DESIGNING A STRATEGIC SOURCING PROCESS FOR LOW VOLUME, HIGH TECHNOLOGY PRODUCTS

by

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Bachelor of Science in Electrical Engineering
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Submitted to the Sloan School of Management and the
Department of Electrical Engineering and Computer Science
in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration and
Master of Science in Electrical Engineering and Computer Science

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ABSTRACT

Axcelis Technologies, Inc. is a capital equipment manufacturer for the semiconductor industry. The semiconductor industry is evidenced by a volatile business cycle that follows the traditional bullwhip effect – that is, companies further up the supply chain see greater demand variability. As an equipment provider, Axcelis is positioned relatively far up the supply chain and therefore, managing these business cycles is an important initiative. Strategic sourcing helps companies manage the cyclical industry by focusing on core competencies, leveraging the expertise of industry leaders, reducing the bullwhip effect, and reducing the number of individual purchased parts.

For companies to execute a sourcing initiative, strategic concepts need to be translated into tactical tools. To develop these tactical tools, this thesis presents a generic four-phase framework: define the overall sourcing process, develop the process objectives, design the required tools, and implement the procedure. Using a case study approach, this four-phase sourcing methodology is compared to a pre-existing process that was more informal and undocumented. The case study shows that the recommended sourcing process reduces the time to outsource a product by 16%. Finally, this work also highlights the importance of incorporating supply chain decisions into new product development and provides an initial framework from which future research may be conducted.

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1.1 Project Setting

This project is the result of a six-month internship at Axcelis Technologies, Inc. a semiconductor equipment manufacturer located in Beverly, Massachusetts. The internship stems from a partnership between the Leaders for Manufacturing Program at the Massachusetts Institute of Technology and Axcelis Technologies, Inc.

Axcelis Technologies, Inc. is a leading semiconductor equipment manufacturer providing products to semiconductor fabrication facilities. The products are used to manufacture semiconductor chips and are characterized as highly technical, complex products. The products are of relatively low sales volumes and list from $150,000 to greater than $4.0 million.

A significant concern within the semiconductor industry is the cyclical nature of demand and the effect it creates on the entire supply chain. This cyclical demand results in the *bullwhip effect.* That is, the further a company is positioned up the supply chain, the more volatile the demand pattern is. As a semiconductor equipment manufacturer, Axcelis is positioned near the beginning of the supply chain and therefore, has significant volatility in their demand pattern. Axcelis recognizes the negative impact these cycles have and dampening these effects is part of the long-term strategic focus. An initiative recently pursued by Axcelis to help manage the business cycles is strategic sourcing and the subsequent outsourcing of products. Strategic sourcing analyzes the capabilities of an enterprise for competitiveness and contribution to the business strategy. Based on this analysis, the company takes new directions to source the work so that the product will deliver a superior competitive advantage and maximum customer value. This thesis provides a framework for developing and implementing a strategic sourcing procedure for low volume, high technology products within a highly cyclical industry.

The completion of this thesis results in a strategic sourcing procedure and associated tools for sourcing teams within the organization. Input from senior leadership, strategic sourcing teams, academic research, and benchmarking studies contributed to the development of the procedures and tools for Axcelis. The results are accessible via an internal website at Axcelis. Using a case

study to validate the process, the sourcing procedure reduces the time to source a product by 16%, incorporates best practices, and remains flexible to incorporate any future improvements.

1.2 Thesis Overview

This thesis will explore a method of creating a comprehensive sourcing procedure at an organization that has traditionally made over 80% of their product in-house. The primary objectives are to:

- Develop a comprehensive procedure to enable cross-functional sourcing teams to strategically source a wide range of commercial and near-commercial products.
- Develop the associated tools required for the cross-functional teams to execute the sourcing procedure.

Chapter 2 presents an analysis of the industry dynamics for the semiconductor industry and the semiconductor equipment manufacturers. Also, this chapter discusses the background of the company, organizational layout, and description of major products.

Chapter 3 discusses the impetus and desired end-goals for instituting a sourcing initiative at Axcelis. Additionally, this chapter reviews previous research focused on outsourcing and strategic sourcing initiatives. This research is segregated by whether the work was strategic (i.e. what is the overall sourcing strategy) or tactical (i.e. what are the tools, processes, and day-to-day actions). Also, the research is organized by whether or not the work applies to all industries or is specific to the semiconductor industry.

Chapter 4 provides a comprehensive analysis of the development of the procedures, processes, and tools required to achieve the goals discussed in Chapter 3. This chapter also discusses Axcelis' decision criteria for focusing first on commercial and near-commercial products instead of new products early in the development cycle.

Chapter 5 discusses an evaluation of the procedures instituted and an analysis into the some of the organizational difficulties in implementing the process. This chapter also focuses on why the

results are important to the company and some of the long-term implications of continuing with strategic sourcing.

Chapter 6 describes an initial framework for integrating strategic sourcing into the new product development process. This framework is an initial recommendation and provides a starting point for future research.

Chapter 7 presents a summary of this project.

2.1 Chapter Overview

The purpose of this chapter is to provide background information on the industry, the company, and its organizational structure. It begins with a discussion of the business cycles inherent in the semiconductor industry and Axcelis' location in the semiconductor supply chain. Additionally, this chapter describes Axcelis and its major products. It then concludes with a description of the organization created to design and implement strategic sourcing.

2.2 Industry Background

> *"Since its inception four decades ago, the semiconductor industry has never been able to defy business cycles that swing wildly between boom and bust."*
> (Reinhardt, 2000)

Semiconductor chips are found in a wide variety of products, including personal computers, cellular phones, children's toys, and commercial and military satellites. Although the supply chain varies from product to product, a simplified supply chain is shown in Figure 1. Axcelis provides products to the semiconductor fabrication facilities, which in-turn provide semiconductor chips to manufacturers of electronic products.

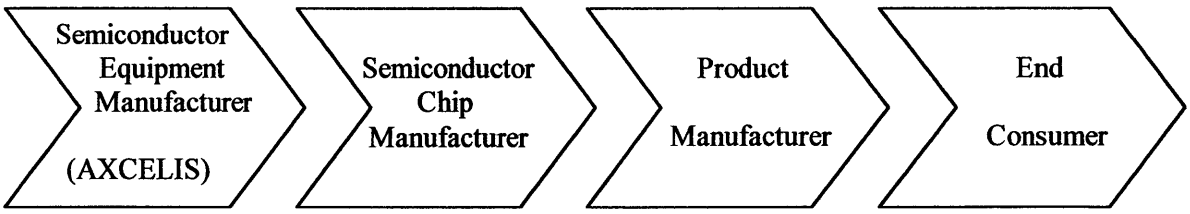

Figure 1: Semiconductor Supply Chain

Although up and down business cycles are inherent in most industries, the semiconductor industry is plagued by a quick cycle resulting in a volatile demand pattern. The effects of this up and down demand cycle are amplified for companies positioned up the supply chain, often described as the "bullwhip" effect. In other words, a small variation in demand caused by the end users can cause significant variations in the upstream businesses. In his book *Clockspeed*, Fine describes this effect: "For example, in the electronics industry, when computer buying

slows down, the chip makers see a steep drop in demand, and the equipment makers, large and small, feel as if they are careening off a cliff." (Fine, pg. 92, 1998)

The bullwhip effect is pervasive within the semiconductor industry, and Figure 2 charts the percent change in six-month intervals for the Gross Domestic Product (GDP), semiconductor billings, and the sale of semiconductor capital equipment. The increase in variability up the supply chain is shown. That is, slight variations in the GDP translate into larger variations for the semiconductor industry and even greater variations for the semiconductor capital equipment providers. These variations challenge capital equipment manufacturers in inventory management, demand planning, and resource planning. Managing these volatile business cycles is an initiative for companies within this industry and is further discussed in Chapter 3.

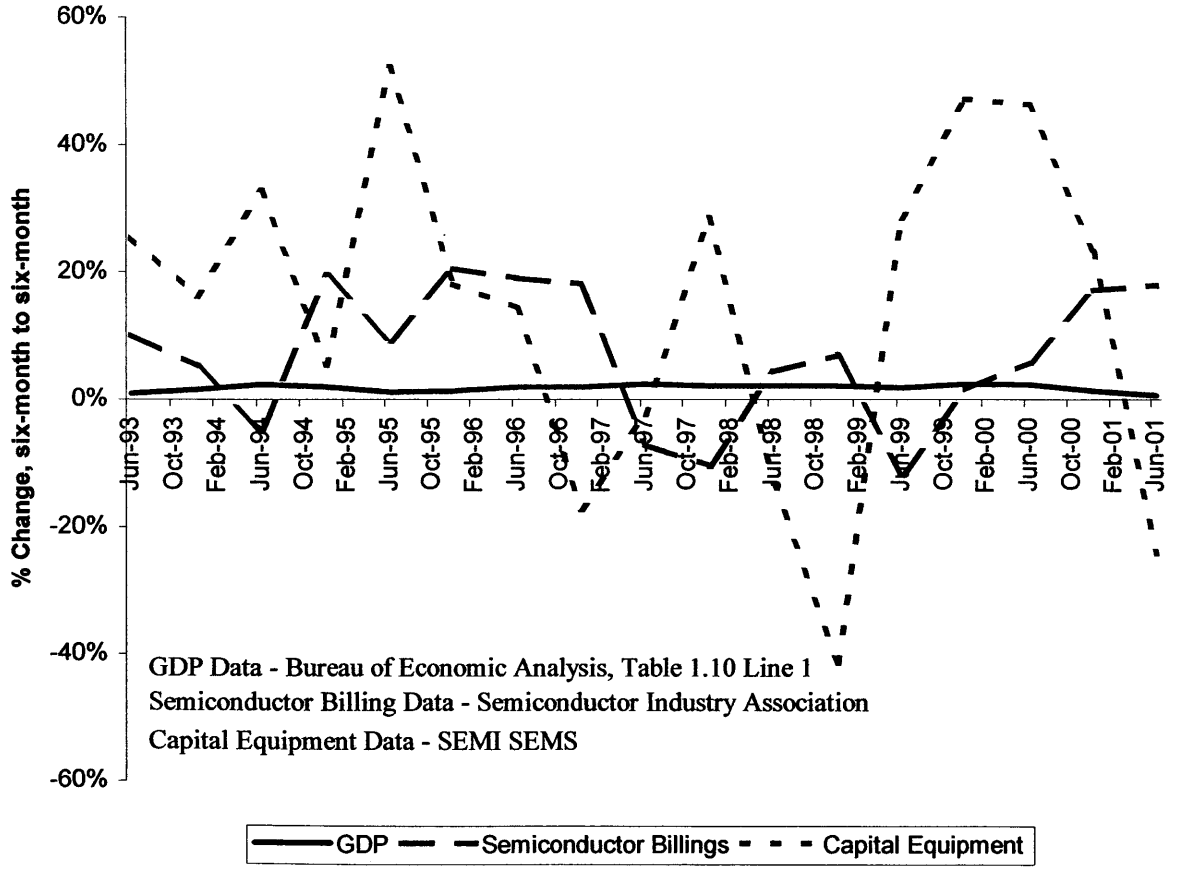

Figure 2: Bullwhip Effect in the Semiconductor Industry

2.3 Company Background

Axcelis Technologies, Inc. is headquartered in Beverly, Massachusetts and produces semiconductor-manufacturing equipment for the United States, Europe, and Asia Pacific. Additionally, Axcelis maintains facilities in Rockville, MD and has a 50-50 joint venture with Sumitomo Heavy Industries, Ltd. in Japan, known as Sumitomo Eaton Nova Corporation (SEN). Although Axcelis' history spans over twenty years, the company also has a start-up atmosphere, since in July of 2000 the company became an independent company. Prior to the initial public offering, the company was a wholly-owned subsidiary of the Eaton Corporation.

Axcelis produces high technology, low volume products that are customizable throughout the manufacturing process. Axcelis' primary products are ion implanters, rapid thermal processing systems, and dry strip and photostabilization equipment. The products are used throughout the manufacturing of semiconductor wafers and provide solutions to complex manufacturing problems.

Axcelis' products are made-to-order and have a build lead-time of six to eight weeks. Additionally, the products are customizable on many dimensions and the customer requirements can change throughout the manufacturing process. Further, the product volumes are relatively low and because of the cyclicality of the industry, the manufacturing volumes can change dramatically from quarter to quarter. This presents a problem in managing inventory, manufacturing capacity, and company resources. Further, because of clean room requirements during the production, the overhead costs are more expensive than a traditional manufacturing facility. Because the product volumes are low and the semiconductor industry is highly cyclical, Axcelis' challenge is to increase capacity in the up-cycles while minimizing the effects of a downturn.

2.3.1 Ion Implanters

Ion implant products and services accounted for 78.5% of net sales in 2000 and are the most significant revenue-generating product for Axcelis. The product is used primarily by fabrication facilities to alter the electrical characteristics of a silicon wafer during the semiconductor chip manufacturing process. More specifically, ion implanters dope the silicon wafers with elements

such as boron, phosphorous and/or arsenic in set patterns at predetermined depths and concentrations to help define the electrical operation of semiconductor chips.

Silicon is the base material for many semiconductor wafers and contains four valence electrons. For semiconductor wafers the silicon is grown, aligning the silicon atoms in a precise structure that forms a crystalline lattice shown in Figure 3.

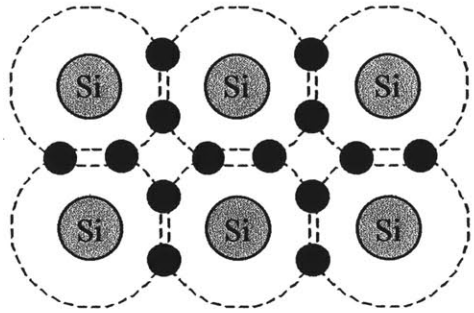

Figure 3: Silicon Wafer Structure

At absolute zero (i.e. 0° K), the silicon shown above is a perfect insulator. No electrical current flows through the structure. However, at temperatures above absolute zero, crystal-lattice vibrations result and generate packets of vibrational energy called phonons. Phonons travel throughout the structure and may strike and break a covalent bond in the silicon structure shown in Figure 3. If the bond is broken, a free electron is released and a positive charge (i.e. hole) remains on the valence structure. The combination of this electron-hole pair generation results in intrinsic silicon becoming conductive at temperatures above absolute zero. However, the relative conductivity is low for intrinsic silicon as compared to metals such as copper. For example, at 300° K (~80° F) the conductivity of silicon is 11 orders of magnitude lower than the conductivity of copper. (Burns and Bond, 1987) However, by adding impurities in a controlled manner, the crystalline structure of the silicon is altered. For example, consider the addition of boron, an atom that has three electrons in the outer shell. After the addition of boron, the structure may appear as shown in Figure 4.

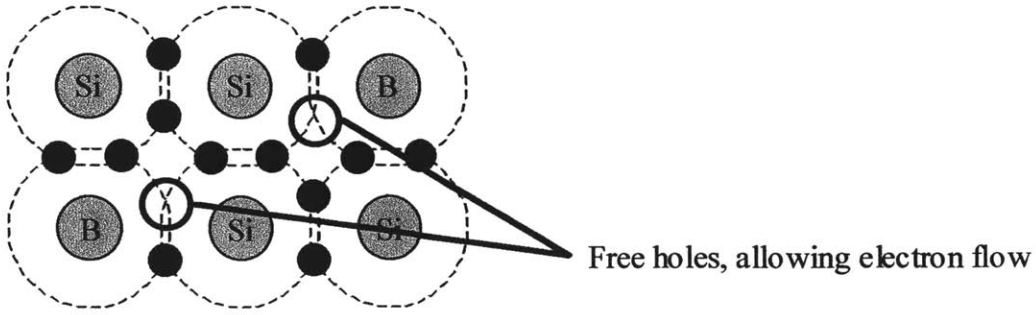

Figure 4: Silicon Structure when Doped with Boron

Because the addition of boron to the structure results in free holes, boron and similar elements are designated as acceptors. The addition of acceptors increases the conductivity of the silicon by reducing the energy required for an adjacent valence electron to fill the hole; thus with less energy, the hole can now "move" to the adjacent valence structure. Hole flow is analogous to electron flow and therefore, acceptor elements such as boron, when doped in the silicon structure, can greatly change the electrical characteristics. Furthermore, similar to acceptors, elements that have one free electron such as phosphorous and arsenic increase the conductivity of the silicon.

Two methods to dope silicon include diffusion or ion implantation. Diffusion occurs by heating the silicon and exposing it to the dopant gas, but this technique can take several hours and requires careful monitoring of temperature and time. Additionally, maintaining uniformity of the heat diffusion is difficult. The other technique, ion implantation, dopes material in the silicon by accelerating the selected ions and injecting the particles into the silicon wafer. Ions, atoms that have gained or lost an electron, are used because the particle can be directed and accelerated into the silicon wafer. Although more complex, ion implantation, as opposed to heat diffusion, is characterized by:

- Better control of the number of ions implanted
- Better choice of depth and range of ion implantation
- Faster and more uniform process
- Little lateral spread of dopant materials
- Lower temperatures

However, ion implantation damages the lattice structure and requires heat annealing of the wafer after implantation. Additionally, the complexity of the process is increased due to high voltages, radiation, and high vacuum systems. Finally, ion implantation can result in channeling of the lattice structure where the ions penetrate to unpredictable depths. (Axcelis, 2001) However, the timesaving and increased productivity associated with ion implantation make the use of ion implanters the choice for most semiconductor fabrication processes.

Although the specific designs of ion implanters vary, the major components of an ion implanter are the ion source, analyzing magnet, ion beam column, and end station. A simplified ion implanter is shown in Figure 5 (Burns and Bond, 1987).

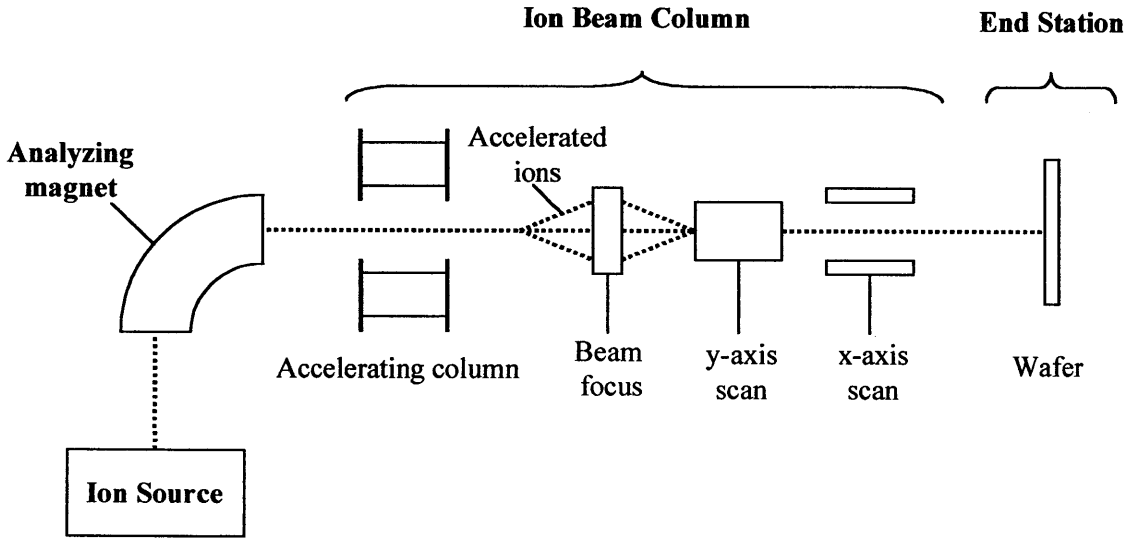

Figure 5: Simplified Ion Implanter

The purpose of the ion source is to produce a stream of ions that can then be accelerated and directed into the wafer. The ions typically used in implantation are boron, phosphorous or arsenic and come from a more stable source such as boron triflouride (BF_3), phosphine (PH_3), or arsine (AsH_3) respectively. These stable sources are in a gaseous state and contained in the ion chamber of the ion source. Inside the ion chamber, a voltage source and filament element emits electrons that collide with the source gas. Some of these collisions create the ion of interest by removing a valence electron from the respective element (boron, phosphorous, or arsenic). An

ion beam is formed when the ions are driven from the ion chamber with an extraction electrode assembly.

Because of impurities in the ionic plasma, the beam from the ion source is not pure. To filter out the impurities, the analyzer magnet carefully controls the magnetic field to allow only the ion of interest to escape from the semi-circular shaped magnet. As the ions pass through the magnetic field of the analyzer magnet, the ion beam is directed in a circular path. The radius r of this path is shown in Equation 1 and calculated by the initial velocity of the beam v, multiplied by the mass of the species m, divided by the electronic charge constant q_e, multiplied by the magnetic flux density B.

$$\text{Equation 1:} \quad r = \frac{vm}{q_e B}$$

Because the velocity of the ion beam v and electronic charge q_e are constants, the beam will change direction proportional to the mass of the respective species m divided by the magnetic flux density of the magnet B. The magnetic flux density is adjusted such that only the ion of interest (boron, phosphorous, or arsenic) will successfully pass through the magnet. This effect is shown in Figure 6.

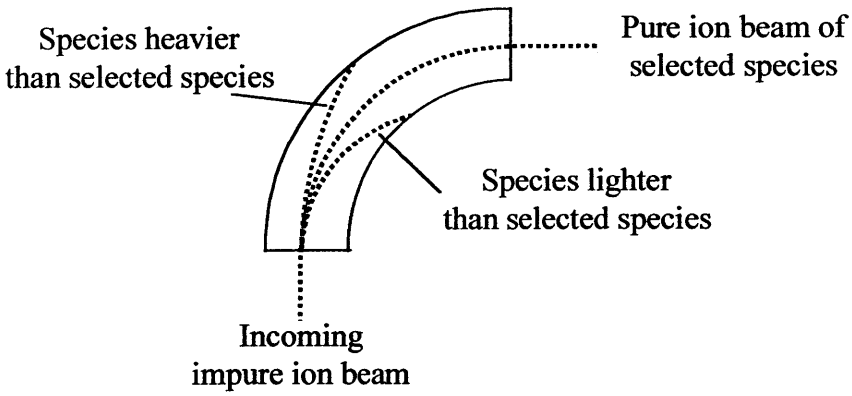

Figure 6: Ion Beam Passing Through Analyzer Magnet

As the ion beam passes from the analyzer magnet, it is accelerated through a linear accelerator. Next, because the beam expands, it is focused using a set of magnets to a beam with a diameter of approximately 1.5 cm. To ensure a uniform doping layer on the silicon wafer, the beam is then deflected in the x and y direction. In other words, because the area of the wafer is larger

than the ion beam, the beam is deflected and the wafer is held stationary to allow the ion beam to affect the entire wafer. It should be noted though, that other methods than beam deflection, such as moving the wafer, can be used to achieve a uniform beam distribution.

Finally, the end station of the ion implanter encloses the user interface and the robot that maneuvers the wafer in and out of the beam. Some end stations only process one wafer at a time, while some use a large rotating wheel to process many wafers all at once. Regardless of the methods used, the end station unit allows the operators to control the ion implanter.

2.3.2 Rapid Thermal Processing Systems

The thermal processing step occurs after ion implantation to anneal the wafer and realign the lattice structure. Stable temperatures and controlled time is necessary to ensure the annealing occurs in a uniform, repeatable method.

2.3.3 Dry Strip and Photostabilization Equipment

Prior to ion implantation, photoresist is applied on the wafer to protect certain areas from ion implantation. In other words, the silicon under the photoresist is not doped and maintains its structure. To ensure that the photoresist, a polymer-based liquid, is hardened correctly prior to the implantation, the resist is exposed to ultraviolet light with photostabilization equipment. After ion implantation occurs, a method to remove the photoresist occurs through ashers, called dry strip. Dry strip uses process gases heated up into plasma to remove the photoresist on the wafer.

The ion implanters, rapid thermal processors, and dry strip and photostabilization products are available for 200 mm and 300 mm wafer fabrication facilities and are customizable on numerous aspects. Most of the development, design, materials management, manufacturing, distribution, and customer service are done by Axcelis. Additionally, because product improvements are made throughout the product's life, numerous versions are used throughout the field.

2.4 Organizational Layout

To focus on strategic sourcing and the subsequent outsourcing of products, the materials department is organized to utilize cross-functional teams to execute the sourcing process. A cross-functional team consists of a team leader and has representation from engineering, value engineering, purchasing, manufacturing, and supplier quality. The use of cross-functional teams provides an advantage by improving coordination and communication between departments. Additionally, because cross-functional teams have departmental representation, the team has the benefit of quick and easy access to functional experts. (Ancona et al., 1999)

However, strategic sourcing is a new initiative and no standardized sourcing procedure existed for the teams to follow. Therefore, a separate group (Lean Enterprise) composed of two personnel, has developed a standardized procedure for the cross-functional teams. Although cross-functional teams have an advantage of communication and coordination, the team usually requires a longer timeframe to become effective. (Ancona et al., 1999) By utilizing a smaller and more flexible sub-group, Lean Enterprise, the process was quickly created for the cross-functional teams. Figure 7 shows the organizational structure that existed during the development of the strategic sourcing process at Axcelis.

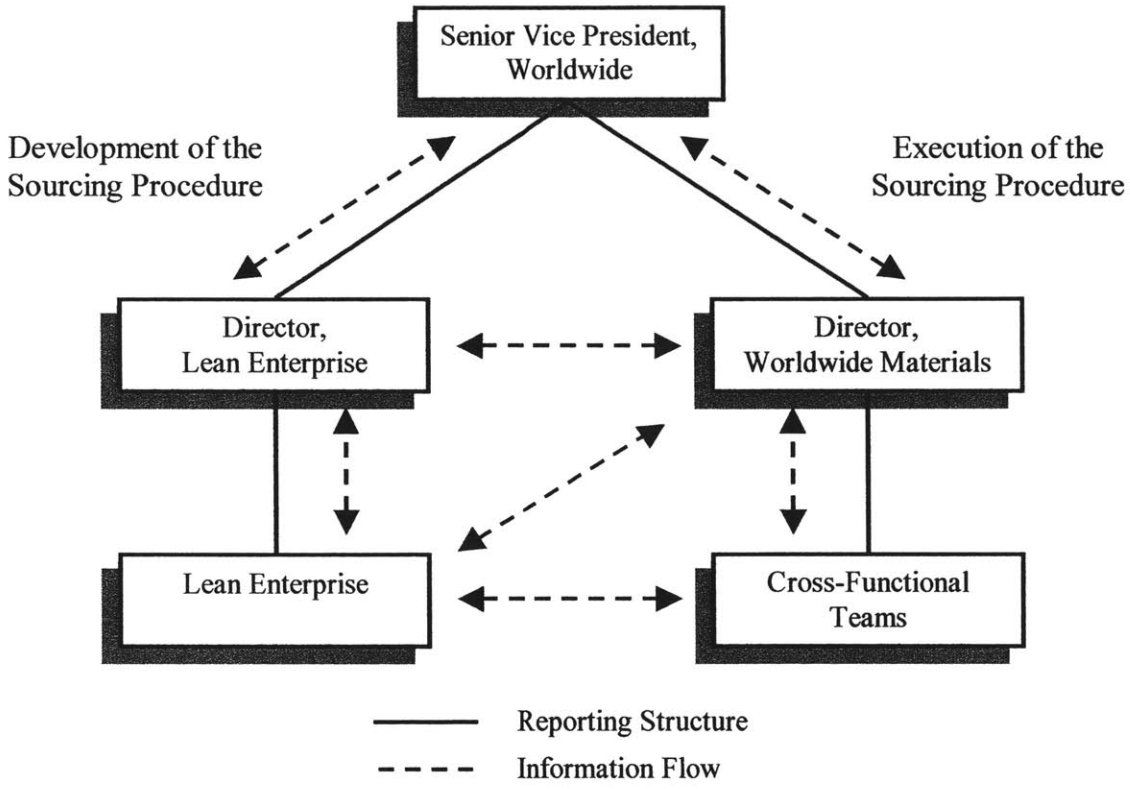

Figure 7: Strategic Sourcing Organizational Layout

2.5 Chapter Conclusion

This chapter provides a background of the industry, company, and organization setup in which the development and execution of strategic sourcing procedure occurred. Furthermore, this chapter illustrates the context for developing a strategic sourcing procedure at a company that is focused on time-based competition with low volume, high technology products in a highly cyclical industry.

3.1 Chapter Overview

The purpose of this chapter is to discuss what strategic sourcing is, why companies would want to implement it, and what previous research has been completed on strategic sourcing. First, it defines and clarifies strategic sourcing. Next, how strategic sourcing adds value to a company and why Axcelis implemented is discussed. Finally, this chapter reviews previous literature written on strategic sourcing.

3.2 Strategic Sourcing

Strategic sourcing is a process that starts with an analysis of the capabilities of an organization. By understanding how those capabilities enable competitiveness and contribute to the overall business strategy, the company can then determine if the product should be obtained in-house, through an alliance partnership, or entirely from an external supplier. In other words, understanding what not to outsource is as important as determining what to outsource. Strategic sourcing therefore refers to the competitive analysis of the product and using that information to determine the best method to obtain the product.

3.3 Why Implement Strategic Sourcing

Until recently, the technological capability of semiconductor capital equipment was the most important customer requirement. Although requirements such as quality, delivery-time, serviceability, cost, and operating cost were important, they were often overlooked if the product had superior technological capabilities. However, in recent years these metrics have become more important for semiconductor manufacturers. For a capital equipment company to succeed, they must focus on providing technologically superior products with a lower cost, shorter delivery time, higher quality, and easier serviceability. The implementation of world-class business processes is important to achieve these goals, and one such process is strategic sourcing. Specifically, the goal of strategic sourcing is to allow companies to:

- Focus on core competencies
- Leverage the expertise of industry leaders
- Reduce the bullwhip effect
- Reduce the number of individual purchased parts

3.3.1 Focus on Core Competencies

> "*Outsourcing noncore activities allows the firm to increase managerial attention and resource allocation to those tasks that it does best and to rely on management teams in other organizations to oversee tasks at which the outsourcing firm is at a relative disadvantage.*" (Gilley and Rasheed, pg. 766, 2000)

There are certain activities, tasks, and capabilities conducted within organizations that provide a competitive advantage. The ability of the company to perform these capabilities better than others is considered a core competency. Companies should foster and devote the majority of their internal capabilities to the execution and development of core competencies. However, most organizations need to complete many non-core tasks. For example, although the wiring of electrical connectors is an essential task for the manufacturing of ion implanters, it is normally not a competency Axcelis should be fostering. By outsourcing non-core competencies, companies can devote more resources to the development of their core capabilities. The caveat, of course, is to ensure that only the non-core competencies are outsourced, or the items that once provided competitive advantages may no longer be in control of the company. The importance of determining which competencies are core and non-core should not be understated, and as shown in Chapter 4, it is one of the first steps of the sourcing process.

3.3.2 Leverage the Expertise of Industry Leaders

> "*As manufacturers focus more on their areas of competence and technical expertise, a greater reliance on external suppliers to support noncore requirements becomes necessary.*" (McDermott and Handfield, pg. 40, 2000)

An additional advantage of outsourcing non-core competencies is to leverage the expertise of industry leaders. Using external experts in the design, manufacturing, distribution, and servicing of non-core products can improve the product along metrics of cost, quality, and functionality. For example, Nike considers its core competencies to be the design and marketing of shoes instead of manufacturing. (Gilley and Rasheed, 2000) Nike has therefore decided to use contract manufacturing and leverage expertise of external suppliers to manufacture the products Nike

designs. This has enabled Nike to use outside manufacturers to produce shoes and associated apparel cheaper and of better quality than Nike could by manufacturing internally. An unfortunate result for Nike, however, has been the alleged use of unlawful child labor by the contract manufacturers. This does not imply that outsourcing was the wrong decision for Nike, but it does emphasize the importance of selecting and monitoring partners used in the sourcing process.

3.3.3 Reduce the Bullwhip Effect

The semiconductor industry is cyclical in nature and the bullwhip effect creates difficult challenges for capital equipment manufacturers. As an example of the bullwhip effect, Figure 8 shows the net sales data for the past four years at Axcelis. Throughout this cycle, several peaks and valleys are observed, with peaks occurring in quarter four of 1997 and 2001, and a low point occurring in quarter one of 1999.

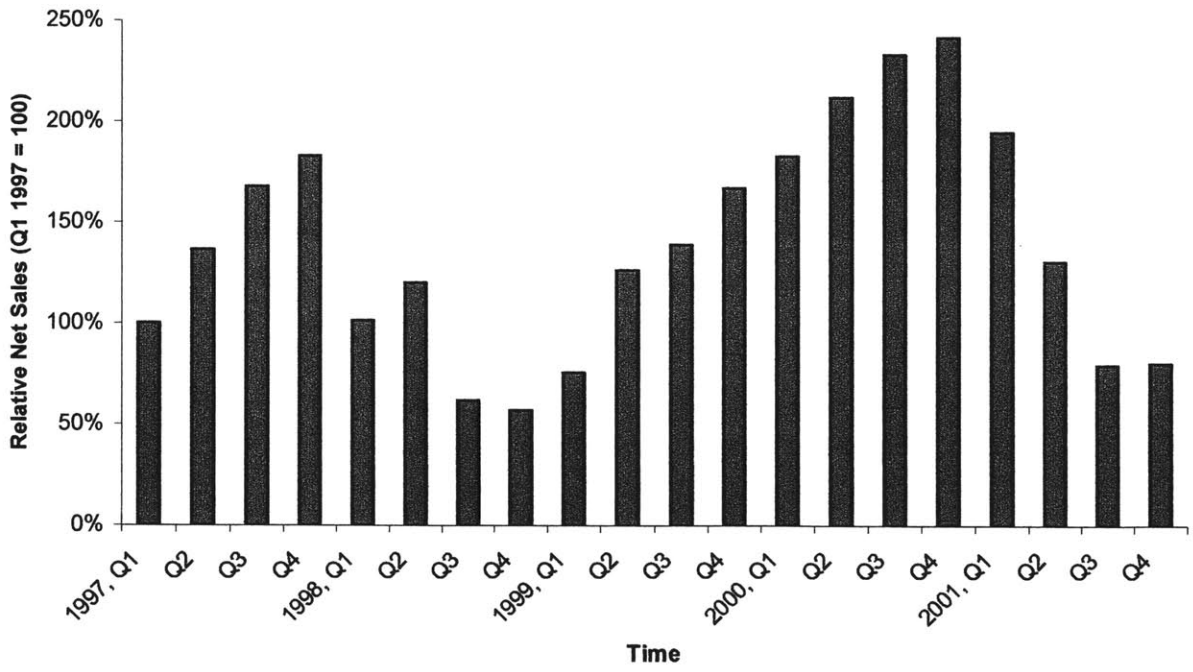

Figure 8: The Effect of the Business Cycle on Net Sales

Throughout this period there were several key workforce decisions made because of the business cycles. For example, during the downturns of 1998 and 2001, employee reductions occurred.

Although the reduction of employees can lower expenses, it can also result in lower morale, cutbacks in long-term projects, and loss of expertise. Furthermore, after the cycle recovers, the company may need to hire and train employees, resulting in increased costs and a possible reduction of product quality. Additionally, actions such as manufacturing capacity planning, inventory management, manufacturing cycle time, and demand forecasting become more difficult in the rapid up and down cycles.

Therefore, the goal of many companies is to develop processes to manage these business cycles. In their book *Designing and Managing the Supply Chain*, Simchi and Levi propose several methods to reduce and/or eliminate the bullwhip effect. One method is through the formation of strategic partnerships. (Simchi-Levi, et al. 2000) The strategic partnerships discussed by Simchi-Levi focus on the increased sharing of information to reduce variability. However, another strategic partnership that can reduce the impact of the bullwhip effect is strategic outsourcing. For example, if a significant amount of product is outsourced to an external supplier during a downturn, Axcelis can order less of the product instead of reducing employees. Additionally, during an upturn, instead of acquiring more manufacturing capacity internally, the capacity can be acquired from an external supplier. Although this may be perceived as pushing the effects to another company in the supply chain, if a well-diversified supplier is selected, those effects are reduced. In other words, because a well-diversified external supplier provides products to customers in several industries, the overall variability of the bullwhip effect is reduced for that external supplier.

A well-diversified supplier is able to react to downturns in the semiconductor industry more easily because low demand in one industry does not necessarily translate to low demand in another industry. Optimally, the other industries the supplier services will experience an upturn, and resources that were originally assigned to semiconductor products could be transferred within the supplier's organization. For example, as shown in Figure 9, the cycles within automotive, aircraft, and semiconductor industries vary, and a downturn in one industry does not correlate to a downturn in another. This diversification positions an external supplier better to absorb the cycles of the industry than a non-diversified capital equipment manufacturer.

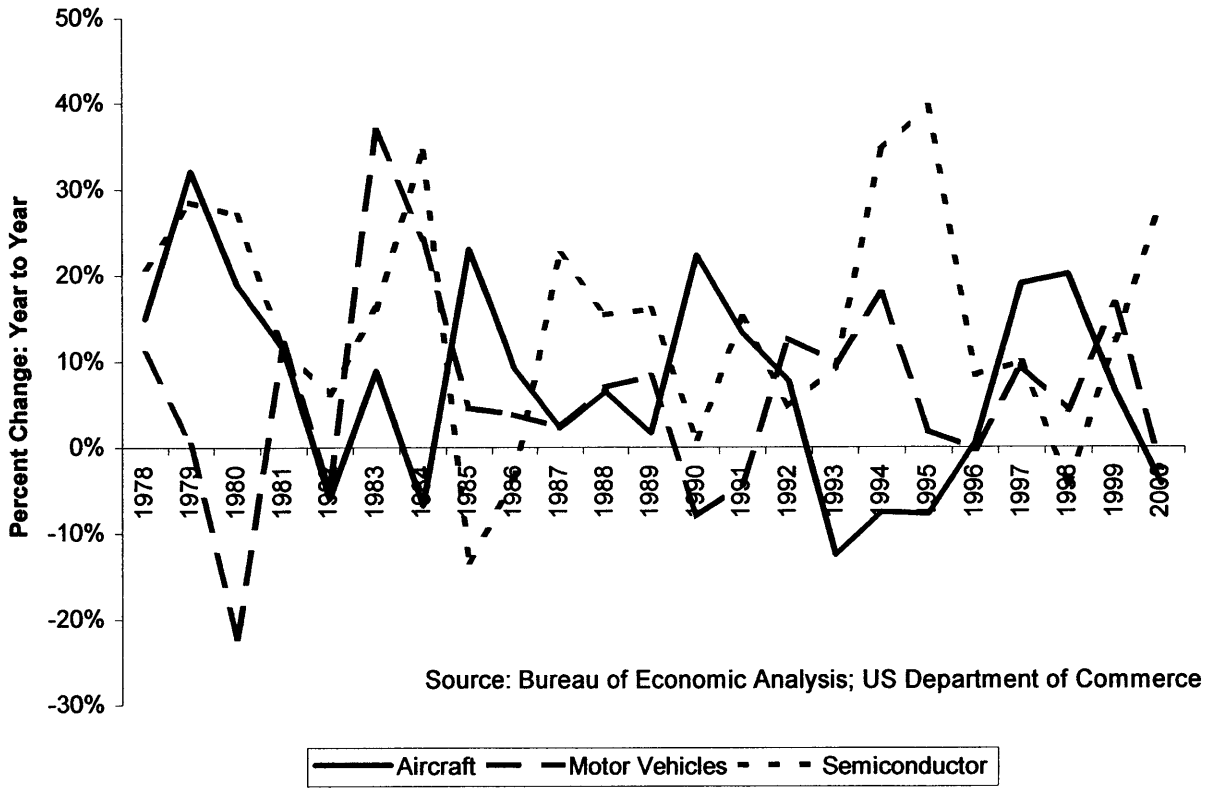

Figure 9: Industry Performance for a Typical External Supplier

3.3.4 Reduce the Number of Individual Purchased Parts

A significant expense for manufacturing facilities is the cost of holding inventory, which includes material, labor, and overhead costs. Outsourcing the manufacturing and material management of a large subassembly with many individual part numbers to a large external supplier allows for reduction of costs. For example, although the material and labor costs for the external supplier may be the same, the external supplier is larger and has greater economies of scale. Second, with an overall reduction of part numbers, the cost of managing the remaining parts in the stockroom are reduced. For example, because the stockroom is smaller, it is easier to sort and pick parts, should be easier to organize, requires fewer employees, and increases the quality of the product. Also, because the purchasing of component parts is a core competency of the external supplier, their costs should be lower. Finally, because the supplier may purchase the same product for a variety of different companies, their material costs also may be lower due to volume price discounts.

3.4 Previous Research

Literature on the subject of strategic sourcing and outsourcing describes many of the individual components of a sourcing procedure. For example, several authors discuss the importance of evaluating core competencies within an organization (Fine, Whitney and Fine). Other authors examine the task of selecting suppliers and what components should be evaluated during supplier selection (Nielsen and Miller, Choi and Hartley, De Toni and Nassimbeni). Literature also emphasizes the development of total cost models (Doig et al.) or the importance of trust and supplier partnerships (Dyer).

In general, the articles address either strategic issues or tactical issues. For example, a strategic article may address the importance of selecting the correct suppliers, whereas a tactical article would describe the day-to-day actions and tools a company uses to select suppliers. To differentiate the research, the literature is divided into whether the article focuses on strategic or tactical processes. Additionally, the literature is divided into general applicability whether or not the research is specific to the semiconductor industry. Table 1 summarizes this research.

Strategic What is the overall strategy for sourcing?	Carr and Pearson: Strategically Managed Buyer-Supplier Relationships and Performance Outcomes Doig, Ritter, Speckhals, and Woolson: Has Outsourcing Gone too Far? Dyer: Collaborative Advantage Fine and Whitney: Is the Make-Buy Decision Process a Core Competence? Fine: Clockspeed Gilley and Rasheed: Making More by Doing Less: An Analysis of Outsourcing and its Effect on Firm Performance Hendry: Culture, Community and Networks: The Hidden Cost of Outsourcing McCutcheon and Stuart: Issues in the Choice of Supplier Alliance Partners McDermott and Handfield: Concurrent Development and Strategic Outsourcing: Do the Rules Change in Breakthrough Innovation?	Applied Materials SEMICON West 2001 Presentation (Industry trends) Chappell: Capital Equipment/Test Trends 2001 Richter: To Outsource or Not to Outsource?
Tactical What are the tools, processes, day-to-day actions, etc.?	Choi and Hartley, An Exploration of Supplier Selection Practices Across the Supply Chain De Toni and Nassimbeni: A Method for the Evaluation of Suppliers' Co-Design Effort McCutcheon and Stuart: Issues in the Choice of Supplier Alliance Partners Nielsen and Miller: Selecting Software Subcontractors Shin et al., Supplier Management Orientation and Supplier/Buyer Performance The Torrington Company: Supplier Requirements, TPS-7000 Ulvinen, Are you Ready for Contract Manufacturing?	Dekens: What's Good for the Goose is Good for the Gander! Mahendroo: Service Redefines Supplier/Customer Relationship McCutcheon and Stuart: Issues in the Choice of Supplier Alliance Partners (p. 288-289)
	General	**Specific to the Semiconductor Industry**

Table 1: Strategic Sourcing Literature Review Matrix

3.5 Chapter Conclusion

This chapter describes the impetus for implementing strategic sourcing at Axcelis. Specifically, strategic sourcing will allow Axcelis to focus on core competencies, leverage the expertise of industry leaders, reduce the bullwhip effect, and reduce the number of individual purchased parts. Previous research on strategic sourcing focuses on either strategic issues or the type of tactical tools that are available. Although specific portions of a sourcing process are available, there is little research on how to design a complete strategic sourcing process for a company.

> *While a vision may guide and inspire during the change process, an organization also needs more nuts-and-bolts advice on what to do, and when and how to do it.* (Ancona et al., pg. 8-22, 1999)

4.1 Chapter Overview

This chapter first discusses the unique requirements for companies that produce low volume, high technology products when designing a strategic sourcing project. Then it details the decision criteria Axcelis used to implement the strategic sourcing initiative on commercial and near-commercial products, as opposed to products in the new development phase. Next, a generic four-phase framework used to develop a strategic sourcing process is described. Finally, using a commercial assessment worksheet as an example, this chapter shows how specific sourcing tools have been created at Axcelis.

4.2 Requirements for Low Volume, High Technology Manufacturers

> *For example, in response to the increasingly competitive and changing environment many companies are looking consciously to apply approaches such as strategic partnering, product development and collaboration agreements with customers and suppliers, which are now common in the high-volume industries. However, the extent to which companies can commit resources to collaborative arrangements with their customers and suppliers can be conditioned by factors such as low product volumes, market instability and short project timescales. Therefore, it is apparent that an approach which is more sympathetic to, and allows for the interpretation of, the general context and individual needs of companies operating in the low-volume industries is required.* (Maffin and Braiden, pg. 207, 2001)

Sourcing for manufacturers with low volume, high technology products focused on time-based competition is different from other companies. For example, the company needs to align with suppliers capable of providing a high mix, low volume product at short notice. This impacts the method of supplier assessment, supplier agreements and contracts, and partnership management. As another example, although web based auctions can provide competitive price biddings for many companies, their effectiveness is questionable for Axcelis' products. Because the product technology is high and many options exist, it is difficult to define the bid parameters and a web-

based bidding system is not advantageous. Instead, supplier bids require a more detailed evaluation and can result in an iterative bidding process. Additionally, the importance of assessing suppliers' capabilities in product design, value engineering improvements, and business planning is critical. Therefore, although portions of the four-phase methodology presented in this chapter may be applicable to other organizations, it is designed for companies similar to Axcelis that focus on low volume, high technology products.

4.3 Sourcing for Immediate Business Impact

Incorporating supply chain decisions into new product development allows for the identification of key sourcing issues before a design is finalized. For example, modularity of the product can determine the ease of outsourcing, material selection can determine the supply base, and design of the product can determine who owns the intellectual property. Therefore, many benchmarking studies and academic research suggest that sourcing decisions should be incorporated early into the design of new products. However, the benefits of integrating sourcing decisions into new product design do not immediately affect the profitability and operations of the company. Because the introduction of a new product at Axcelis occurs approximately every five to seven years, the payback period of focusing strategic sourcing on new products is long. Therefore, Axcelis initially focused its strategic sourcing efforts on commercial (200mm) and near-commercial (300mm) products. The majority of the product design and development for these products is complete, with the commercial products in full-scale production for at least five years and production just beginning on the near-commercial products.

There are many pros and cons at Axcelis for incorporating strategic sourcing on commercial and near-commercial products. First, the products are not designed for outsourcing. For example, in general, the product is an integral and not modular design, which makes outsourcing difficult. Second, when outsourcing, closer and more collaborative supplier relationships are required than what currently exists. Third, the supply base at Axcelis consists of smaller suppliers that are not capable of handling a large outsourcing initiative. Fourth, it is more difficult to achieve organizational buy-in when outsourcing a product already in production. Finally, analyzing the exact costs and benefits of outsourcing the commercial and near-commercial is a complicated

task. There are however, two significant reasons for starting the outsourcing effort on the commercial and near-commercial products. First, lessons learned can be incorporated into the new product development process. Second, and most importantly, the strategic sourcing effort will have a faster financial impact if focused on the commercial and near-commercial products.

Although significant reasons exist for beginning the strategic sourcing process on new products, quickly impacting the business most influenced the decision. The time period required to see the financial benefits on new products was unacceptable and therefore, it was important to aggressively apply strategic sourcing efforts to the commercial and near-commercial products. However, as discussed in Chapter 6, it is recommended that Axcelis use the lessons of this research to apply strategic sourcing to future products.

4.4 Designing the Strategic Sourcing Process

Prior to this research, there was no documented method to strategically source a large sub-assembly. The majority of the purchasing efforts focused on the component level and reducing costs, expediting parts, reducing inventory, and supporting engineering and manufacturing. Therefore, as Axcelis entered into an aggressive strategic sourcing campaign, it was important to have a well-thought out, documented procedure.

However, the sourcing teams were beginning to outsource products, and it was also important to develop a procedure quickly. To create the sourcing procedure quickly, a small sub-group from Lean Enterprise developed the sourcing process using a four-phase methodology. This methodology is used at Axcelis and is a generic framework that can be applicable to other companies. First, the sub-group develops the overall steps of the sourcing process. Second, prior to developing tools for the process, the sub-group defines the objectives for each step of the process. Next, tools for the process are selected to enable the sourcing procedure. Finally after creating the base process, understanding the objectives, and defining the tools, the last step requires creation of the tools and implementing the process.

4.4.1 Phase 1: Develop the Overall Steps for the Sourcing Process

Sourcing a product follows several generic high-level steps independent of the type of product. The steps include items such as supplier selection, negotiation, bid evaluation, and sourcing execution. These steps are valid for most companies and products, and provide the basis for the specifics of sourcing procedure. Although the precise number of steps is not important, the number should be reasonable in scale and scope and not overwhelm the end users with excessive sub-tasks. The key steps to complete a strategic sourcing initiative for commercial and near-commercial products are as follows:

1. Identify the product
2. Identify and prioritize specific sourcing actions
3. Identify potential suppliers
4. Conduct a supplier assessment
5. Perform an initial supplier selection
6. Prepare the bid package
7. Analyze supplier bids
8. Conduct formal supplier conference
9. Negotiate and award contract
10. Qualify incoming products
11. Manage the supplier

These steps can be adapted depending upon the needs of the company. For example, prior to this research, Axcelis had instituted a 14-step sourcing process. The 14-step process was ingrained in the culture of the purchasing organization, and to maintain continuity within the company, the 11-step process above was incorporated into the existing 14-step framework as shown in Figure 10.

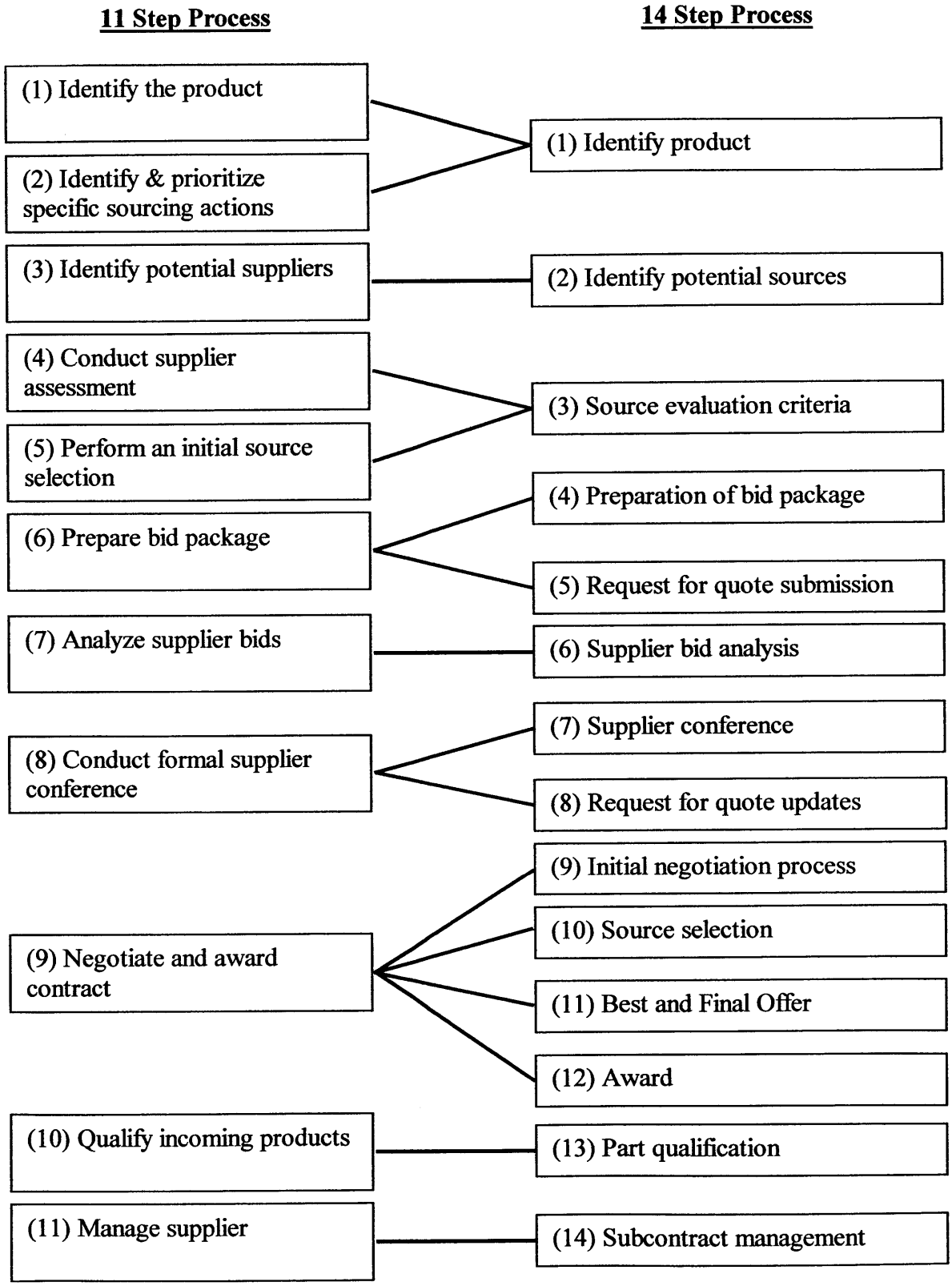

Figure 10: Adapting the 11-Step Process

The steps for the sourcing process provide a high-level description of what is required to source a product. First, the product to source is selected. Next, it is important to develop a set of detailed tasks, timelines, and resources required for sourcing the product. After identifying and selecting suppliers, the suppliers submit bids for the product. As a result of their bid, the final supplier(s) are selected and the final price is negotiated. Finally, the incoming product is inspected and approved, and the supplier relationship is managed. How a company plans to complete these tasks can vary significantly. For example, are suppliers selected from the current supply base, a new supply base, or a mix? Do suppliers bid on the product via the Internet, with face-to-face meetings, or do the suppliers submit their bids in writing? Are bids selected on price only or are the bids selected using a total cost model? Regardless of the specific company's requirements, the remainder of the four-phase methodology helps low volume, high technology manufacturers create their specific strategic sourcing process.

4.4.2 Phase 2: Define the Objective for Each Step

Prior to creating the tools and day-to-day tactical processes of the strategic sourcing procedure, it is important for sourcing teams to understand the desired output and objective for each step. The outputs for each of the 11-steps are described below and summarized in Appendix A.

Step 1: Identify the product

> *The make-or-buy riddle can be answered correctly only if you first understand the strategic (and not just the dollar) value of key activities and then assess the efficiency and capabilities of their providers, internal or external.* (Doig et al., 2001)

After completing this step, the sourcing team should have a list of product candidates that could be outsourced because they are considered non-core competencies. Additionally, the team should have a plan that describes the overall short-term and long-term actions required to source the selected product. For example, if the team decides to outsource all hydraulic systems on a product, they need to understand how to complete this action. Specifically, if the product is not designed for strategic sourcing because the hydraulic system is integrated into other sub-assemblies, the system may need to be redesigned. Additionally, the hydraulic system may need redesign or manufacturing changes to allow an external supplier to test the system prior to

shipping the product. The requirements vary from product to product, but it is crucial that the team understand how the selected product will be outsourced.

Step 2: Identify and prioritize specific sourcing actions

After selecting the product, the sourcing team must clearly define the actions required to source the product. First, the team should understand the type of supplier relationship required to source the product. Specifically, should the product be outsourced completely to the supplier, or should a partnership be established? Second, the team must fully develop the project plan and create a detailed timeline for the sourcing initiative. Finally, the team should understand the internal resources required to complete the outsourcing initiative. That is, the team should identify what work needs to be done prior to outsourcing the product and who will complete that work. For example, before a supplier can correctly manufacture a product, manufacturing instructions, engineering prints, and assembly instructions must include the most up-to-date changes and modifications. Because many changes may be undocumented and understood only by "expert" operators on the manufacturing floor, the company must determine if internal resources should be allocated to capture these changes or if the supplier should document the changes by observing the assembly on the manufacturing floor. Understanding how resources will be allocated to complete work required for strategic sourcing is an important issue.

Step 3: Identify potential suppliers

The ability to outsource a product is dependent upon finding a potential supplier. If few suppliers are available, the supplier may not be able to provide the capabilities required or the supplier power may become too great. If no capable suppliers are available, then a supply base must be developed. Developing a supply base can even be difficult for large companies with significant market power and thus, even more challenging for smaller companies. Therefore, if too few or no suppliers exist, an evaluation must be made to either develop a supply base or continue to produce the product in house. Assuming a capable supply base exists, the output from this step should be a list of potential suppliers.

Step 4: Conduct supplier assessment

> *Companies have increased their level of out-sourcing and are relying more heavily on their supply chain as a source of their competitive advantage. Thus, determining which supplier to include in the supplier chain has become a key strategic consideration.* [Choi and Hartley, pg. 333, 1996]

After a potential supplier is identified, it is important to fully understand their abilities, methodologies, and capabilities. Completion of this step will provide an evaluation of the technical and business capabilities of the potential suppliers. Financial stability, business planning, and supply chain management competencies are important, as well as the supplier's manufacturing and design performance.

Step 5: Perform an initial source selection

After potential suppliers are identified, only those suppliers that can meet the requirements of the sourcing initiative should be kept in the process. This step is one of the first opportunities to reduce the number of suppliers. The number of suppliers after this step in the process will depend on the product, but based on previous initiatives at Axcelis for example, between four and ten suppliers allows for sufficient competition while ensuring the process is manageable by the sourcing team.

Step 6: Prepare bid package

Clearly defining the expectations for the potential supplier is important to ensure the product matches design and manufacturing specifications, as well as delivery, cost, and quality requirements. To ensure that the bid package from the potential supplier matches the required specifications, it is important to clearly define the product. Therefore, an outcome of this step should include documentation outlining the technical requirements of the product. The document that allows this is a Statement of Work (SOW). Another part of this step is defining the expectations for delivery, cost, quality, and year over year savings. These expectations are included in the terms and conditions, supplier agreements, and confidentiality agreements. Contracts are important methods for setting expectations between suppliers and the buyers; as partnerships become more alliance based, however, it becomes difficult to capture all the requirements in a contract.

> *A firm that uses only arm's length contracts can normally safeguard itself from possible problems (such as non-performance or exposure of trade secrets) by legal means. Trust, while it may be present, rarely plays a significant overt role in such business-to-business dealings. However, forming strategic alliances usually means opening up more informal channels of communication and broadening the range of expectations, many of which cannot be effectively captured in a legal contract. To move beyond a relationship that can be safeguarded by legal contracts alone, the buyer firm must have a means of keeping the risks in check as it develops these more permeable boundaries with its key suppliers. Most of the literature...indicates that firms use trust to reduce the*

risks associated with establishing this form of relationship. (McCutcheon and Stuart, pg. 291, 2000)

Trust, though important, must be cultivated over time despite the best intentions between the supplier and the buyer; contracts therefore can be used to clearly establish expectations. As relationships are developed between the supplier and buyer, it is expected that the importance of trust will grow. Additionally, the partnering agreements and terms and conditions can serve as another filter. For example, although a supplier may have the technical competence to provide a product, they may be unwilling to meet certain delivery, cost, and quality expectations. Because the bidding process is time consuming for all participants, the ability to deselect incompatible suppliers is important. The output of this step should be a Request for Quote (RFQ) package that contains associated technical documentation, a Statement of Work, Terms and Conditions, Supplier Partnering Agreement, and confidentiality agreement.

Step 7: Analyze supplier bids

The assemblies and products that are sent for bid are complicated and may require redesign and development of test procedures. Additionally, the bids from the suppliers may discuss different options for payment times, delivery, and quality control. The first purpose of this step is to determine if the bids are complete and address all items asked for in the RFQ package. The second objective of this step is to compare the bids. For example, although final price is important, the payment terms, quality, location, and delivery abilities should be reviewed to determine the most competitive bids. After this step, the number of potential suppliers will be further reduced to only the most capable and most competitive. It is not the intent to choose the final supplier at this point, but to narrow down the selection process to two or three suppliers.

Step 8: Conduct formal supplier conference

> *"We are much more likely to bring a new product design to Chrysler than to General Motors. The reason is simple...we take them to Chrysler because we have learned we can trust Chrysler."* (Dyer, pg. 97, 2000)

Prior to entering into formal negotiation procedures, a clear understanding of the roles and responsibilities must occur. A method to accomplish this is to have formal supplier conferences with the remaining suppliers. The conference clarifies any remaining questions on costs, capabilities, and other requirements contained in the contracts. The purpose of this step is not to negotiate, but to answer any remaining questions. Additionally, the conferences help establish

relationships between the suppliers and buyer and begin to develop a trusting partnership. The time spent in this step clarifies expectations and allows for a faster and smoother negotiation process. Additionally, any requirement changes such as redesigns, engineering changes, and material selections can be incorporated into the RFQ.

Step 9: Negotiate and award contract

The output of this step is to negotiate the best position, while ensuring a productive and profitable relationship for both supplier and buyer. Negotiations require compromise, but it is important to ensure that the compromises are thoughtful and deliberate. The negotiations will also impact the relationship fostered throughout the sourcing process and can set the stage for future actions. For example, McCutcheon and Stuart describe a capital equipment manufacturer in the semiconductor industry that expanded manufacturing operations in another location. An external supplier had the only up-to-date prints, specifications, and manufacturing knowledge for complex pieces. Instead of forcing the buyer to incur high shipping costs, the supplier agreed to build a new plant next to the buyer's plant without any long-term guarantee. The high-trust relationship established between the supplier and buyer provided a very economical solution for the buyer. (McCutcheon and Stuart, 2000) How negotiations are conducted can often predict how the relationship will be between supplier and buyer. As a cautionary note, it is not necessary (or desired) for every partnership to become a strategic alliance, but prior to entering negotiations, it is important to understand the type of relationship desired.

Step 10: Qualify incoming products

After awarding a contract, but prior to accepting assemblies from a supplier, it is important to qualify and approve the parts and processes. The objective of this step is to ensure that the incoming product meets or exceeds quality specifications. Transferring lessons learned, undocumented knowledge, and clear specifications allows for a smoother transition of the product to the supplier.

Step 11: Manage supplier

> *During the past two decades, there has been a paradigm shift in the role of purchasing in many firms. Accordingly, purchasing has evolved from a mere buying function to a strategic function.* (Carr and Pearson, pg. 497, 1999)

The supplier partnership must be managed to provide product improvements and quality products throughout the sourcing relationship. The objective of this step is to manage the

supplier relationship and ensure the optimal relationship is promulgated. Not all relationships need to be close partnerships, but all suppliers need to be managed.

4.4.3 Phase 3: Select the Tools for Each Step

After the objective of each step is defined (i.e. Phase 2), it is important to develop a series of tools, procedures, and processes to allow the sourcing teams to complete the tasks. However, developing a comprehensive tool set must be tempered with feasibility. In other words, the number of tools should be sufficient to complete the strategic sourcing process successfully, but not so large that the process becomes overly burdensome. Additionally, it is important to ensure that the process is generic and adaptable to many products across the value chain. To complete this action at Axcelis, information was gathered from the Lean Enterprise group, sourcing teams, management, and academic research. Evaluating the tools based on their applicability, complexity, and criticality to success provided a useful method by selecting only the most important tools. The final selection of tools used at Axcelis is summarized in Table 2.

Sourcing Step	Tool	Explanation
Overall	Sourcing procedure	Documented procedure providing a step-by-step process for teams to complete the sourcing process
	Failure mode analysis (FMEA)	Formal method to understand the risks inherent in outsourcing
	Transition plan	Documented procedure for transitioning work to the supplier. Includes instructions for transferring inventory, engineering changes, and information
1. Identify the product	Strategic souring process	Presentation stating overview of strategic sourcing
	Strategic sourcing workshop	Workshop materials to complete make-buy decision
	Commonality assessment	Workshop materials to assess how common a product is across the product line
2. Identify and prioritize specific sourcing actions	Project plan template	High-level description of tasks required for sourcing a product
	Resource evaluation worksheet	Worksheet for teams to evaluate the internal resources required for sourcing a product
3. Identify potential suppliers	Supplier capability matrix	Matrix of previously reviewed suppliers. Provides list of their capabilities and competencies
	Industry lists	Lists from industry publications naming top suppliers
	Internet links	Links to helpful websites for selecting suppliers
4. Conduct supplier assessment	Pre-assessment survey	Electronic survey to gather basic information about a supplier's capabilities
	Commercial assessment	Comprehensive worksheet to evaluate suppliers
	Assessment visit materials	Generic letter and agenda for teams to use during supplier assessment visits
5. Perform an initial source selection	Supplier capability matrix	Matrix of previously reviewed suppliers. Provides list of their capabilities and competencies
6. Prepare bid package and request for quote	RFQ package checklist	Worksheet for teams to verify the RFQ is complete prior to providing the materials to a supplier
	Contracts and materials • Standard RFQ letter • RFQ guidelines • Statement of Work • Partnering agreement • Terms and Conditions • Confidentiality agreement	Provides standard forms, letters, and contracts for teams to use during quoting process
7. Analyze supplier bids	Total cost model	Evaluates financial impact of make-buy decision based on material, labor, overhead costs and any future cost reductions
	Bid analysis checklist	Verifies bid from supplier is complete
8. Conduct formal supplier conference	None	None
9. Negotiate and award contract	Negotiation strategy checklist	Defines strategy for negotiation process
10. Qualify incoming products	Part approval procedure	Guidelines for supplier quality engineers to qualify products
11. Manage supplier	Supplier management guidelines	Guidelines and recommendations for continued management of supplier relationship

Table 2: Final Selection of Tools for Sourcing Procedure

4.4.4 Phase 4: Develop the Tools for each Step

Because the tools will be used on a day-to-day basis, it is important to ensure that the final end users have input into the design. Although cross-functional teams working with a consensus-based decision approach can ensure that the tools are developed with the greatest amount of input, it can also require a significant amount of time and effort. To balance the conflicting goals of creating a robust process while keeping within a definitive time constraint, the tools have been developed using a simple decision matrix.

More specifically, the tools are evaluated based on their criticality to the sourcing process. If a tool is critical, developing it with a cross-functional team provides a high amount of input. A sub-team is adequate for tools of lower criticality. If the tool is of even lower criticality, an interview process provides is recommended. Finally, it is sufficient to independently develop tools with the lowest criticality to success. As an example, Table 3 shows how the tools for Axcelis were developed.

Criticality of tool to success of strategic sourcing	**High**	**Cross-Functional Team** Supplier capability matrix Resource evaluation worksheet
	Med to High	**Sub-team** Project Plan Pre-assessment survey Commercial assessment survey Part approval procedure Negotiation strategy checklist Failure mode analysis (FMEA) Standard contracts and materials Total cost model Strategic sourcing workshop materials Sourcing procedure
	Low to Med	**Interviews or Sub-Team** RFQ checklist RFQ letter Bid analysis checklist
	Low	**Independent development or Interviews** Industry lists / Internet links Assessment visit materials

Table 3: Decision Matrix for Sourcing Tool Development

At Axcelis, the majority of the tools have been developed with a sub-team composed of two to six people. Using sub-teams allows for a rapid development of the tools, while receiving adequate input and organizational buy-in. Furthermore, at least twice during the development process, all members of the sourcing teams (~25 people) met to review the tools and procedures.

Although the details of the four-phase methodology need to be tailored for the individual organization, the overall sourcing process and types of tools can be applied to many companies. The methodology of using a small sub-group to develop the tools and coordinate the design of the sourcing process allows for a faster development cycle. Additionally, continuity throughout the process and a point of contact for any questions or suggestions is also ensured. However, it is critical that end users have input into the process to incorporate best practices and achieve organizational buy-in.

4.5 An Example of Tool Development: Axcelis' Commercial Assessment Worksheet

Across Axcelis there is agreement that assessing the capabilities of suppliers is important for the success of strategic sourcing. Because strategic sourcing relies on suppliers providing complex assemblies with strict quality, delivery, service, and cost requirements, it is important to understand their abilities prior to any sourcing decision. At Axcelis there was little historical precedent to answer the question of how to assess suppliers. With no formal supplier assessment process in place, most of the supplier selection decisions were pushed down to the individual purchaser. Each purchaser assessed suppliers differently and little documentation was available to indicate the abilities of current suppliers. A two-person team therefore, developed a supplier assessment methodology for the strategic sourcing teams. Using the development of the supplier assessment worksheet as an example, insight is gained into how sub-teams are used to design strategic sourcing tools.

The sub-team was composed of two personnel, a purchaser and a member of the Lean Enterprise group. The first step of the sub-team was to understand the purpose and requirements for the worksheet. After discussion within the sub-team and input from leadership of the Lean Enterprise group and Materials organization, the sub-team determined the worksheet should permit the following:

- An evaluation on a variety of business and technical measurements to assess the overall health of the supplier
- An easy methodology to compare different suppliers
- A consistent assessment methodology. That is, suppliers can be compared even if different teams conduct the assessment
- An assessment that is applicable to all of Axcelis' products

To satisfy these requirements, the sub-team researched previous assessment techniques at Axcelis, academic journals, other companies, and input from existing suppliers. The assessment components most applicable to Axcelis were selected and incorporated into the assessment. For instance, a supplier assessment initiative recently introduced at the Rockville, Maryland site graphically displayed the results on the cover sheet, allowing a quick visual understanding of the supplier's capabilities. Additionally, Rockville's assessment evaluated a supplier on a variety of metrics: leadership, manufacturing, design and development, cost, quality, delivery, environment, health and safety, and procurement and supplier development. These metrics were compared to another benchmarked company and research conducted by Choi and Hartley. For example, the benchmark company assessed suppliers on financial, delivery/flexibility, quality, engineering technology, software, and supplier field support metrics; whereas, Choi and Hartley found the most common metrics used by companies in the automotive industry include finances, consistency, relationship, flexibility, technological capability, customer service, reliability and price. (Choi and Hartley, 1996) To help create a more objective assessment method, the same benchmarked company provided written criteria for each assessment question. That is, the company documented what conditions are required for a particular score. Additionally, the benchmarked company used a scale from one to five, one being the lowest score and five being the highest score. This technique matched the assessment process for software subcontractors on Motorola's Iridium project, in that the group found "that the rating system we had been using [i.e. a three-level system]...did not offer the fine granularity we needed to fully assess a supplier." (Nielsen and Miller, pg. 107, 1996) Therefore, to better distinguish suppliers from each other, Motorola changed the system to a five-level rating system.

The sub-team consolidated the information and selected the best practices to meet Axcelis' requirements. A five-level scoring system is used; one is the lowest score and five is the highest score. The supplier is assessed on a variety of metrics: quality, manufacturing, design and

development, business planning, customer relations and markets, cost, procurement and supplier development, field support and after market, and financial. Also, to enable an objective score, criteria now exist for each question. For example, a question and corresponding criteria in the manufacturing section is shown in Table 4.

Question	Score (1 to 5)	Criteria for scoring
Are the work instructions used throughout the manufacturing process detailed & current?		1 = There are little to no work instructions available for the manufacturing process. Most manufacturing is based from prints, partial instructions, or common knowledge. 3 = There are adequate work instructions for most manufacturing processes - however, some specialized or highly customizable work does not have detailed instructions. 5 = There are detailed instructions for all manufacturing processes readily available at all applicable work stations.

Table 4: Supplier Assessment Question

After the sub-team developed the assessment, teams were polled to help incorporate different ideas, receive feedback, and promote organizational buy-in. For example, though the final supplier scores summarized on the cover sheet originally ranged from one to five, several team members felt using a percentage would make it easier to understand the final results. Additionally, because teams can elect to answer only the applicable questions, the teams felt it would be useful to show the percentage of questions answered.

Feedback from a local supplier also introduced improvements to the assessment worksheet. For example, the supplier recommended clarification on several of the rating explanations and the importance of training the teams conducting the assessments. Using internal personnel and an outside supplier to review the assessment form was important to create a suitable assessment process. After the commercial assessment form was refined, senior leadership was asked to

review and approve the worksheet. The sub-team made final modifications and then the tool was assigned to a "tool owner".

A "tool owner" is a person on the sourcing team designated as the point of contact for the applicable tool. They act as the point of contact and answer any questions or problems the sourcing teams may have. The "tool owner" is also responsible for updating the tool and making any changes and modifications. In this instance, because the sub-team member from purchasing was assigned to a sourcing team, he became the "tool owner" for the supplier assessment form. Designating the "tool owner" is important for accountability, achieving organizational buy-in and for providing a sense of ownership by the sourcing teams. After the development of each tool, a "tool owner" was assigned. Representative questions from the final supplier assessment worksheet are shown in Appendix B.

Figure 11 provides a graphical depiction of the supplier assessment form creation process. Although this process was slightly modified for each tool, the overall methodology is the same. That is, first the requirements for the tool were developed. Then, the tool was created with the applicable members according to the decision matrix shown in Table 3. The tool was reviewed with the sourcing teams and approved by the applicable leadership. Finally, Lean Enterprise and the sourcing leadership transferred the tool to the "tool owners". Ensuring that the sourcing teams reviewed and provided input throughout the design process facilitated greater acceptance of the tools and associated processes.

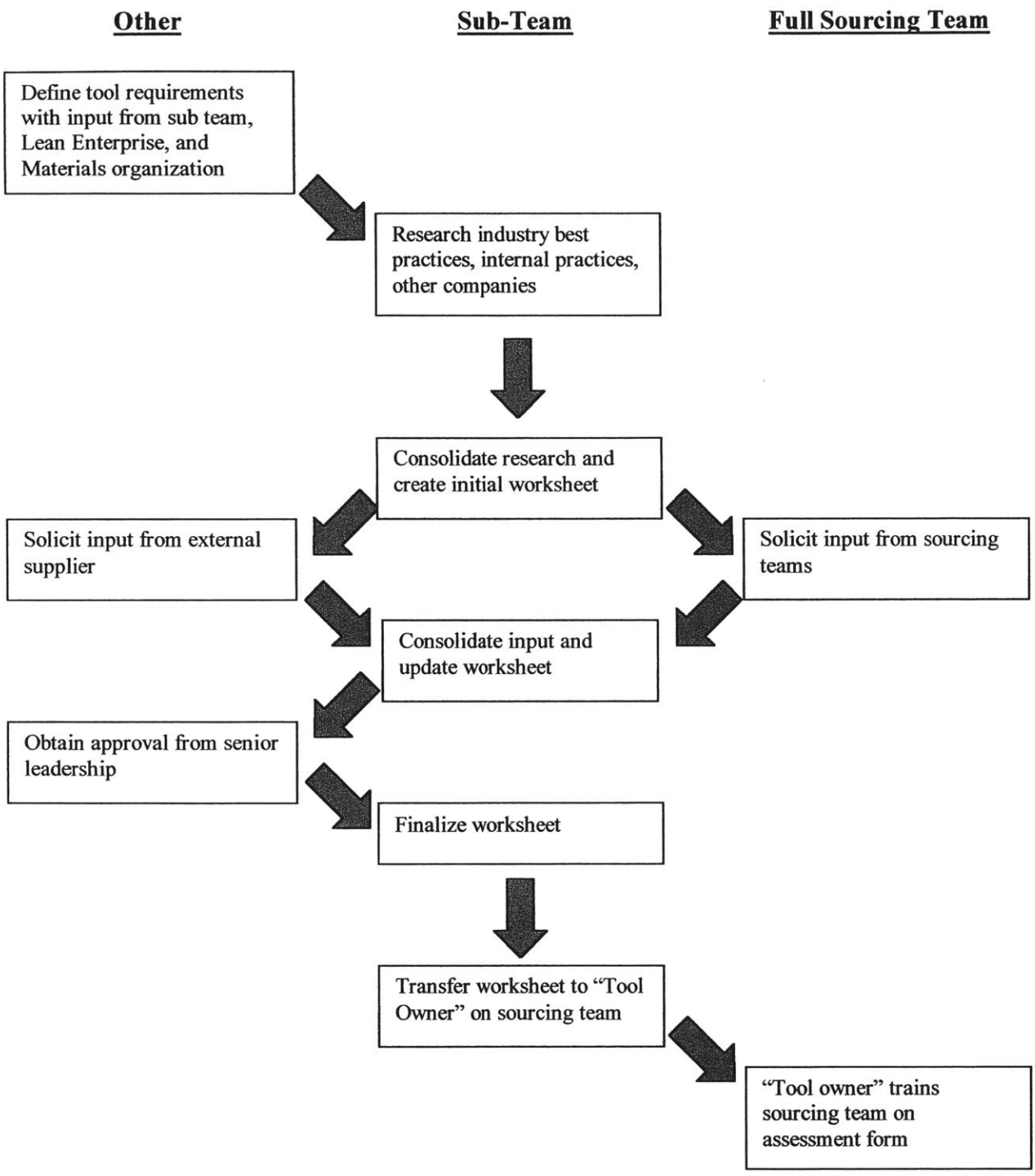

Figure 11: Supplier Assessment Development Process

4.6 Chapter Conclusion

This chapter discusses the reasoning for implementing the strategic sourcing initiative on commercial and near-commercial products and concluded that having an immediate impact on the business financials overrode the difficulties and challenges of sourcing products not designed for outsourcing. Additionally, this chapter describes the process steps, objectives, and types of tools for a strategic sourcing process. The methodology of developing the supplier assessment is similar to the other tools and shows the advantages of using a small sub-team to create the tools for the sourcing teams.

5.1 Chapter Overview

This chapter discusses how the strategic sourcing process was implemented at Axcelis and some of the organizational challenges that were encountered. Additionally, this chapter uses a recent outsourcing example from the Rockville, Maryland site to evaluate the performance of the new sourcing process. More specifically, because the Rockville site used an internal procedure, their results are compared to *what would have occurred* if the new sourcing process had been used. Finally, this chapter discusses some of the long-term business metrics that will improve because of the implementation of a strategic sourcing process.

5.2 Implementing the Strategic Sourcing Process

The previous chapter describes the methodology used in developing the sourcing steps and associated tools at Axcelis. However, implementing the process is a critical phase and can be the determinant for the success or failure of a new initiative. There are numerous recommendations found throughout management literature on how to implement change within an organization. For example, Ancona et al. describe a list of "ten commandments" for instituting change within an organization (Ancona et al., 1999):

1. Analyze the organization and its need for change
2. Create a shared vision and common direction
3. Separate from the past
4. Create a sense of urgency
5. Support a strong leader role
6. Line up political sponsorship
7. Craft an implementation plan
8. Develop enabling structures
9. Communicate, involve people, and be honest
10. Reinforce and institutionalize change

The list of "ten commandments" is a compilation of concepts and summarizes many of the components required for successfully instituting change within an organization. Although having a well-conceived change management program is important, the focus of this chapter is not to describe an overall framework for an organization, but to describe three specific tactics that enable the implementation of the sourcing process. These three tactics include the

implementation of the sourcing procedure by 1) involving employees 2) simplifying the procedure, and 3) ensuring accountability of the sourcing teams.

5.2.1 Involving Employees

An important method for soliciting input and promoting organizational buy-in is through the use of employees in the development and implementation of the sourcing procedure. For example, as described in the previous chapter, input from employees is assured by using a decision matrix (Table 3). Allowing all members of the sourcing teams to periodically meet and discuss changes to the process allows the sub-team to address questions and concerns. Also, because various members of the sourcing teams are involved during the development of the tools and procedures, the credibility of the development process is enhanced. Involving the members of the sourcing teams prior to the implementation allows the rollout of the process to proceed quickly and with little controversy. Additionally, after the process is formally implemented, managers commit to continue the all-member reviews on a monthly basis. Finally, the concept of "tool-owners" enables sourcing members to have an immediate point-of-contact after the rollout of the sourcing procedure.

5.2.2 Simplicity of the Process

The mantra of simplicity is a helpful concept in implementing the sourcing procedure. For example, prior to the development of the sourcing process at Axcelis, a form was available to collect information about a potential supplier such as name, location, phone number, and a list of general capabilities. However, the form was only available as an electronic template, and to collect the information from the supplier, the purchasing agent would first send the potential supplier the form electronically. The supplier would then need to print out the form, fill it out, and mail it or fax it back to the supplier. The purchasing agent would then place the document in their personal filing cabinet, since no common collection point existed, and most likely never look at the information again. It was not uncommon for multiple teams to contact the same supplier and ask for the identical information. Adhering to the goal of creating a simple process, the document now allows the information transfer to occur electronically and become part of an electronic database available to the entire organization. Although the new form provides similar content, it is easier to use and more accessible.

Ensuring the process is simple and easy to use facilitates the use of the procedures and the implementation of the process. A method for promoting simplicity is the development of an internal web site from which the sourcing procedure is accessible to the sourcing teams. During the execution of the sourcing process, the teams can utilize the web site to access all the tools, procedures, and sourcing processes. The web page is available to all employees and is simple to navigate and use. During the development of this site, employees provide suggestions to enhance the features.

5.2.3 Accountability of the Sourcing Teams

In the previous chapter, the use of "tool owners" was discussed. After a tactical tool or procedure is developed, the ownership is transferred to a member within the sourcing teams. This ownership includes the responsibility for maintaining tools and training others on their use, but it also empowers the members of the sourcing teams. Additionally, because most of the "tool owners" volunteer for this responsibility, it helps achieve organizational buy-in. Another method to drive accountability and verify that the sourcing teams are using the procedure is through a phase-gate review process. For example, prior to submitting a Request for Quote package to potential suppliers, the sourcing teams must demonstrate that they follow the overall sourcing procedure and use the tactical tools. Insisting on accountability is an important method for ensuring that the process is adopted.

5.3 Organization Challenges Found During the Implementation Process

During the implementation of the sourcing process at Axcelis, there were two significant organizational challenges. First, the senior leadership and sourcing teams needed to agree on what level in the bill of materials (BOM) the product should be sourced: senior leadership advocated as high a level as possible and the sourcing team members desired to start low in the BOM. The second challenge was identifying and then obtaining support of all involved constituents.

5.3.1 Agreeing on the Level of the Bill of Materials to Source

In general, the products designed and produced by Axcelis are considered integral products. An integral product architecture can occur when the product's subsystems are tightly woven together and it is difficult to separate assemblies. For example, Fine proposes that integral products feature:

- Components that perform many functions
- Components that are in close proximity or close spatial relationship
- Components that are tightly synchronized (Fine, pg. 134-135, 1998)

Modular product architecture, on the other hand, includes systems that are easily separable. For example, a typical personal computer is modular because the monitor, hard drive, modem card, microprocessor and printer are components that are easily removed. In general, Axcelis' products at a high level in the BOM are very integrated. Proceeding down the BOM, the assemblies become more modular. This architecture is depicted in Figure 12.

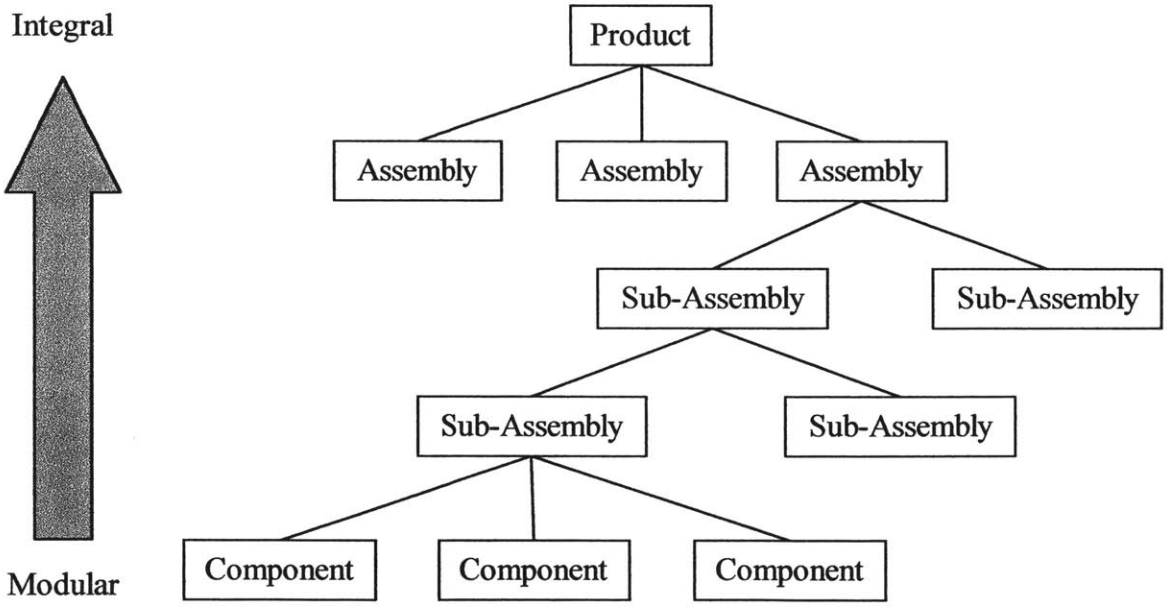

Figure 12: Typical Product Architecture

The understanding of integral versus modular is important because with all else being equal, sourcing a modular product to an external supplier is easier than sourcing an integral product. For Axcelis, during the implementation of the sourcing process, there was significant discussion at what level of integration should the product be sourced. Senior leadership felt the greatest

return on investment would occur by sourcing at the highest level of the BOM, whereas, the sourcing teams felt the greatest chance of success for sourcing would occur at the lower levels of the BOM. At first, the harder senior leadership advocated for sourcing at the higher level in the BOM, the harder the sourcing teams resisted. However, utilizing representatives from each group, concerns were discussed and the two groups reached a satisfactory compromise. Specifically, the sourcing teams now start at the higher levels of the BOM and move to lower levels only when it is unfeasible to source the product at the high BOM level.

5.3.2 Identifying and Incorporating Input from all Constituents

Implementing a major sourcing initiative will affect many different groups throughout the organization such as engineering, manufacturing, materials, quality, sales, and marketing. To help ensure the correct input is solicited, at Axcelis, cross-functional sourcing teams include members from engineering, value engineering, purchasing, manufacturing, supplier quality, and sales and marketing. However, an important issue not understood was who had decision-making ability within the organization. For example, although manufacturing had representatives on the sourcing teams, the output was not transferred to the decision-makers within the manufacturing group. This problem was also seen in the engineering, purchasing, and supplier quality groups. It was unclear if the systemic problem was poor information transfer between representatives and their leadership. Because the problem existed for nearly all the groups, decision-makers of the functional groups, team leaders of the sourcing groups, and an overall strategic sourcing leader now meet on a weekly basis to discuss the progress of the sourcing initiative. Additionally, this overall sourcing team is able to review the progress for each sourcing team and help transfer information from team to team. Finally, this overall sourcing team is now an important link to the senior leadership.

5.4 Evaluation of the Sourcing Process: A Case Study

In March of 2000, a senior manager from Axcelis' Materials Department was on an extended trip to the Rockville, Maryland site. During his visit and review of material management issues, the conversation turned to outsourcing, and more specifically, the strategic sourcing of assemblies. No formal decisions were made, but discussions of outsourcing became more prevalent throughout the company. As discussed in Chapter 3, the leadership within the company began to

feel strategic sourcing would allow Axcelis to focus on core competencies, leverage the expertise of industry leaders, reduce the bullwhip effect, and reduce the number of individual purchased parts. The strategic sourcing of assemblies was a relatively new idea for Axcelis and a formal standard procedure was desired to help control the sourcing initiative. However, to verify the advantages of strategic sourcing, the Maryland site sourced a pilot assembly *before* a formal procedure developed. The assembly is representative of many of the assemblies at Axcelis and has electrical, mechanical, and electric-mechanical components with approximately 750 unique part numbers. A team with responsibility for sourcing the pilot assembly was formed and consisted of a team leader, two purchasers, and a mechanical engineer.

The team began work in March of 2001 and was faced with sourcing a complex product in a short period of time. The sourcing procedure described in the previous chapters had not been started and the team faced the daunting task of completing the project without the benefit of a formal procedure or tools[1]. The Rockville team created their own methodologies to source the pilot assembly, thereby providing a test case on how a "typical" team would source a product. Comparing the actual results of the Rockville team to how the pilot assembly *would have been* sourced if the new sourcing process was used provides insight into the potential performance of the new sourcing process. Because the new sourcing process has not been used yet, the conclusions made are not absolute. However, detailed interviews of personnel at the Rockville and Beverly sites create sufficient confidence in the methodology to allow an initial assessment of the performance of the new sourcing process.

5.4.1 Results from the Actual Sourcing Process

Without the advantage of a formal sourcing procedure, the Rockville team began the process of sourcing the manufacturing of a relatively complex assembly. The team approached the sourcing initiative by leveraging individual experiences, team discussions, and input from senior leadership. The final methodology used would have likely remained unique; because no formal procedures existed, it is assumed a different process would have been created a different team.

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[1] The situation faced by the Rockville sourcing team was similar to most previous sourcing initiatives at Axcelis. In other words, because little documentation of past sourcing projects existed, the teams were left to their own methods to determine how to source a product.

The team did use the high-level, 14-step process as a guide, but few of the associated procedures and tools existed. For example, although the team had access to standard work contracts and confidentiality agreements, the team developed many tools such as assessment forms, negotiation tools, and bid analysis methods. Further, other than the high-level, 14-step process, the team needed to determine the sequence of events for the sourcing procedure.

Rockville's sourcing process took 241 days and the process was grouped into 56 tasks. The 56 tasks provided further details of the high-level, 14-step process and included items such as: identify potential suppliers, conduct supplier assessment, develop negotiation strategy, review supplier's assembly procedure, transition in-house inventory to supplier, and turn over production to the supplier. The team, in the end, successfully sourced the assembly to one supplier and received production quality assemblies into the Rockville procedure.

5.4.2 Results if the New Sourcing Process Was Used

Although more specific than the 14-step process, the 56 tasks described above are still general enough to match the new sourcing process. In other words, all 56 tasks in the actual sourcing process would have been completed in the new sourcing process. As an example, during the negotiation step, some of the formal process sub-tasks include reducing the number of suppliers based on assessments or the supplier conference, requesting a best and final offer (BAFO), receiving the BAFO, reviewing the BAFO, developing a negotiation strategy, negotiating with the suppliers, and selecting the final supplier(s). Because each sourcing process has the same number of medium-level tasks (56), the two sourcing methods could be compared by three metrics: when the task was completed, how long it took to complete the task, and how the task was completed. For example, one of the 56 tasks is a core/non-core evaluation[2]. In the actual sourcing process example, the core/non-core evaluation was started on day 132 and took one day. Whereas in the new sourcing process, the core/non-core evaluation would start on day one and take five days to complete; thus although the task is the same, the order and duration are different. Furthermore, the methodology to complete the tasks is different, and in the case of the core/non-core evaluation the new process uses a more thorough and comprehensive procedure.

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[2] An evaluation of whether or not the product under consideration is a core competency for the business. In general, a business should not outsource their core competencies.

Table 5 summarizes the tasks that varied in timing and/or duration from the *actual* process used by Rockville and the *new* process described in Chapter 4.

Task[3]	Actual Start Date	"New" Start Date	Actual Duration to Complete Task	"New" Duration to Complete Task
FMEA	Day 108 (Task 14)	Day 4 (Task 2)	-	-
Core vs. Non-Core	Day 132 (Task 19)	Day 1 (Task 1)	1 Day	5 Days
Test Strategy	Day 136 (Task 20)	Day 8 (Task 8)	3 Days	6 Days
Test Metrics	Day 146 (Task 22)	Day 13 (Task 9)	-	-
ID Suppliers	-	-	37 Days	10 Days
Pre-assessment	-	-	33 Days	20 Days
Prepare RFQ	-	-	5 Days	4 Days
Analyze Bid	-	-	7 Days	5 Days
Assessment	-	-	9 Days	15 Days
Review BAFO	-	-	8 Days	6 Days
Negotiate	-	-	29 Days	4 Days

Note: Tasks with no entry in Table 5 indicate that the actual and new process were consistent.

Table 5: Comparison of Actual Process and New Process

As shown in Table 5, four tasks had timing differences, whereas nine tasks had duration differences. The new sourcing process reduced the total duration to source an assembly by 39 days or sixteen percent.

Examining the core/non-core evaluation task in greater detail provides insight into some of the reasons for altering the timing, duration, and methodology in the new sourcing process compared to the case study. The core/non-core evaluation is an important step in determining if the product is suitable for outsourcing. If the product is a core competency, the company should be cautious of outsourcing those capabilities to an outside supplier. Because the evaluation determines if the product is suitable for sourcing, this evaluation should commence at the beginning of the process. In the actual Rockville case, this evaluation occurred at day 132, or after 56% of the total project time had elapsed. If the evaluation had determined the pilot assembly was a core competency and not suitable for outsourcing, unnecessary work and time

[3] FMEA: Failure Mode and Effect Analysis
ID: Identify
RFQ: Request for Quote
BAFO: Best and Final Offer

would have been spent sourcing an inappropriate product. Although the core/non-core evaluation determined that the product was appropriate for outsourcing in this case, as stated by a manager on the sourcing team: "[Although there were] no implications for the pilot assembly...some [other] assemblies were taken off the list." Completing the evaluation earlier is an improvement made by the new sourcing process. Additionally, the time to complete the evaluation is increased from one day to five days, allowing for a more comprehensive evaluation. Although the overall time to source an assembly is reduced, the core/non-core evaluation is increased to ensure that a better assessment is made. By utilizing input from functional experts within the organization, case studies like those at Rockville, best practices from industry, and academic research, companies can create a leaner and more comprehensive sourcing process than could be developed by an individual team.

5.5 Long-Term Goals of the Sourcing Process

As products are strategically sourced throughout the organization, the company expects to see an increase in benefits as measured on a variety of metrics. Chapter 3 stated that the impetus for sourcing products at Axcelis was to focus on core competencies, leverage the expertise of industry leaders, reduce the bullwhip effect, and reduce the number of individual purchased parts. The long-term metrics to determine the success of the sourcing initiative are:

- Inventory turns
- Number of suppliers
- Manufacturing floor space
- Product factory margin
- Cycle time

5.5.1 Inventory Turns

As a more efficient supplier relationship is developed, the number of days of inventory should decrease since the external supplier will hold (i.e. own) the inventory until required by Axcelis. However, transferring ownership of inventory will require innovative solutions because many of Axcelis' assemblies are of low volume that are configurable at any time during the manufacturing process. The supplier may be unwilling or unable to hold all possible configurations and therefore, managing the supplier relationship will be a critical part of this sourcing procedure. For example, providing transparent forecast information to suppliers, redesigning the product so that the specialized configuration occurs at the final step, or

developing risk-sharing contracts may help create a better solution for all parties involved. The final step of the sourcing process (i.e. Step 11) is Subcontract Management and these issues must be addressed as the sourcing initiative evolves.

5.5.2 Number of Suppliers

Another metric used to measure the success of the sourcing process is a reduction of the number of suppliers. However, a more accurate statement should be a reduction of the number of primary suppliers. For example, if an assembly requires sub-assemblies and components from ten suppliers, and that assembly is then sourced a single supplier, Axcelis will only need to manage one primary supplier. Of course, it is important to select a primary supplier with adequate supply chain and material management capabilities or the sourcing of the assembly may create additional problems.

5.5.3 Manufacturing Floor Space

As assemblies are sourced from the manufacturing facilities, an increase in floor space will occur. Instead of maintaining the space to manufacture an assembly, the factory floor instead only needs to allocate space to hold the final assembly as it is integrated into the machine. Because many of the assemblies are produced in a clean room environment this will help reduce the need to increase the floor space, and therefore reduce manufacturing overhead requirements. By sourcing the assemblies to an external supplier, it is easier to increase or reduce manufacturing capacity.

5.5.4 Product Factory Margin

Leveraging the skills and scale of external suppliers, product margins should also increase. If an assembly requires a large amount of aluminum for example, a large supplier may have increased buying power and provide a reduction of cost. Additionally, if a supplier has expertise in a certain area, they may be more effective at reducing costs with design improvements and cost-out efforts. The ability for suppliers to improve the cost of the product will help improve product margins for Axcelis and the supplier.

5.5.5 Cycle Time

The time to produce an assembly includes material ordering and procurement, manufacturing, final integration and test, and delivery. By improving the material management of the assemblies and subsequent parts, the suppliers should help improve the cycle time of the manufacturing process.

5.6 Chapter Conclusions

Implementing change within an organization is a challenging process that elicits numerous emotions from all levels of the organization. Three tactics to help ensure a smoother implementation include involving employees, simplifying the procedure, and requiring accountability of the sourcing teams. At Axcelis, organizational challenges were observed during the implementation, but by ensuring a better transfer of information these challenges were overcome. Using a case study method to evaluate the potential performance of the new, formal sourcing process, it was determined that the new process could save significant time (~16%) during the outsourcing of a product. Finally, this chapter concluded with a review of some of the long-term metrics that Axcelis expects to improve as the implementation of the sourcing process continues.

> *When firms do not explicitly acknowledge and manage supply chain design and engineering as a concurrent activity to product and process design and engineering, they often encounter problems late in product development, or with manufacturing launch, logistical support, quality control, and production costs.* (Fine, pg 133, 1998)

6.1 Chapter Overview

The strategic sourcing process described in this project focuses on commercial and near-commercial products. The purpose of this chapter is to describe an initial framework for integrating the supply chain into new product development. This issue is examined by addressing three aspects of the organization: people, processes, and technology. More specifically, this chapter will discuss the integration of the supply chain into new product development through three questions:

- How should the organization be setup? (people)
- What procedures should be established? (process)
- What technology is required? (technology)

This chapter discusses several ideas and methodologies, but it is intended that Axcelis and similar companies utilize these thoughts as a springboard for a more comprehensive analysis. In other words, the ideas proposed in this chapter should provide interesting starting points from which to conduct future research into how companies can better integrate the supply chain into new product development.

6.2 People: How Should the Organization be Setup?

Successfully integrating supply chain issues into new product development requires competent cross-functional teams. Cross-functional teams provide a forum for different groups in the organization to help shape the design and development of a product early in the design phase. Four critical factors that impact the success of teams and the new product development process are:

1. Senior management vision and leadership
2. A clear and formal reporting / authority structure
3. Appropriate incentives, rewards, and measurements
4. Significant participation from the supplier

6.2.1 Senior Management Vision and Leadership

Having a clear and executable vision promulgated by senior leadership is important for two distinct reasons. First, the initial implementation of supply chain integration is a tremendous mental shift for an organization and requires senior leadership to keep the initiative active and heading in the right direction. Although the integration will be very beneficial, the process will often be complicated and require significant resources. Showing long-term commitment to supply chain integration helps instill a sense of importance to the project. Of course, this commitment must be tempered with accountability, but the active involvement of the senior leadership helps ensure the program remains focused and on track. The second reason senior leadership is required occurs during the period when teams are executing the new product development process. During a study of concurrent engineering, Componation, Utley, and Armacost found that the two most important components leading to the success of development teams are "leadership" and "support for [concurrent engineering] CE teams". The ability of senior management to provide leadership, support, and a clear vision will provide the credibility, enthusiasm, and authority the teams need to succeed. In other words, by senior management becoming an active and visible participant in the new product development process, the teams will have a better chance of success.

There are many methods senior management can use to get involved with the teams, such as formal participation on an overall steering committee and periodic reviews with the teams. Furthermore, the leadership should also take advantage of informal methods, such as periodically visiting weekly team meetings, expressing interest through "management by walking around", and maintaining and encouraging open door policies. Applications of these techniques can vary, but Table 6 highlights some of the methods senior management can use to provide leadership and support for the cross-functional teams.

Method	Activity & Frequency	Goal	Positive effects	Negative effects
Formal Process				
Review board meeting	Team meets with leadership board at pre-scheduled points in the product development process to review progress	Review team's progress at designated gates Maintain focus of the team	Formal "phase-gate" process Focuses team Keeps senior leadership informed	Addresses only high level issues Long period between meetings
Periodic status meetings	Team meets with a smaller review board on a routine and frequent basis ~ twice a month	Review team's actions on a more periodic basis Maintain team's accountability	More frequent reviews keeps leadership more involved Allows leadership to assist on many issues	Perception of micro-management Burden for team to prepare information
Routine communication	Senior leadership provides periodic email / memo highlighting and reinforcing vision and goals of the project ~ twice a month	Demonstrates commitment and involvement by senior leadership	Easy to generate Reinforces vision and expectations	Communication is only one-way
Informal Process				
Attending team meetings	After informing team lead, a member of the leadership board attends a meeting or part of a meeting ~ once a quarter	Demonstrates commitment and involvement by senior leadership Visibility to day-to-day workings of team	Allows team members to see senior management is committed Insight into daily problems / activities	Senior leadership presence may impact the effectiveness of the meeting Meeting may be altered because of senior leadership
Management by Walking Around	Members of senior leadership take an active role by "walking around" ~ several times per week	Demonstrates commitment and involvement by senior leadership Helps senior leadership understand the real problems	Senior leadership can get real-time information & insight into daily problems / activities	Requires time of senior leadership in an already full schedule Perception of micro-management
Open-door policy	Senior leadership encourages employees to stop-by As required by employees	Demonstrates commitment and involvement by senior leadership	Allows team members to see senior management is committed	Policy not utilized May encourage individuals to over-step their bounds May encourage "whining"

Table 6: Methods for Leadership to Participate in New Product Development Process

6.2.2 A Clear and Formal Reporting/Authority Structure

In addition to the leadership and vision provided by senior management, how the teams are structured in terms of roles, responsibilities, and formal authority is important to the success of the integration. The method teams use to make choices and reach decisions is also critical to their success. The opinion presented in this section asserts that the cross-functional teams should operate primarily by consensus to achieve results and organizational buy-in. However, the structure must be able to support and react to times when the consensus is not in-line with the vision or consensus cannot be reached. There are numerous organizational layouts that can achieve this, but any design should clearly define the reporting structure and roles and responsibilities of the members. In other words, although consensus may be the goal for the team, the ultimate authority/decision maker should be clearly defined and understood by all members.

Each team should also have a clear understanding of roles and responsibilities. For example, the team as a whole should be responsible for the product design and development, preparing information for review board meetings, and managing any key extended team activities. Each project team member should be responsible for sharing the responsibility for the success of the project, bringing their expertise to the team, and managing the extended teams in their respective department. Finally, the team lead should act as a project manager, team facilitator, and the main communication conduit to senior leadership.

Another critical issue the team must understand is how decisions will be made, who has the final decision authority, and who is the team accountable to. In general, it should be left to the team to determine how decisions will be made and may include methods such as majority vote, consensus, or near-consensus. What happens if the team cannot reach a decision? Although the final decision-maker could be the review board, the team leader, or another person in a leadership role, it is critical for the team to understand who has the final authority. In addition, each team member must understand how their participation on the team impacts their day-to-day accountability. Some of the questions that must be addressed and clarified are:

- Who manages the day-to-day actions of the team members?

- Who provides input on performance evaluations?
- What are the bounds of the team leader? In other words, can the team leader hold individuals accountable for their actions?

6.2.3 Appropriate Incentives, Rewards, and Measurements

After the teams understand their roles and responsibilities, how decisions will be made, and the authority structure, it is important for senior leadership to design the correct metrics and incentives to drive team behavior towards the end-goal. Although some of the rewards should be based on individual performance, it is also critical to hold individual members responsible for the success of the entire team. Rewards and benefits can consist of raises, bonuses, gift certificates, cafeteria vouchers, stock options, etc., but the end-goal is to help reward and drive productive behavior. Personnel must also be held accountable for actions that may be counter-productive to the team, the product, or the company.

The supplier should also become an integral part of the cross-functional team, and it is appropriate to establish similar incentive programs with suppliers. Although a formalized risk/reward agreement may not determine the success of supplier integration into new product development, it can help avoid problems and create a more trusting relationship between companies and the supplier. (Ragatz, Handfield, and Scannell, 1997) Risk/reward agreements can take many forms, such as profit sharing, sharing of design costs, and innovative contracts, but the end-goal is to help drive the supplier to the vision of the buyer.

The ability to drive the team towards the end vision often results from choosing the correct metrics and measurements. As an example, suppose a company's vision for integrating the supply chain with new product development includes items such as a greater focus on the customer, faster time to market, lower overall cost, higher quality, and better product performance. Although these goals are fairly generic and each company's vision may be more specific, several metrics for the cross-functional teams can be created. As an example, Table 7 identifies various metrics the company could use to evaluate the performance of individuals and the team. The final choice of metrics should be tempered by ensuring that the metric is measurable, drives the right behavior, and is manageable.

		VISION				
		Focus on customer	Time-to-Market	Cost	Quality	Product Performance
METRICS	Development time	X	X	X		
	Time-to-market	X	X	X		
	Engineering changes		X	X	X	
	Manufacturing cycle time		X	X	X	
	Time in final integration			X		
	Factory square footage			X		
	Number of suppliers			X	X	
	Product factory margin			X		
	Product market share	X				X
	Customer orders	X			X	X

Table 7: Linking Metrics to the Vision

6.2.4 Significant Participation from the Supplier

The composition of the cross-functional team within the company is important, but a critical member that will become more important as the supply chain is integrated is the supplier. Ragatz, Handfield, and Scannell use an extensive survey to determine what factors contribute to the success of supplier integration into new product development and found that the top three factors are:

- Supplier membership/participation on the buying company's project team
- Direct cross-functional inter-company communication
- Shared education and training (Ragatz, Handfield, and Scannell, 1998)

The article discusses other statistically significant factors, but as shown by the top three factors, the common theme is frequent and active participation by the supplier. The supplier should become an integral part of the cross-functional team and, depending on the product, can participate through web conferences, phone calls, emails, visits, or in some cases, co-location. Despite the method of interaction, the key should be recognizing that suppliers are a critical component and that the level of participation should be tailored to the scope of the project.

The converse of integrating the supplier is ensuring that the company can disengage from a supplier if the relationship is unsatisfactory or complete. These issues must be thought of at the *beginning* of a relationship or decisions such as control of intellectual property, design and

manufacturing competence, or long-term contracts may prevent disengagement. There are numerous issues that may affect the ability to disengage from a supplier, including:

- Control of intellectual property
- Number of suppliers (e.g. single-sourced)
- Maintenance of capabilities
- Type of long-term contracts

The ability to manage suppliers and understand the relationship and implications of that relationship must become a core competency for companies focusing on long-term strategic sourcing initiatives.

In summary, there are four critical factors regarding the setup of the organization to successfully integrate the supply chain into new product development: senior management vision and leadership, appropriate rewards, incentives, and measurements, a clear and formal reporting/authority structure, and significant participation from the supplier

6.3 Process: What Procedures Should be Established?

Although having a clear organizational structure is important, it is also critical to have established procedures for how teams should integrate the supply chain into new product design. This section presents an initial generic framework for integrating the supply chain into new product development. The first step in the procedure is to use suitable decision criteria to determine the level of supply chain integration. The second step is to follow a detailed process on how to integrate the supply chain into new product development.

6.3.1 Decision Criteria to Determine the Level of Supply Chain Integration

McDermott and Handfield argue that a decision criterion for determining the level of supply chain integration and type of concurrent engineering initiative should be based on the type of product design: incremental or radical[4]. (McDermott and Handfield, 2000) They argue that because there is significant risk and uncertainty inherent in radical design, a better design can be

[4] The definition of a radical design is open to interpretation, but for this thesis, a radical design is a disruptive technology that fundamentally changes the previous method. As an example, McDermott and Handfield suggest "radical innovations [as opposed to incremental improvements] include the shift from piston aircraft engines to turbojets, the change from steam to diesel electric locomotives, or the move from core to semiconductor memory." [McDermott and Handfield, pg. 41, 2000]

achieved through a methodical approach vice a concurrent engineering approach. This conclusion aligns with how many companies conduct research and development. However, the more interesting conclusion is that the type of supplier relationship and required supply chain actions vary significantly depending on whether the design is incremental or radical. McDermott and Handfield state, "our study found that...the relative degree of supplier integration required for success increases significantly as" the design becomes more radical. (McDermott and Handfield, pg. 46, 2000) In other words, a radical design approach requires different and more comprehensive supplier management than an incremental design approach.

To understand the design process and what tangible actions should be taken, it is helpful to examine a factor not discussed by McDermott and Handfield; that is, the complexity of the product. Complex designs require different types of supplier management techniques than simple designs. By evaluating a design based on its type (radical or non-radical) and its complexity (low or high), teams can make a better evaluation on the type of supplier integration. Table 8 summarizes the initial decision criteria described above, as well as recommended actions.

			High	Medium	Low		High	Medium	Low
Type of Innovation	**Radical**	Level of senior leadership focus and involvement	✓			Level of senior leadership focus and involvement	✓		
		Use of cross functional teams and concurrent engineering approach		✓		Use of cross functional teams and concurrent engineering approach		✓	
		Level of supplier participation		✓		Level of supplier participation	✓		
		Discussions of supply chain production issues		✓		Discussions of supply chain production issues			✓
		Ex: Post-It Notes				Ex: Initial R&D research on breakthrough technologies			
	Non-Radical	Level of senior leadership focus and involvement			✓	Level of senior leadership focus and involvement	✓		
		Use of cross functional teams and concurrent engineering approach		✓		Use of cross functional teams and concurrent engineering approach	✓		
		Level of supplier participation			✓	Level of supplier participation	✓		
		Discussions of supply chain production issues	✓			Discussions of supply chain production issues	✓		
		Ex: "New and Improved" dish detergent				Ex: Pentium IV (from Pentium III) Ex: Windows 2000 (from Windows 98)			
		Low Complexity				**High Complexity**			
		Type of Product							

Table 8. Decision Criteria for Determining how to Integrate the Supply Chain

As shown in Table 8, the greatest requirement for supply chain participation occurs for products of high complexity. However, the type of supply chain integration varies as a high complexity product transitions from radical to a non-radical design. For example, a radical design of high complexity requires a significant level of involvement based on trust and information sharing with emphasis on producing a radical design. As the design transitions to a non-radical design, it then requires increased discussion on supply chain production issues (e.g. modularity, test specification development, etc.), an increased emphasis on cost reduction and consistent quality, and a greater reliance on cross-functional teams.

Using the lower right-hand quadrant as an example (i.e. radical design with high complexity), insight into how supply chain issues should be addressed in the new product development cycle can be obtained. For example, the project should have high visibility with senior leadership, as well as a strong cross-functional team. Additionally, the supplier should be an integral part of the team and may be co-located if warranted based on the scope of the project. Also, supply chain production issues should be a significant part of the design process. In other words, design issues such as material selection, modularity, testing, aftermarket service and repair, shipping, packaging, and commonality across machines should be addressed from a sourcing perspective. As a note, a similar discussion is not desired when a radical design is being developed because the focus should be on developing a radical design and not the specific sourcing strategies. However, as the product design transitions from radical to non-radical the supplier relationship should be adjusted to meet the requirements shown in Table 8. By understanding why supply chain requirements vary and which quadrant is applicable for a particular assembly, the optimal type of partnership can be employed for internal sourcing groups and external suppliers.

6.3.2 Process for Integrating the Supply Chain into New Product Development

After determining the level of supply chain integration, it is important to follow an established procedure to ensure that the maximum benefits are achieved. A five-step generic process can be tailored based on the type of assembly and which quadrant (Table 8) is applicable. The five-steps are: selection, involvement, sharing, execution, and feedback.

6.3.2.1 Step 1 - Selection

The selection step consists of first identifying the level of sourcing integration and the type of supplier relationship desired (Table 8). Additionally, this includes the selection of the members of the cross-functional team and the organization of the authority and reporting structure for the team. Initial selection of the supply base and type of relationship desired should also begin in this step. For example, the team should begin to ask and answer questions such as:

- What capabilities should the supplier have?
- Should the supplier relationship be a close alliance? At arms-length?
- Is it critical for our company to control the intellectual property?

An important question posed above is the type of supplier relationship; that is, should the relationship be a close alliance or at arms-length? Although alliance partnerships can provide significant benefits, not all partnerships should be alliance based.

> *While a firm may benefit from establishing alliances with a few key suppliers, it may be better served to maintain arm's length contractual relationships with its suppliers of lower-importance inputs. One firm, the UK computer manufacturer ICL, found this out the hard way. Its initial attempts to treat all its suppliers as partners led to excessive relationship development costs. Additionally, many suppliers did not feel that the special relationship was warranted and preferred a less intensive form of communication.* (McCutcheon and Stuart, pg. 283, 2000.)

Thus, the goal is to understand which relationships should be an alliance and which should be held at arms-length. One method to evaluate the type of relationship - alliance, arms-length, or somewhere in between - is to combine part of Table 8 and work done at Michigan State University (Monczka et al., 1997). This decision criterion is shown in Table 9 and helps evaluate the type of supplier relationship based upon design complexity and type of design work done by the supplier.

		Type of Relationship: Alliance or Arms-Length?			
Type of Product	**Low Complexity**	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%
	High Complexity	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%	Alliance: 100% Alliance: 0%
		None[5]	**White Box[6]**	**Gray Box[7]**	**Black Box[8]**
		Type of Design Relationship (Monczka et al, 1997)			

Table 9: Decision Criteria for Determining Type of Supplier Relationship

[5] None: No supplier involvement. Supplier "makes to print".
[6] White: Informal supplier integration. Buyer "consults" with supplier on buyer's design.
[7] Gray: Formalized supplier integration. Joint development activity between buyer and supplier.
[8] Black: Design is primarily supplier driven, based on buyer's performance specifications.

As shown in Table 9, the strongest alliance should occur for "Gray Box" type designs of high complexity. Using a simple decision matrix can help companies avoid choosing the incorrect type of relationship structure.

6.3.2.2 Step 2 - Involvement

Throughout the design process, but especially at the beginning, senior leadership and the team lead should ensure all team members clearly understand the vision. Also, senior leadership should express interest in the project by periodically attending routine meetings, asking for informal status reports, and so on. How suppliers and team members are involved is also a critical component of this step. Furthermore, the amount of supplier involvement in the process should be established and should address issues such as reporting structure and co-location. Finally, senior leadership working with the teams should establish the key performance metrics that the team will be measured and evaluated on.

6.3.2.3 Step 3 - Sharing

An important component for this process is the ability to share information between different groups and different companies. This should include establishing a clear methodology to share information through the use of technologies such as email, common CAD/CAM systems, Electronic Data Interchanges (EDI), and web and video conferencing. Furthermore, it is important, especially in close alliances, to share information such as customer requirements, costs, technology, product roadmaps, and industry roadmaps. As the information sharing is increased, companies may become more concerned about the disclosure of proprietary information.

> *A major barrier to open communication and information sharing for many companies is a concern over disclosure of proprietary information. This can be alleviated to some extent by the use of formal confidentiality agreements. Such agreements set the groundwork for information sharing, but at some level, the sharing must be based on trust between the parties. Solid buy-in and commitment of top management in both firms can help to establish an environment of trust, but often the only way to firmly establish a trusting relationship is to perform over time and earn the trust of the other party.* (Monczka et al., 1997)

Companies should be prepared and willing to share more information as the relationship increases and a careful evaluation should occur by the cross-functional team to ensure that the

proper confidentiality agreement is utilized. However, companies must understand that for the best type of relationship, trust may often be a more significant factor than legal contracts.[9]

Another method to share information should include increased training and education to ensure members of the cross-functional teams have a basic understanding of key technologies and requirements. Understanding of the product and its key characteristics is critical, as shown using an example from Fine's book *Clockspeed*:

> *...Intel had historically used a mounting system that relied on nine small machined metal pins to support contact between the chip and the board. Annual sales volumes of the new product were expected to be approximately 100 million units; thus, 900 million machined metal pins would be needed. Exploration of the capacity characteristics by Intel's supply chain team revealed that in the entire world there were not enough of the type of machine tools for making 900 million machined pins! Needless to say, this work on the key supply chain characteristics, done early in the design process so that the product features could be redesigned, prevented what could have been a disaster for one of Intel's key product launches.* (Fine, pg. 194, 1998)

6.3.2.4 Step 4 - Execution

The previous steps discussed establishing a team and the vision, reporting structure, performance metrics, type of relationship, and the methodology to transfer information. This foundation is critical to help ensure the team can successfully integrate the supply chain into the new product development process. Another facet should be a concerted effort to identify several key supply chain actions that must occur during the new product development (NPD) process. That is, when executing the process, what are the key leverage points in the NPD process where supply chain issues should be addressed? An appropriate methodology to determine these key leverage points is to conduct several workshops with a cross-functional team whose members represent different departments and understand the NPD process. In general though, supply chain issues should be addressed early in the NPD process and should be specific enough so that the cross-functional teams can understand the impact to sourcing the product.

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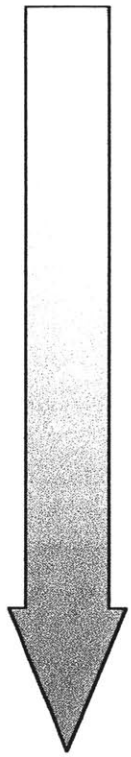
[9] McDermott and Handfield support this conclusion as they found that successful supplier involvement in radical design involved a greater reliance on trust and little use of formal contracts.

6.3.2.5 Step 5 - Feedback

As the integration process is completed, it is critical to provide feedback and an evaluation of the steps. For example, the team and senior leadership should periodically monitor and review the key performance metrics to ensure they are still applicable. Also, the teams should constantly evaluate which quadrant (Table 8) the design process is in, and then modify the supplier relationship and type of supply chain integration to ensure the best product can be designed.

Table 10 summarizes the four steps to incorporate the supply chain into new product development.



Selection • Identification of the type of supply chain integration (Table 8) • Selection of team members on the cross-functional team: experts & willing participants • Selection of supply base and evaluation of type of partnership required	Preparation
Involvement • Promulgation of vision by senior leadership and team lead • Description of team member involvement in the process (e.g. supplier co-located, purchasing member assigned 100%, etc...) • Establishment of clear performance targets	
Sharing • Establish methodology to share information across team and to other groups that may be impacted • Training and education • Increased emphasis on creating a trusting partnership with the supplier. This may include less emphasis on contractual agreements and more emphasis on treating the supplier as an extended enterprise	
Execution • Completion of several key "supply chain" actions in the NPD process	Action
Feedback • Periodic review of process (specific and general) • Periodic evaluation of project metrics	Review

Table 10: Steps to Incorporate the Supply Chain into New Product Development

6.4 Technology: Selecting the Right Technology

Successful supply chain integration requires companies to share information quickly, accurately, and easily. Utilizing the right technology is important to help ensure the seamless integration of the supply chain into new product development. More specifically technology can enable better communication between team members and more efficient exchange of design ideas. These two reasons are in-line with academic studies that surveyed numerous companies and individuals regarding concurrent engineering and new product design. For example, based on a literature review and focus groups, Componation, Utley, and Armacost found that the most important components of technology and concurrent engineering are:

- Technology to support communications between [concurrent engineering] CE team members
- Software to support coordination of team activities
- Technology to support integration of design activities
- Software applications to support concurrent design (Componation, Utley, and Armacost, 1999)

As another example, Ragatz, Handfield, and Scannell found that a significant factor for the success of integrating suppliers into new product development is the use of "common and linked information systems (EDI, CAD/CAM, e-mail)." (Ragatz, Handfield, and Scannell, pg. 195, 1997) Although the implementation of an efficient technology suite is important, it is also important to ensure that resources are utilized to increase value-add work as opposed to using technology for technology's sake. Table 11 describes different technologies and if they are essential, recommended, or optional for the new product development process.

Essential	Description	Primarily For:	
		Communication	Design
E-mail	Common form of communication. Depending on relationship, may provide supplier with company email and access to company intranet.	X	
Conference calling	Common method of communication that provides an easy way to involve members from various location	X	
Common CAD systems	Allows easier transfer of designs from supplier(s) to buyer and vice-versa		X
Electronic Data Interchange (EDI) or similar method via Internet	An electronic method to exchange and process documents in a method that is compatible for all parties	X	X
Recommended			
Video conferencing	Provides a more robust method of communication other than email or phone conferencing.	X	
Web-based conferencing	Allows an easier and more robust method for conducting presentations and exchanging information	X	
Common Internet site	Provides a communication forum, as well as a repository for designs, documents, communiqué, etc...	X	X
Optional			
Linked CAD/CAM systems	Allows "seamless" transmission and work on designs by all members at all locations		X
Network coordinated copiers / printers / faxes	Provides an easy method to transfer documents electronically to a variety of different mediums	X	
Strategic sourcing software /	Companies provide software and training to help implement and integrate sourcing decisions into new product development.	X	X
Supply chain management collaborative software	Tools such as collaborative design and project management	X	X

Table 11: Evaluation of Technologies for Incorporating the Supply chain into New Product Development

6.5 Chapter Conclusions

Thoughtful integration of the supply chain into new product development will help develop a better product faster and at a lower overall cost, and therefore help create real value. However, if it is not implemented and executed properly, it can result in a process that is expensive, ineffective, and problematic. This chapter outlines several components to help companies properly incorporate sourcing decisions into new product development. First, the organization should be structured to promote the use of cross-functional teams with members from applicable internal departments as well as external suppliers. Furthermore, a clear and executable vision should be promulgated and continually reinforced by senior management and the team leader. Second, this chapter developed a decision matrix to help determine the type of supply chain integration that should occur. After this decision is determined, the teams should incorporate the supply chain into new product development using a five-step process that consists of selection, involvement, sharing, execution, and feedback. Also, this chapter recommends that the identification and implementation of key leverage points in the new product development process is critical to the success of the integration of the supply chain incorporation. Third, this chapter suggests several technologies to help the incorporation of the supply chain into new product development. By reviewing the three factors of people, processes, and technology, this chapter describes an initial framework on how to successfully integrate the supply chain into new product development.

7.1 Chapter Overview

Axcelis Technologies is a company that designs, manufacturers, and develops high technology, low volume capital equipment products for the semiconductor industry. Axcelis' position in the supply chain makes them particularly vulnerable to the booms and busts inherent in the industry. Managing these cycles is a large concern and the point of focus for several initiatives within the organization. This thesis addresses a specific initiative at Axcelis, strategic sourcing.

7.2 Translating Strategic Concepts into Tactical Tools

Translating strategic thoughts into tactical tools is a primary goal for this thesis. In other words, although strategic concepts are critical to develop a vision and plan for an organization, it is also important to provide employees with the tools and processes to execute that strategic thought. However, as companies and organizations design tactical processes, the applicability of the tactical tools to other companies is reduced. For example, although the strategy of completing supplier assessments may hold for a large, high-volume company like General Motors and a small, low-volume company like Axcelis (strategic), the methodology by which the assessment is completed will vary (tactical). This project presents a tactical four-phase strategic sourcing framework applicable to companies with low volume, high technology products. The structure communicated in this thesis discusses a high-level, 11-step process for strategic sourcing and a methodology for defining, developing, and implementing tactical tools for the process.

7.2.1 The Overall Process

The four-phase framework to source a product is relatively generic and valid for many companies and industries. Furthermore, the 11-step process presented in phase one of the framework provides general guidance for companies completing sourcing initiatives so that the tasks can be split into manageable segments. Eleven steps were selected because it provided adequate detail while not making the process appear burdensome. Specifically, the 11-step process is as follows:

1. Identify the product
2. Identify and prioritize specific sourcing actions
3. Identify potential suppliers
4. Conduct supplier assessment
5. Perform an initial supplier selection
6. Prepare bid package
7. Analyze supplier bids
8. Conduct formal supplier conference
9. Negotiate and award contract
10. Qualify incoming products
11. Manage supplier

7.2.2 Defining, Developing, and Implementing the Tactical Tools

To complete the 11-steps, the sourcing teams require a formal procedure and tactical tools. This thesis summarizes the tools and objectives created for the sourcing process by Axcelis; however, more importantly, the project presents a framework by which others can develop a similar process. Using a decision matrix to select the method (cross-functional team, sub-team, interviews, or independent development) for developing the tactical tools helps establish organizational buy-in, create effective tools, and reduce the development time. Designating ownership of the processes and procedures to "tool owners" ensures accountability and knowledge transfer to the sourcing teams.

7.3 Validating the Process

The use of a case study helped determine the effectiveness and attributes of the new sourcing process. Because no formal sourcing methodology previously existed for the company, teams (such as the Rockville sourcing team) needed to create a procedure on an independent basis. This re-creation of tools, procedures, and processes is time consuming, inefficient, and can lead to poorer execution of the sourcing process than if a formal sourcing procedure were present. Reviewing the actual process used at Rockville compared to *what would have occurred* if the new sourcing procedure were used, two observations are made. First, using the new sourcing process could have reduced the time to outsource an assembly by 16%. Second, the new sourcing process utilizes conclusions from benchmark studies, input by functional experts, and academic research to carefully design the process and therefore, reduce the possible number of failure modes. Time will tell if the quality of the sourcing process is improved, but all

observations indicate that the new sourcing process will be more effective than disparate procedures designed and implemented by previous sourcing teams.

7.4 Future Work

To realize the full benefit of strategic sourcing it is necessary to apply the same concepts to new product development. Although there are numerous articles and research on the strategic concepts of integrating the supply chain with new product development (Fine, McCutcheon and Stuart, McDermott and Handfield, and Monczka et al.), sourcing teams must have tactical tools and processes to execute on these concepts. This project provides an initial framework for doing so by discussing the people, processes, and technology issues from which future work can be done to more fully develop appropriate tactical tools.

Appendix A: Sourcing Steps, Objective, and Tools Used

Sourcing Step	Objective of Step	Associated Tools
1. Identify the product	• Develop list of potential non-core competencies to outsource	• Strategic souring process • Strategic sourcing workshop • Commonality assessment
2. Identify and prioritize specific sourcing actions	• Define type of supplier relationship (outsource or partnership) • Develop detailed project plan to include timeline and tasks • Evaluate the internal resources required to source the product	• Project plan template • Resource evaluation worksheet
3. Identify potential suppliers	• Develop list of capable suppliers	• Supplier capability matrix • Industry lists • Internet links
4. Conduct supplier assessment	• Evaluate the technical and business capabilities of the potential suppliers	• Pre-assessment survey • Commercial assessment • Assessment visit materials
5. Perform an initial source selection	• Develop list of suppliers capable of sourcing the product	• Supplier capability matrix
6. Prepare bid package and request for quote	• Request for Quote Package: - Technical documentation - Statement of Work - Terms and Conditions - Supplier partnering agreement - Confidentiality agreement	• RFQ package checklist • Contracts and materials - Standard RFQ letter - RFQ guidelines - Statement of Work - Partnering agreement - Terms and Conditions - Confidentiality agreement
7. Analyze supplier bids	• Determine completion of bids • Determine most competitive bids	• Total cost model • Bid analysis checklist
8. Conduct formal supplier conference	• Clarify questions on RFQ • Define roles and responsibilities of supplier and buyer • Initiate foundation for supplier / buyer relationship	• None
9. Negotiate and award contract	• Obtain optimal negotiation position	• Negotiation strategy checklist
10. Qualify incoming products	• Transfer lessons learned and undocumented procedures • Ensure incoming product meets or exceeds specifications	• Part approval procedure
11. Manage supplier	• Understand and manage supplier relationship	• Supplier management guidelines

Appendix B: Excerpts of the Supplier Assessment Form

Cover Sheet

axcelis

Commercial Assessment Report

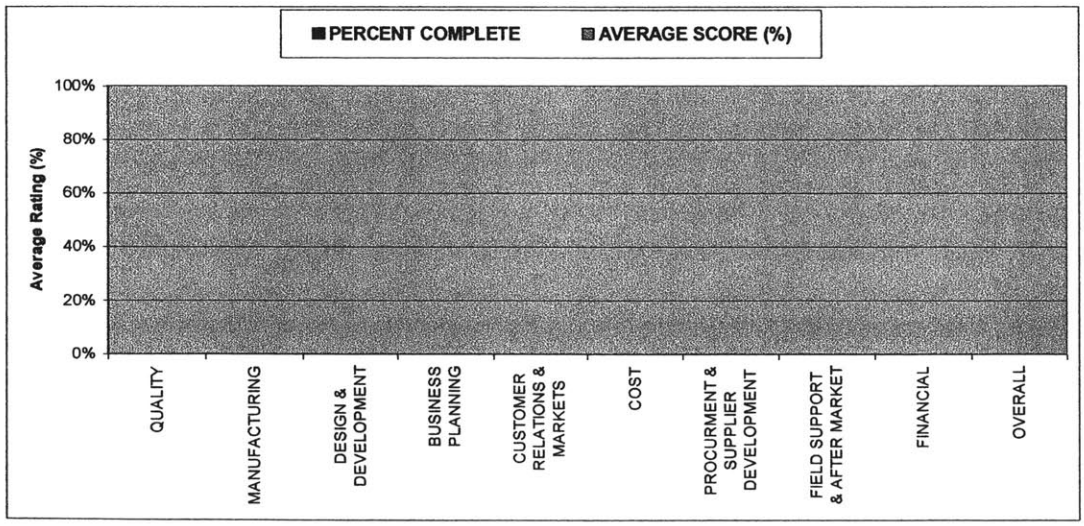
Purchasing, Strategic Sourcing & Supplier Development

Message(s)

WEIGHTING FACTOR*	SECTION	TOTAL ELEMENTS	RATED ELEMENTS	PERCENT COMPLETE	AVERAGE SCORE (%)
10%	QUALITY	26	0	0%	
10%	MANUFACTURING	25	0	0%	
10%	DESIGN & DEVELOPMENT	12	0	0%	
10%	BUSINESS PLANNING	9	0	0%	
10%	CUSTOMER RELATIONS & MARKETS	7	0	0%	
10%	COST	5	0	0%	
10%	PROCURMENT & SUPPLIER DEVELOPMENT	8	0	0%	
10%	FIELD SUPPORT & AFTER MARKET	9	0	0%	
20%	FINANCIAL	N/A	N/A	N/A	
100%	OVERALL	101	0	0%	

* Weighting factors may be adjusted by supplier assessment team. Ensure sum of the factors equal 100%.

OVERALL RATING	0%



Appendix B: Excerpts of the Supplier Assessment Form (cont.)

Section	Assessment Question	Rating	Criteria
Quality	To what degree is corrective action taken to assure that the causes of nonconformance are found and action is taken to prevent reoccurrence?	0	1 = Procedures exist for corrective action, but evidence indicates they are not followed. Planning is not always changed as a result of corrective action. 3 = Procedures exist for corrective action. Evidence indicates that corrective action is taken and documented. 5 = Includes #3 and: Planning is changed as a result of corrective action. Evidence indicates that the corrective action is monitored for effectiveness and additional action taken as required. Once root causes are determined, all critical requirements are evaluated and statistical capability is reviewed. Supplier embraces problem solving and corrective action techniques, non-conformances analyzed to identify quality trends (e.g. periodic management review of corrective actions for adequacy, resource allocation and determination if systemic problems are present).
Manufacturing	Is there a systematic process to identify and manage bottleneck constraints in the production process?	0	1 = The supplier cannot identify the plant bottleneck, nor does the supplier have any understanding of the impact of bottlenecks on the production process. 3 = The supplier can identify the bottleneck and has a defined plan on how to manage the bottleneck. 5 = The supplier understands the impact of bottlenecks, can identify the current bottleneck, and has an established plan to effectively manage the bottleneck. Additionally, the supplier utilizes constraint management techniques to continuously improve plant efficiencies.
Design &Development	To what degree is the supplier willing to provide design assistance?	0	1 = The supplier is only willing to make the part to print. 3 = The supplier is willing to take full design responsibility and work concurrently and cooperatively. Additionally, the supplier can show design work they have completed with other customers. 5 = The supplier is willing and capable to provide worldwide technical support and on-site engineering assistance for extended periods. The supplier has examples of technical service and support they have provided globally within the past three years.
Business Planning	Is there a documented strategic 3-5 year plan that addresses facilities, capital requirements, new market and customer penetrations, and continuous improvement based upon benchmark data?	0	1 = No plan is developed, and no central focus is evident. 3 = There is an established documented strategy in place that is defined and clearly communicated. 5 = The plan is defined, contains a strategy for achieving the mission, and is understood throughout the business. Individuals in various functions know the strategic plan and have action items to support it. Finally, performance measurements support the strategic plan and are reviewed with all members of the organization.

Appendix B: Excerpts of the Supplier Assessment Form (cont.)

Section	Assessment Question	Rating	Criteria
Customer Relations& Markets	Is the sellers market diverse enough to ensure stable performance through the business cycles? - List other industries currently supplied and percentages.	0	1 = Greater than 30% of the current customer base is from the semiconductor industry or an industry that follows the same cyclical pattern. 3 = Between 10% to 30% of the current customer base is from the semiconductor industry or an industry that follows the same cyclical pattern. 5 = Less than 10% of the current customer base is from the semiconductor industry or an industry that follows the same cyclical pattern.
Cost	Does the supplier have a system for determining standard rates/costs for labor, material and overhead?	0	1 = The supplier does not have an established system for determining standard rates/costs for labor, material, and overhead. 3 = The supplier has a system for determining standard rates and costs for material, labor, and overhead. 5 = The supplier has a documented system for determining standard rates/costs for labor, material, and overhead. These costs are reviewed on a regular basis and documentation exists to support such.
Procurement & Supplier Development	Does the supplier have a program that measures supplier performance in the areas of quality, delivery, etc.?	0	1 = No program exists to measure supplier performance. 3 = Suppliers are measured on performance however the system is not consistent, updated, nor does it utilize effective performance metrics. 5 = An effective an organized performance system is established. Suppliers are rated and feedback is provided on a consistent basis.
Field Support & After Market	Does the Supplier have a spare parts program in place to support the requirements of Axcelis?	0	1 = There is no spare parts program in place 3 = The supplier can commit to spare parts delivery to destination within 24 hours of notification. The supplier can provide recommended spare parts lists based on on-site field service engineer repair. The supplier can provide recommended consumables list and frequency of replacement (mean time & mean cycles between PM). An RMA process is required. The supplier provides a list of worldwide spare parts stocking locations and normal and emergency order lead times. Parts ordering hours of operation include 7 day x 24-hour coverage is preferred. 5 = All of #3 above and the following; Supplier has a list of recommended spare part stocking levels by location (local, regional, and central stocking). Supplier has consignment stocking locations. The supplier can provide MTBF and MCBF data on all spare parts.

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