets, magnet power supplies, and Hall generators.

Lake Shore is constantly seeking new markets for present technology and acquiring new ideas and patents by license, purchase or informal associations. The company holds several of its own proprietary technologies. Over the years, Lake Shore has received five "IR-100" awards, demonstrating its successes as this award recognizes research and development projects that have been successfully brought to the market place. Honeywell, General Electric, Minnesota Mining and Manufacturing, and Hewlett-Packard are among the competitors for this recognition.

Today, Lake Shore's influence extends far beyond the borders of the United States. The company has been honored by Ohio with the state Excellence in Exporting Award for successfully meeting the challenges of developing overseas markets. Lake Shore has built an international distributor and representative network which extends throughout North and South America, the United Kingdom, Europe, India, Japan, China, Taiwan, and Korea.

Products

- **Temperature Products**
  - **Sensors –** Silicon diodes, GaAlAs diodes, Platinum RTDs, Rhodium-iron RTDs, Cernox™ RTDs, Germanium RTDs, Carbon-Glass™ RTDs, Ruthenium oxide RTDs, Thermocouples, Capacitance
  - **Controllers**
  - **Monitors**

- **Accessories –** Wire, Cable, Solder, Epoxy, Grease, Varnish, Miscellaneous Accessories
- **Current Sources**
- **Transmitters**

- **Magnetics Products**
  - **Vibrating Sample Magnetometer**
  - **Gaussmeters**
  - **Hall Probes –** Axial Probes, Transverse Probes, Flexible Transverse Probes, Tangential Probes, Cryogenic Probes, Gamma Probes, Multi-Axis Probes, Brass Stem Probes, Extension Cables
  - **Hall Sensors/ Magnetic Sensors –** Axial Hall Generators, Transverse Hall Generators, Cryogenic Hall Generators
  - **Fluxmeter**
  - **Coils –** Helmholtz Coils, Fluxmeter Search Coils, Fluxmeter Coils
  - **ELF Meter**
  - **Magnet Power Supplies –** Superconducting Magnet Power Supply
  - **Electromagnets**

- **Systems Products**
  - **Vibrating Sample Magnetometer**
  - **Hall Effect System**

Facts & Figures

Company Type	Private
Founded	1968
2003 Sales	$4 MM
2003 Employees	150
Patents Assigned since 1976	16
NAICS	334

The Lake Shore Facility

Westerville, a suburb of Columbus, Ohio, serves as headquarters for the company where it occupies 30,000 square feet of manufacturing and office space.

The mechanical and electrical engineering design staff works with three-dimensional CAD/CAM systems, allowing customized designs for nearly any application. The manufacturing facilities utilize statistical process control to insure the highest quality and product reliability. Some of Lake Shore's leading edge manufacturing facilities include complete burn-in testing, a state of the art sputtering system, wafer dicing equipment, a clean room, photolithography equipment, diffusion furnaces, ion milling equipment and evaporation equipment.

Lake Shore's Materials Requirement Planning (MRP) manufacturing, accounting and order management software system is a real-time system providing its distributors and customers with accurate stocking levels and up to date order progress information.

Lake Shore's Employees

The company was founded in 1968 by the current president Dr. John M. Swartz, a former professor of electrical engineering at The Ohio State University. Like the president, nearly one half of Lake Shore's employees have technical degrees, many of these with Masters or Ph.D.'s in either engineering, physics, or material science.

Interview

Q: How do you keep up with technological change that relates to developing, producing or delivering your products and services?

A: In Lakeshore's sensor business, Lakeshore engineers read trade publications, cooperate with their vendors, watch leading products in other larger industries for trends, and listen to their customers to try to identify unmet needs. In terms of looking for new ideas in trade publications, however, by the time ideas show up in a publication it is usually too late. The idea has probably already been incorporated into a product by a competitor. Additionally, Lakeshore hires new employees right out of school who have some cutting-edge knowledge. (Interestingly most of these students are not American.) Lakeshore, however, does not create a lot of new sensors. The last new sensor Lakeshore created was twelve years ago, and some of the sensors the company is currently selling have been around 35 years, since the company was founded. Rather than creating new sensors, Lakeshore has continually improved and modified their sensors and introduced new versions to the market. For example, the company has changed some of the materials used in its sensors and has made efforts to improve the sensors' packaging in response to customers' needs. Two trends the company has noticed among their pharmaceutical and integrated circuit customers are the need for smaller sensors and the need for sensors made of new materials (e.g., magnetic materials).
In Lakeshore's instrumentation business, because the company is not very competitive in the market (they produce small numbers), Lakeshore engineers only look at existing products that are already established in the market place. Lakeshore's instrumentation business involves assembly, not original manufacturing.
Lastly, in Lakeshore's systems business, engineers also assemble system products from products that are already established in the market place. However, because Lakeshore is more responsive to their customers in this business than in the instrumentation business, engineers attend conferences to gather information from customers about their needs that are not being met. Lakeshore's systems products are intended to enable their customers to become more innovative.

Q: Do you conduct any of your own research? How much?

A: Yes. In the sensors area, Lakeshore's research has broadened. In the instrumentation and systems areas, Lakeshore's research is more focused on solving specific application problems that a customer brings to the company.

Q: How do you learn about outside technology developments?

A: In terms of process improvements, Lakeshore relies heavily on its ISO 9000 quality system. Product manufacturing and assembly processes are well documented, and new employee training is straight-forward because of this documentation. There is a system in place that allows for process improvement suggestions, and improvements are made regularly. One

area where Lakeshore could improve relates to obtaining feedback from customers. Lakeshore currently does not proactively seek feedback from customers (other than those few customers who return their products). In the near future, however, the Lakeshore quality manager plans to take steps to create a customer feedback system.

Q: Where and how do you capture and store technology knowledge until you need it?

A: In the sensors group, Lakeshore has electronically scanned some of the company's research papers, interesting journal articles, and patents, and placed them into a searchable database. Also some of this information has been put into "job files." Additionally, Lakeshore's sensor, instrumentation and systems groups have traditionally documented their products and the "paths to get to the final products" (e.g., decisions made during product development, inputs to those decisions, descriptions of any testing that was done). – That documentation does not, however, include "things we have learned and not implemented." To supplement this documentation, Lakeshore intends to purchase some "document control software" this year.

Q: How do you learn about your customers' needs and priorities?

A: In the instrumentation and systems businesses, Lakeshore primarily serves niche markets in which the customers are willing and able to tell the company their needs and priorities. In the sensors business, Lakeshore is looking for new customers. To develop Lakeshore's sensors business, Phil, the "head" of the sensors business, primarily approaches organizations (such as the small business innovation research initiative) that have clearly defined requests (for solutions) and are looking for a company they can fund to develop those products. The Cernox product, for example, was developed based on NSF and DOE funding. Also, in some product lines, Lakeshore does solicit customer feedback on questions such as "what features would you like to see?"

Q: Do you use any organizing scheme or conceptual framework to help you interpret the information that you acquire?

A: Yes – but no one person's work in particular. Clay Christensen's name was mentioned.

Q: How do you keep in-touch and up-to-date with any changes in your customers' needs or priorities?

A: In Lakeshore's systems and instrumentation businesses, the customers actively let Lakeshore know their needs and priorities. In the sensors business, Lakeshore keeps in-touch and up-to-date with customer needs by soliciting new product requests from funding organizations.

Q: Do you use any special techniques or methods to tie together the technological and customer-based knowledge that you acquire so that you can continue to enhance the value that you provide to your customers?

A: Lakeshore currently does a poor job of tying together the technological and customer-based knowledge that the company acquires. The quality manager plans in the near future to purchase and install software that will allow Lakeshore to track "things like service calls that don't result in returned equipment [and] put that together with the [company's] sales force automation software [and] … ERP software" in an effort to better tie together the technological and customer-based knowledge the company acquires. Currently the

company's ERP system does include sales force automation and after-sales features, but these features are not being utilized as much as they could and should be. There is a need for a system that organizes sales and customer feedback information and reports that information to Lakeshore's management in a summary format. Indeed new ISO 9000 changes have prioritized the development and utilization of such systems.

Q: What have you done recently (within last three years) to increase profits by top-line growth (increased sales of existing products or services, added new customers, introduced new products or services) and/or cost cutting?

A: Lakeshore has hired new engineers with the goal of releasing more new sensor products each year. Much of the company's recent sales growth has come from new, innovative sensor products (e.g., fiber optic sensors, porous semiconductor devices). The management of the sensors business has reasoned that Lakeshore could obtain greater profits from new, innovative products rather than from trying to compete against larger, established companies that manufacture sensors that are perceived more as commodity products. Also, to increase profits, company employees have made several international trips to train and spend time with international distributors. One of the goals of these trips has been to improve personal relationships with the distributors, which is recognized as an important factor for success in many other countries.

Q: Do you take any special measures or precautions to assure that competitors can't use any knowledge that you acquire about your technologies or customers and imitate your products or services? These may include patents or informal polities and practices, or could arise naturally form the way you make products or relate to customers

A: Lakeshore patents their technology and uses trade secrets. However patenting is useless in some of the countries in which the company is selling its products (e.g., China). Additionally the nature of Lakeshore's business is such that the company's customers are very knowledgeable and want to know how their products work. If Lakeshore is too secretive about how its products work the company will alienate its customers. Therefore it is difficult to keep trade secrets from customers. Lakeshore's sensors business however restricts more information from customers than do the instrumentation and systems businesses. Additionally, name recognition and the power of international distributors to dictate terms serve as market entry barriers and dissuade competitors and imitators.

Q: Did you design and develop your current organization structure, policies and practices with any conscious and consistent values or objectives in mind? If so, what were the values or objectives?

A: Lakeshore is a family-owned business that is still managed by the family. Therefore the values of the family are evident in the organization's structure. Also since Lakeshore adopted ISO 9000 standards, these standards (especially around quality, continuous improvement, customer and employee satisfaction, and financial stability) have influenced how the company has re-organized itself. Lakeshore also employs a lot of folks with PhDs. Therefore the company's culture is somewhat academic and laid-back in nature

Q: Do any of your answers to previous questions apply to policies and practices regarding human resource management, e.g., employee motivation and compensation? If so, what are these polices and practices? Have they had their intended consequences?

A: Although Lakeshore is a small company, it does have a human resources department. Because much of Lakeshore's most valuable resources are its intellectual resources that reside in individuals, the human resources department attempts to limit employee turnover. This is done by attempting to provide competitive compensation packages, giving some employees ownership, providing bonuses, sending the message that the contribution of every employee counts, openly publishing the company's sales and profit figures, re-investing profits in the company's research and development efforts, and empowering employees at lower levels.

INNOVATION TAXONOMY

	Factors			
1	Intellectual Property	High	Medium	**Low**
2	Innovative IT Applications	High	Medium	**Low**
3	Ownership	**Private (Family Owned)**	Private (Non-Family Owned)	Public
4	Age of Enterprise (years)	< 25	25-50	> 50
5	Employee Turnover	High	**Medium**	Low
6	Profit-Sharing programs	Yes	**N.A.**	No
7	Closeness to Customer	**High**	Medium	Low
8	Market Focus	**High**	Medium	Low
9	Geographical Focus	**International**	Regional	Domestic
10	Market Entry Risk	High	Medium	**Low**
11	Marketing Aggressiveness	High	**Medium**	Low
12	Technology Integration	High	Medium	**Low**
13	Service / Manufacturing Mix	Service / Manufacturing	Service	**Manufacturing**
14	Competitive Advantage	**Technology / Innovation**	Service	Product Quality
15	Partner Relationships	High	Medium	**Low**
	Innovation Type	Radical		**Incremental**
	Firm Type	Entrant		**Incumbent**

Sources:
Interviewww
www.lakeshore.com