Implementation of Supplier Management in a Defense Subcontractor

by

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University of Pennsylvania
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Submitted to the Sloan School of Management
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Abstract

As American companies struggle to become more competitive, many are embracing the concepts of lean production. These concepts, discussed in The Machine that Changed the World, by Womack, Jones and Roos, have been shown to be highly successful in improving quality, productivity and cost in the automobile industry. The benefits of applying these practices to other industries continues to be studied.

A key component of the lean production system is supply chain management. This recognizes that managing relationships with suppliers is critical to the achievement of quality, productivity and cost goals. For my thesis, I considered how American companies are applying lean production techniques in the area of supply management. That is, how successful have they been at implementing and institutionalizing these practices?

To accomplish this objective, I considered current literature in the area of supply chain management. I then conducted interviews at a subcontractor in the defense industry to determine where lean practices in the supply arena have been implemented. I also spoke with the related suppliers.

The results of my review indicate that there are successful efforts to implement lean supplier practices at this defense company. These efforts have clearly resulted in cost, quality and delivery improvements. However, fully implementing and realizing the potential benefits of such relationships on a company-wide basis will require a fundamental mindset change on the part of the primary customer, contractor and the supplier.

Thesis Advisor: Dr. Janice Klein
Title: Visiting Associate Professor
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Introduction

As American companies struggle to become more competitive, many are embracing the concepts of lean production. These concepts, discussed in *The Machine that Changed the World*, by Womack, Jones and Roos, have been shown to be highly successful in improving quality, productivity and cost in the automobile industry. The benefits of applying these practices to other industries continue to be studied.

A key component of the lean production system is supply chain management. This recognizes that managing relationships with suppliers is critical to the achievement of quality, productivity and cost goals. These relationships are exemplified by those used by Japanese auto manufacturers, like Toyota. Certain American companies have had success in adapting these lean supplier techniques to their companies, showing that these techniques are not limited by cultural boundaries. Examples of this include Chrysler, Ford, Hewlett-Packard and Bose Corporation. While these companies have been shown to benefit greatly from these relationships, other companies have not been as successful in implementing these relationships or as quick to adapt this thinking. Given that American companies have been able to apply and benefit from this lean methodology, one wonders why other companies have not been as successful, or as quick to jump on board.

The American companies that have had success in the supplier area are much like Toyota in their production concept. These companies, like Toyota, build large volumes of products that evolve slightly from year-to-year, for the consumer. That is, Chrysler plans to build cars next year, with perhaps somewhat new variations on the bells and whistles. The hope is that once a car is built, a family will wish to buy one. In contrast, other American companies run job shops, where the customer may be contracted with before the item is built. They often do not know exactly what they will be building next year, or who the next customer will be. Can the lean manufacturing techniques in the supplier management area be applied in these environments?

A case in point is the American defense industry. In this industry, the defense contractor bids for a contract with a government agency. The contracts are often awarded to the lowest bidder. If a contractor is awarded the contract, they will provide goods or services to the agency within a specified time frame, for the agreed upon price. The contractor often does not know if there will be follow-on work to the current contract. Additionally, with shrinking defense budgets, the contractor also cannot be sure if their
existing contract will be completed for the expected volumes. Finally, as the contract has been awarded to the lowest bidder, the contractor as a matter of course will usually award the subcontracts to suppliers with the lowest bids. These suppliers also have limited security about the future volume of their work that will be required. Given the increased uncertainty in this industry, applying the tenets of lean manufacturing would appear to be more of a challenge than in a mass production environment.

Although it may be more difficult, it would seem that the application of supplier techniques to this industry could be beneficial. My hypothesis is that there is benefit to implementing supply chain initiatives in this industry. However, implementing and benefiting from these types of relationships requires more than simply instituting lean practices. It requires adaptation of the lean methodologies to the company and industry environment in which one operates. It also requires a fundamental change in both internal and external mindsets regarding the function of the supplier. Thus, merely implementing programs which mimic supplier organizations in Japan will not result in the maximum long-term benefits associated with the lean methodology.

To examine this hypothesis, my thesis will consider supplier initiatives at a defense subcontractor. I will consider the following questions: How successful have they been at implementing lean supplier practices? What have been the benefits from doing so? What is it within their company and industry that may impede or benefit the supplier process? The hope is that this thesis may assist other such companies in understanding the value of and in implementing lean supplier programs.

The structure of the analysis is as follows. I will examine the tenets supporting the lean supplier relationships in the auto industry, where most of the work in the supplier arena has been done, and consider the benefits of implementing these relationships. Then, I will consider examples of American companies transitioning from traditional relationships with suppliers to lean practices. Next, I will consider the case of an American defense subcontractor, and examine situations where they have addressed improving supplier management. I will consider the successes, and the impediments to success.
Lean Manufacturing in the Context of Supplier Relations

The majority of the analysis in the supplier arena has been in the automotive industry, with the Toyota Production System often seen as the definitive source on lean manufacturing and supply chain management. In the 1980's, Womack, Jones and Roos examined supply chain management as a component of lean manufacturing in the auto industry, in *The Machine that Changed the World*. They describe lean supply as:

"Rather than price - determined by the relative bargaining power of the two sides - as the main link with outside suppliers and bureaucracy as the chief link with in-house supply divisions, the lean assembler substitutes a long-term agreement that establishes a rational framework for analyzing costs, establishing prices, and sharing profits. It is therefore in the interests of all parties constantly to improve their performance by being completely open with one another, with neither party fearing that the other will take advantage of the situation exclusively for its own ends. The relationship between suppliers and assemblers in Japan is not built primarily on trust, but on the mutual interdependence enshrined in the agreed-upon rules of the game. However, a stable set of rules doesn't mean that anyone can slack off. Quite the opposite. It keeps everyone striving constantly to improve performance."  

As discussed in *The Machine that Changed the World*, lean supply is a collaborative framework between the automotive assembler and his supplier. This framework includes the following elements:

- Pre-selection of supplier
- Supplier input into component design
- Supplier assignment of entire component
- A contractual framework for mutual benefit
- Use of value engineering
- Frequent deliveries of supplier product
- Mutual problem solving
- Outsourcing of non-core components.

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2 Womack, Jones and Roos. 138-168.
These elements and the associated benefits are described in more detail below.

The first item, pre-selection of supplier, refers to the practice of selecting suppliers up front, before the concept or design phase. This relates to two issues. First, the suppliers are selected before the product is designed, so that they may participate in this effort. Secondly, the suppliers are selected based on their prior relationships with the company, and their past performance. This indicates that the relationship with the supplier is focused on long term effort and trust, as opposed to short term bids. This selection process also requires the maintenance of a supplier grading system, to simplify selection of the suppliers.

Given that the suppliers are identified before the product is designed, the company can take advantage of their expertise in helping to design the product. The supplier may aid in the development of the product, initially. Then, once the product planning is finished, the supplier will be given the task of designing a specific component to meet the designated performance specifications.

This supplier is assigned an entire component to design and build. This supplier, called a first-tier supplier, usually has several second-tier suppliers who provide sub-assemblies for the component. In turn, these second-tier suppliers may have third-tier suppliers. The first-tier supplier will work with both the second-tier suppliers and the assembler to design and develop the primary component. With this tiering system, primary customers effectively limit the number of suppliers they have to coordinate.

This supplier framework is usually delineated in a basic contract. This contract sets the terms for pricing, quality levels, and delivery. It also signifies the long-term relationship that the assembler and supplier will undertake, setting the scene for a collaborative relationship. This will result from the sharing of information and the mutual benefit from continuous improvement.

Part of this relationship involves the mutual determination of product pricing. Using value engineering, the assembler and supplier work together to determine the appropriate price for the supplier's product. For the auto, this means that the assembler determines the price that the market will bear for the overall car, and identifies a target price for each component based on this. Then, the supplier and assembler work together to determine how to best meet the target while still making an appropriate profit. An important
implication of this method is that the supplier shares cost information with the assembler. Additionally, the price of the product will be expected to decrease over its lifetime, given learning curve effects and process improvements.

Another implication of this system is that the supplier will deliver product to the assembler frequently, or just-in-time (JIT). By doing this, the assembler limits the amount of inventory that they must maintain, and improves their production flexibility. If the suppliers are able to maintain a similar production schedule, they too will reduce the inventory that they maintain. Since there is then little inventory in this system to serve as a safety net, this requires that the product quality be extremely high, and production quantities be fairly stable. The process is also hastened by reducing the need for supplier product inspection at the assembler. This system therefore places increased importance on the quality and flexibility of the product process, as well as the delivery schedule.

Lean supply also relies on mutual problem solving to handle defects, delays and continuous improvement. This reliance on mutual problem solving results from the collaborative relationship between the parties. This relationship recognizes the mutual benefit from cost reductions and quality improvements. Given that there is little to no safety net in terms of inventory, it is in the best interests of both parties to work to improve the product over time. This also requires that the supplier open his assembly process and data to the assembler, and that the assembler involve the supplier with product problems found at their site.

The final element of lean supply, regarding the outsourcing of non-core components, is more subtle. It recognizes that the assembler's value-added should come by way of proprietary parts, technology or competencies. It is critical that the assembler maintain in-house capabilities for key components which they see as driving their success. Therefore, they should only outsource those parts which are less significant to the product as a whole.

In order for this lean system to succeed, there are several prerequisites. One is that there is cooperation between engineering, manufacturing, and purchasing at the assembler in order to obtain the most possible from the supplier relationship. This is necessary in order to pre-select the supplier, and to encourage their involvement in the concept or design stage. Coordination among these groups is required for value engineering to be effective. Another issue is with the production volume. In order to maintain the JIT production
schedule, the system must have fairly steady demand. To accomplish this, the assemblers in Japan practice heijunka, or production smoothing. This levels production over time, relative to demand. This provides the supplier with fairly steady product demand and an ability to be flexible with the product mix. To practice production smoothing, the assembler must have a fairly large, somewhat predictable demand. Lastly, trust and openness in the relationship between the supplier and assembler is key. This is a prerequisite to mutual problem solving and mutual benefit, as well as a long term relationship.

One could argue that there are characteristics of the auto industry that make this system effective. Relatively high product demand results in enough production volume to allow for production smoothing. This volume also provides incentives to the supplier and assembler to invest in the relationship given economies of scale. The supplier and assembler may also be motivated to invest in this relationship since there are long term relationship expectations. This is because the car itself evolves rather slowly over time. That is, a seat manufacturer would be expected to be producing some type of seat for the assembler's car for the next twenty years, regardless of design changes and improvements. It is therefore to the supplier's benefit to invest in the relationship for the long term. Another issue that may help this system work in the auto industry is economies of scope. For example, the assembler has a variety of car models, all of which will require some variation of a seat. Thus, there is continued learning and cost reduction benefits, as well as increased volume, across the assembler's product lines. Another characteristic of the auto industry is the assembly line process. Given the steady production beat, it is easier to make the JIT system work.

What is clear is that this system results in benefits to both the assembler and suppliers in terms of profits, quality and delivery. The Japanese have proven their prowess in these areas. In *The Machine that Changed the World*, the studies showed that the Japanese assemblers, who were most closely identified with lean practices, had more suppliers involved with design, had reduced inventory levels, and had more just-in-time deliveries, than their American or European counterparts. This is shown below.
### Comparison of Suppliers

<table>
<thead>
<tr>
<th>Averages/Region</th>
<th>Japanese in Japan</th>
<th>Japanese in America</th>
<th>American in America</th>
<th>All Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplier involvement in design</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering hours carried out by suppliers (%)</td>
<td>51</td>
<td>n/a</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>Supplier proprietary parts (%)</td>
<td>8</td>
<td>n/a</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Black box parts (%)</td>
<td>62</td>
<td>n/a</td>
<td>16</td>
<td>39</td>
</tr>
<tr>
<td>Assembler designed parts (%)</td>
<td>30</td>
<td>n/a</td>
<td>81</td>
<td>54</td>
</tr>
</tbody>
</table>

**Supplier/Assembler Relations**

<table>
<thead>
<tr>
<th></th>
<th>170</th>
<th>238</th>
<th>509</th>
<th>442</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of suppliers per assembly plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory level (days/8 parts)</td>
<td>.2</td>
<td>1.6</td>
<td>2.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Proportion of parts delivered just-in-time (%)</td>
<td>45.0</td>
<td>35.4</td>
<td>14.8</td>
<td>7.9</td>
</tr>
<tr>
<td>Proportion of parts single sourced (%)</td>
<td>12.1</td>
<td>98.0</td>
<td>69.3</td>
<td>32.9</td>
</tr>
</tbody>
</table>

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3 Womack, Jones and Roos. 157.
The American System for Supplier Relations

Historical Relationship

In contrast, the American system for dealing with suppliers was historically bargaining based. In the auto industry, for example, the large assemblers used their relative size and power to obtain what they desired from the suppliers. Their primary concern was cost. They encouraged competitive bidding amongst suppliers in order to achieve the lowest possible cost levels. Contracts were relatively short term so that the product could be re-bid over time. As a result of this supplier system, the suppliers did what was required of them, and often little more. That is, they produced the part as required and met quality guidelines, as specified. As a result, the relationship between the assembler and supplier was a trusting one, focused on getting the most out of the other player.

In contrast to the lean supplier relations described above, the assemblers completely designed the car before talking to the suppliers. When the suppliers were called, after the design phase, it was to prepare a bid for the product, as designed by the assembler. The supplier also was given quality and delivery guidelines stipulated by the assembler. In short, they were told when and what to do. If they had the lowest bid, they might win the contract.

Although this initial contract might be for less than one year, the follow-on work might extend for several years. There would also be the chance of replacement parts sales. Given that the auto companies had historically allowed for price adjustments each year based on inflation, there was essentially a business annuity associated with the bid, if quality and delivery levels were reasonable. There was also a precedent of the auto manufacturers allowing price increases in later years for reasonable costs, once they were bought into the supplier. In this situation, suppliers might be motivated to underbid the contract, in order to win the future work. They would count on the assemblers wanting to avoid switching costs to help their case. Other than their bids, suppliers would share no information about their processes or costs with the assembler. This would be detrimental to their bargaining position.

Having supplied the winning bid, the supplier would prepare a prototype for the assembler to test. Given that there were multiple suppliers providing parts for each component, there would frequently be problems when the assembler tried to put them
together. Once the assembler was satisfied with the parts, changes would be provided to the supplier, and the supplier would begin to produce.

In following production periods, the assembler might attempt to reduce the product price per unit further by putting the part out to bid again. In this way, the first supplier would be forced to compete against other suppliers who, if they won the contract, would benefit from the first supplier's efforts to trouble-shoot the part. If this supplier also had underbid the contract initially, they would lose out if another supplier gained the work.

Quality problems also complicated the relationship. If the assembler discovered customer problems with the car, it might make changes to the supplier's design. This, of course, would require price adjustments. If the supplier was delivering defective parts, the assembler would accept them, up to the target defect rates that had been set in the contract. The supplier would not be notified that there was a problem to be fixed. If the supplier parts began to exceed the target rates, the parts would be returned, and payment stopped. The supplier would have to fix the problem by themselves, or lose the business.

Another issue was with the contracted volumes. Given the cyclicality of the American auto industry, the demand for cars is not stable. The auto manufacturers historically treated this fact as a business risk that the suppliers were assuming by playing the game. Thus, if demand was down, the assemblers would reduce or cancel the suppliers' contracts.

It is clear from this summary that the historical American approach to dealing with suppliers was less than optimal, and significantly different from lean techniques. With a short term focus on cost and competition, this bargaining based system resulted in a distrusting relationship between the suppliers and assemblers. With this type of relationship, there was wasted opportunity for improving cost and quality of the product. Additionally, there was wasted energy spent optimizing each individual's bargaining position by competing and not disclosing information. The result was that quality was poor, and the suppliers' profits continued to decline. It became apparent that there was much to be learned from the Japanese in the way of supplier management.
American Transition to Lean Supplier Relations

When American companies first began to consider the benefit of lean supplier relations, they looked at the Japanese system as being a function of Japanese culture and society. That is, they assumed that the relationships were primarily paternalistic and closed-looped, and that the practices were not transferable to other cultures.

When they eventually tried to implement these practices in the United States, they often considered only the resulting metrics of the systems, and set about to achieve them. These metrics included a reduced number of suppliers, product costs and inventory levels. The first tendency was thus to decrease the supplier base. This resulted in increased price pressure on suppliers, forcing them to bear the brunt of the expected cost reductions and to hold inventory for their customers. Companies tended to ignore other impacts, such as the design benefits and the reduced long term costs of production by having suppliers involved early in the process. All in all, they did not realize that the maximum benefit would result from a change in attitude regarding the suppliers' contribution to the program.

One disastrous example of this was General Motor's attempt to reduce purchasing costs. In 1992, GM consolidated its world-wide purchasing operations into a centralized system led by Jose Ignacio Lopez de Arriortua. Lopez sent existing contracts out to bid, and used several bidding rounds. "Just because you came in with the low bid didn't mean you got the job," says Dennis Virag, managing director of the Automotive Consulting Group in Ann Arbor, Michigan. "They sent it out again and asked the same suppliers to bid." Although GM claims that these practices reduced costs by $4 billion in 1992 to 1993, the effect was short term. Given these practices, many suppliers now refuse to deal with GM. "I don't know of any major supplier who will take a new design to GM today, because, in the end, GM will give it to the lowest bidder," says Kim Korth, president of International Resource Network, a supplier consultant in Grand Rapids.4

The next progression came when American companies began to realize that there was more to these relationships than merely pushing harder on the suppliers. They began to see that the full benefit of these relationships could come from a fundamental mindset.

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change about the role of the supplier. By treating the supplier as someone whose success is critical to their success, rather than an adversary, companies could improve their cost and quality positions. This type of thinking was exemplified by NUMMI (New United Motor Manufacturing Inc.) and other automotive start-ups in the United States.

Eventually, American companies also realized that while the Japanese supplier systems have had great success, they are not necessarily the perfect system for everyone and every company. That is, the tenets should not be applied blindly. By considering the basic elements of the lean system, and tailoring it to a specific company, increased benefit from these relationships could be achieved.

For example, recent studies on supplier management suggest that companies need to look internally before implementing a supply chain management program. In "Strategic Outsourcing," Quinn and Hilmer state that companies need to consider where they can best concentrate their own resources in-house, by focusing on their core competencies. Focusing on these areas will provide the company with the best return for their investment. By recognizing this, they can then determine where they should outsource work. Doing this will allow the company to take advantage of a supplier’s expertise, thereby providing improved product, cycle time and reduced risks. As with most business decisions, these should be made using cost-benefit analysis to determine where to invest time and resources in managing suppliers. That is, the critical decision in managing these relationships is determining where you can get the best investment return.

Finally, many companies are beginning to look beyond the supplier as a simply a subcontractor. In this way, the company recognizes that the supplier is a critical component of meeting customer requirements. In the increasingly competitive marketplace, requiring better products, faster, with less resources, companies are moving beyond merely outsourcing, to allying with their suppliers. Hamel, Doz and Prahalad argue in "Collaborate With Your Competitors - and Win," that this relationship may be cultivated in order to innovate, increase knowledge, increase flexibility and/or reduce market response time. Establishing these type of relationships can result in significant leaps in development and learning. Key to managing these type of relationships is strong

leadership and an environment that fosters collaboration and trust, rather than individual gain. It also requires a structured relationship that sets expectations, and recognizes and measures improvement over time.

Combining the investment return requirements with the partnering concept leads to the understanding that supply chain management must be balanced. That is, there are trade-offs between maximizing the value of the supplier relationship and the costs involved. The best use of management's investment in a partnership arises when there is a long-term, strategic benefit to the company from the relationship. Thus, critical components of the supplier to be evaluated before partnership status is considered are it's technology, management capability and the company's strategic needs.

Kamath and Liker, in "A Second Look at Japanese Product Development," propose that long-term, collaborative supplier relationships be stratified into four areas, based on the company's needs. These needs should be determined based on the company's competitive focus and strategy. They define these relationships between the customer and the supplier as follows:

- **Partner:**
  Relationship between equals; supplier acts as an arm of the customer for an entire subsystem and participates from the preconcept stage onward; full-service supplier has technology, size and global reach.

- **Mature:**
  Customer has superior position; supplier takes major responsibility with close customer guidance; customer provides specifications, then supplier develops system on its own for a complex assembly; full-system supplier may suggest alternatives to customer.

- **Child:**
  Customer calls the shots, and supplier responds to meet demands; customer specifies design requirements for a simple assembly, and supplier executes them.

- **Contractual:**
  Supplier is used as an extension of the customer's manufacturing capability; customer gives detailed blueprints or orders from a catalog for a commodity or standard part, and supplier builds.  

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Management can maximize the benefit of their supplier relationships by understanding that not all products require the investment of resources in a long-term strategic alliance with a supplier. This is not to say that suppliers are doomed to 'contractual' or 'child' status if their current product places them there. But, becoming a partner with a company should require that the supplier have more than just a product that the company needs. They should also have the technology and management systems to provide them with an evolving and improving product in the future. In short, they must provide the company with a competitive edge that outweighs the resource investment that they would have to place into the partnership. It is this mutual investment and dependency in a partnership that binds the customer and supplier together over time in a jointly advantageous relationship.

**American Successes in Applying Lean Supply Techniques**

There has been success in applying and adapting the lean supply model to American industry. These successes have been in a variety of industries and companies, from Chrysler to Hewlett-Packard and Motorola, to Harley-Davidson and Bose Corporation. In order to gain an understanding of the ability of American firms to adopt lean supply chain management techniques, and the benefit gained from doing so, I will consider two recent examples, below.

The most convincing example to date has been Chrysler. After facing bankruptcy several years ago, they have now come to be admired as a leader in the American automotive industry. In making this dramatic come-back, the company used platform teams to develop and produce each line of cars. These teams had members from design, engineering, purchasing, marketing and manufacturing. The company also reduced its supplier base from over 2,000 in the 1980s to 300 currently. In January 1994, Chrysler introduced the Neon, a small model car. In contrast to its prior bargaining based bidding system, Chrysler focused on selecting suppliers early in the concept phase. These suppliers were used to engineer and design the car to meet a target cost level. The result was that the time to bring this car to market was just 31 months, as compared to 60 months for a car in the 1980's. The number of engineers used to develop and combine the systems was reduced in half. The manufacturability of the product was also
significantly improved, reducing assembly time and problems, as well as product defects. Robert Lutz, President of Chrysler, described this effort as follows:

"The assembly process accounts for maybe 15 percent of the total cost of a car in less efficient companies. In the best of companies, it will consume 8 or 9 percent of the total cost of the car. The real secret of Neon is a highly focused and totally targeted approach with what I can only describe as a keiretsu-style relationship with the suppliers who were selected very early. They did the major part of the engineering job with us and for us and showed us how to get the features and the quality at what we call the target cost. If you don't get cost down on the 70 percent of the vehicle that you buy outside, what you do in the assembly plant is almost irrelevant." 

Chrysler has provided for longer-term supplier contracts, over the life of the model, that require cost reductions over time. These cost reductions are the result of expected continuous improvement efforts by both the supplier and Chrysler.

One supplier who was involved with the Neon project identified five ways in which Chrysler handled its suppliers differently than historically. These changes, he feels, improved product cost, quality and customer satisfaction for the Neon. They also reduced Chrysler's risks associated with producing a new car. These changes in the supplier relationships are identified below:

- Build to print is evolving to gray-box design
- Post-design sourcing is giving way to pre-design sourcing
- Quote to print is giving way to affordable cost targets, based on product benchmarking and market-driven vehicle prices
- Component-specific perspectives are evolving toward a systems focus
- Sourcing strategies and communication are evolving from individual suppliers to supplier teams approach.

As identified above, it is clear that Chrysler's supplier practices are adaptations of the lean supply techniques discussed previously. It is also clear that Chrysler's strategic use of

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9 Joseph Bonn, "Interview with the President: Chrysler, Under Lutz, the Learning Curve Never Ends." Automotive News 14 June 1993: 44.
suppliers has improved their competitive position. According to a recent article in "The Economist," Chrysler makes more profit per car any of its American competition. It produced 20 new models during the 1990's; more than it produced in the prior 20 years. In 1993, the company earned net profits of $2.5 billion (without accounting changes), as compared with a loss of $538 million in 1991.  

Another example of American companies adapting lean supplier techniques is Bose Corporation. Bose produces high-end audio-equipment. Bose has taken the supplier partnership concept one step further than Chrysler, by making key suppliers resident at their Framingham facility. This program has been called 'JIT II,' and was begun in 1986. Bose has JIT II relationships with providers of components, hardware and software, office products, and transportation companies. The system relies on the empowerment of the suppliers, involving them in the entire production life cycle. For example, where appropriate, these key suppliers are involved during the concept stage for new products, working alongside Bose's design and manufacturing team. This process takes advantage of the supplier's expertise in designing and manufacturing, and allows for quick problem solving during production.

The in-house suppliers are also given responsibility to order from themselves. The goal was to reduce inventory levels, reduce redundant purchasing responsibilities at both the supplier and Bose, and take advantage of the suppliers' expertise by having them become more knowledgeable about Bose. Because the supplier would place the purchase orders and manage the inventory, JIT II resulted in eliminating the buyer, supplier's salesman and material planner. Doing this required that both companies share critical data. For the supplier, this means sharing cost information about their product. For Bose, it means sharing production and forecasting data to allow the supplier to plan his requirements. This data is usually strictly guarded by most companies.

In order to protect against the loss of proprietary information, suppliers are carefully selected. They are asked to sign confidentiality agreements, and agree to certain limitations. For example, the supplier agreement stipulates the part cost which was negotiated. When the supplier representative orders parts for Bose, the computer system assigns them the standard cost per the agreement. In return for this arrangement, the

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suppliers are allowed to fill their own orders, and process engineering changes, with the aid of Bose personnel. The key to this is, of course, a trusting relationship that is based on mutual gain.\textsuperscript{12}

Bose expanded the concept of JIT II from its suppliers to its transportation network. With these representatives, from trucking, shipping and customs in-house, Bose is now able to better manage both its incoming and outgoing inventory. This is because these in-house representatives have access to their companies’ systems, and thus, tracking incoming and outgoing merchandise is no longer a mystery. With this data, Bose has been able to reduce its inventory levels on some large items from two to three weeks worth to one day. Having this data in-house has also reduced the number of lost and damaged shipments. This is because having the information in-house along with the responsible party has made the transportation suppliers more motivated to get to the root cause of problems, and solve them. This information has been helpful to both suppliers and customers, as well as Bose. Based on Bose’s innovation and success, JIT II has been implemented at other companies, such as IBM, Xerox, Intel, and Honeywell.\textsuperscript{13}

It is apparent from these examples that it is possible to apply the lean supply techniques to American companies. That is, it is not just a Japanese phenomenon that requires Japanese workers, companies and culture. It is also evident that there are benefits to implementing these techniques. These include improved profits, quality, cycle time and customer satisfaction. It is also clear that these well-documented successes are in industries that have some characteristics which are similar to the Japanese industry in which these techniques were developed; that is, the automotive industry. There is a fairly standardized product, with limited technology and structural changes each year, and a relatively large level of demand. Given that the benefits of these programs are significant, how can companies apply the lessons of lean manufacturing to other industries, which are less steady in terms of product design, product type, and customer expectations? This remains to be seen. One case in point is the defense industry. The particularities of this industry will be described in more detail below.


\textsuperscript{13} "Jit II Supply Chain Management." \textit{Chief Executive} June 1993: 40.
The Defense Industry

Can the supplier lessons from other industries be applied to the defense industry? This industry differs vastly from the automotive industry, where supplier management has been honed. In this section, I will analyze some characteristics of the defense industry that may make the direct application of lean manufacturing techniques in the supplier arena more challenging.

As discussed, the auto industry is characterized by a relatively slowly evolving product-line, an assembly manufacturing system, and a large volume of production. In contrast, many defense contractors operate essentially as job shops, working on varied products with limited expected contract life-span and volumes. They work on a variety of projects at a time, with each project requiring a different design, manufacture and implementation process. Product life cycles are relatively short for many components. This is very different from an auto company, which might expect to be producing a ‘car-like’ product for at least the next 20 years. Accordingly, in the auto industry, there are great benefits to partnering with a supplier, say a seat supplier, whose product they can envision needing for at least the next 20 years. With this longer term relationship, there is a higher expected return from working with the supplier to design the product, and reduce cost and quality problems over the expected life of the product. Making the same argument regarding cost savings over the long term is harder in the defense industry, given that product life cycles and volumes are smaller.

In the defense environment, the contractor may have limited ability to forecast what they will be working on in the future. Many contracts are relatively short term. Even if they have a long term contract with a government agency (the customer) to build a certain product, the contract usually provides options, which stipulate the range of the amount of product that will be built each year. These contracts must be ‘optioned’ each year, meaning that the contractor has limited knowledge about the exact number of systems they will need to build even over the life of a contract. The contracts are also for relatively small volumes, compared with the production levels in the auto industry.

Another issue is the system specifications that are provided by the customer for a project. Often, these either stipulate the overall design of the system, or severely restrict it. This thereby reduces the benefits of having a supplier get involved up front in design, especially if the system is fully specified. The industry is moving more toward
commercial specifications to reduce production costs. Nonetheless, the speed at which this cultural change to commercial specifications occurs may be relatively slow.

Another issue is with the way the contract's performance is evaluated by the customer. That is, the customers (the government agencies) still tend to evaluate the defense contractor's performance based on cost. This metric system is then propagated throughout the supply chain. The prime contractor is awarded the contract by providing the requisite technological performance at the lowest cost. The program managers will then be evaluated by their ability to control costs on the project. This then determines the way suppliers are handled. Suppliers are, as a matter of course, often chosen based on being the lowest cost provider. This short term view of the product costs tends to ignore such longer term expenses as quality, delivery, and design. There is also hesitance to get the suppliers involved early on in the project, because funding this front-end effort will effect the program budget.

Another concern is with the way quality must be evaluated by contractors. The government has libraries full of quality guidelines which determine the appropriate methodologies to ensure that the product they receive is of a certain quality level. Most of these guidelines result in processes which verify specification conformance (inspect quality in), at the end of the process, rather than focus on building in quality through process validation initially. The contract for a program may also stipulate additional quality specifications, which results in added cost to the project.

Yet another issue is with the variety of projects. Though a company may not be able to predict the number of systems that they will deliver under a particular contract, one could argue that they could achieve a better forecast of product needs by looking across contracts. This itself raises issues, because many of these projects are classified, or may have slight modifications to somewhat standard parts. Therefore, trying to aggregate product across boundaries to take advantage of such volume can also be difficult. This effects the ability to learn and improve the product over time, given that the products in one contract may be classified relative to another.

Another concern is from the supplier side. If the primary contractor itself is uncertain about the number of systems they will produce, the supplier will also have uncertainty about their required production levels. As a particular project may eventually be discontinued, there may be limited to no benefit to a supplier to invest in a relationship.
A defense contractor may also be a relatively small portion of a company's sales, meaning that the supplier may not be interested in investing the time and effort to partner with a contractor. Coupled with the decline in the defense industry, such suppliers may be more motivated to invest their time in developing commercial relationships with a longer term, steady need. Other issues from the supplier's point of view result from the fact that the primary contractor often provides the specifications for the supplier. This means that the supplier can have limited impact on the design of the product. But having such an involvement might allow them to improve their process and the product, in order to improve quality and reduce cost. Even if the supplier can get involved, they may not wish to invest in a certain design, because the specifications may be changed over time as technology evolves.

From the contractor's point of view, there are risks to a relationship with a supplier. If the supplier prepares the design for the component, the company may end up in a sole sourcing situation. Given that the supplier invested time and money in the design and process, the contractor may be stuck. They would have to incur additional development costs and lead time if they wanted to switch to another supplier. This raises questions about the suppliers' need to be competitive price-wise given that they own the design. Thus, the contractor may be subject to the risk of receiving less than competitive pricing.

There is also a risk in such a relationship that the technology may change. By partnering with a supplier, the company is essentially betting that that supplier's technology is the appropriate one for the future, or that they will have the ability to move forward as the technology evolves. If the supplier is unable to do this, over time, the contractor may be left with older technology if they continue to uphold the relationship.

Product quality is key to system performance in this situation. The defense products have historically been inspected upon receipt from the supplier. That is, the focus was on verifying conformance at the contractor. There is effort being made in the industry to reduce the reliance on inspection after-the-fact, and improve the quality of each process in the production chain. This requires some investment by the customer in certifying the supplier's processes, and in trusting the supplier to maintain this level of quality in each process. However, there are some risks associated with relying solely on the quality of processes for systems' excellence in any industry. For example, systems produced by a defense contractor may be used to land commercial and military planes. Thus, there is a
'life and limb' risk associated with the product. When viewed in this way, it is a big step to reduce inspection of all incoming parts.

Designing a supplier component is also an issue. With the classified nature of many products, the contractor may not be allowed to disclose what the entire system is to the supplier. Without this information it can be very difficult for the supplier to optimally design the component.

Historically, many defense contracts were written on a cost plus profit basis. Increasingly, the customers are requiring that the contracts be bid at a fixed price. Given the focus on cost, the contractor may have a tendency to shift this burden, where possible, to the supplier, by focusing on short term component costs.

A final, critical issue is the shake-out in the American defense industry. Reductions in defense budgets have driven a consolidation and downsizing in the contractor arena. This raises uncertainty about the survival of certain defense programs, as well as the contractors, themselves. This uncertainty makes it more difficult for contractors and suppliers to invest financially in longer term relationships. Reduced defense budgets have placed an increased focus on the cost of contracts, making contractors increasingly concerned about the short-term cost impacts of their supplier relationships. With the number of programs declining, contractors may be inclined to keep more and more work in-house, regardless of their comparative expertise, to reduce the number of lay-offs. This will impede the creation of longer-term relationships with suppliers, as contractors may make future decisions based on headcount, rather than the supplier's past experience and capabilities.

It is clear that there are many contrasts to the automotive industry. Given these differences, can lean manufacturing techniques in the supplier arena be applied and benefited from in the defense industry? To answer this question, I will examine a defense subcontractor, and their supplier initiatives. I will consider situations where supplier partnering has been implemented. I will evaluate the success of these efforts, and the difficulties encountered. Then, I will question whether these efforts can be applied to other circumstances.
Defense Subcontractor

Introduction

The company I have reviewed is a key player in today's weapon system acquisition base. In reviewing this player's supplier initiatives, I interviewed both subcontractor personnel and the related supplier's management. With the shrinking defense budget, this company, like most of its competitors, is striving to increase its commercial business relative to its defense business. An increasing percentage of its business is now commercial. As its competencies lie in its particular systems, it continues to see that the majority of its business will lie in the defense sector. The company has also changed its focus over the past years as the defense budget has declined. It historically was a systems fabricator, designing and manufacturing a large portion of its systems. It is now focusing on transitioning into a systems integrator, by designing and assembling systems. This is because it sees its value in the design and integration of systems, rather than as the producer of all components. It continues to operate as a job shop, with different projects operating at various stages in its facilities. The focus on becoming a systems integrator has meant that an increasingly large percentage of their systems cost is derived from purchases outside of the company. As a result, supply chain management has become a key issue.

The subcontractor's system for supplier management has evolved over the past thirty years, as it has at many American companies. One quality manager described the change in focus as follows: In the 1960's, the suppliers were usually contacted after the contract had been awarded to the company. They were often handed the company's design specifications, and had to build to them. The engineers usually found suppliers that they worked well with, and put their name on a drawing for a component. If the supplier's name was on the drawing, the supplier selection process ended. Otherwise, if there were several suppliers to choose from, the company evaluated them first on price, second on technical skills, and third on delivery capability. After the supplier produced the parts, they were delivered to the company, and inspected at the company's receiving operations. Some problems with supplier parts were not found until the part was being used in production.
In the 1970's, the practice of having supplier names on drawings was still maintained. For drawings without specific supplier names, the company kept an approved vendor listing. This was developed by a vendor evaluation board, which was created to review suppliers for their pricing, quality and capabilities. This list was maintained by performing up-front surveys about the suppliers, some source inspection, and periodic audits. These efforts had improved the subcontractor's vendor selection process, but there was still poor feedback from the factory about problems. As in the 1960's, suppliers were rarely contacted before the system had been fully designed.

In the 1980's, the subcontractor began to look at reducing the number of suppliers to a more manageable level. With a team of personnel from design engineering, component engineering, quality and purchasing, they created one electronic approved supplier list. This reduced the number of approved suppliers from approximately 3,500 to 1,000. The company also began to reduce the level of inspection performed. They created a system to rely on vendors' processes. That is, vendors who had historically been reliable, and were able to show that they had controlled processes and quality systems, were given the opportunity to ship product without inspection by the company. The subcontractor performed quarterly reviews at the suppliers to ensure that their quality systems were still intact. Their supplier's shipping status was revoked if there were audit problems or consistent defects found in the assembly line. While these efforts improved the management of the supply base, it only created a system for approval. If a new design was called for, or a vendor had not worked with the company before, they might not meet the criteria to be considered for this special status. Additionally, the system lacked the ability to handle problems or defects. That is, the company did not work with suppliers to improve the design and manufacture of products, or share information about consistent problems.

In the 1990's, the subcontractor has worked to improve upon its previous supply chain management programs. As more and more of the company's product is being built outside of its walls, the company has had to focus on the supply chain as a critical component of their success. As their customers have continued to focus on cost as a major determinant of contract awardance, the company had had to find new and better ways to reduce costs. With customer contracts shifting from cost-plus to fixed price, one quality manager acknowledged, "We can no longer make money in this environment without doing things right up front." The subcontractor's supply management philosophy is evolving to one of risk management. To evaluate alternatives and manage risks, the
company's goal is to assemble multi-functional teams for major procurements, at the earliest stage possible. Management is recognizing that investing time initially working with the suppliers will allow both the company and the suppliers to improve their positions over time. That is, by working with the suppliers to improve design and manufacturability prior to production, the supplier, the subcontractor and the customer will all benefit.

Management acknowledges that encouraging program managers to do this early in the product life cycle is difficult. The program office controls the major decisions about the program, and, of course, is evaluated on them. Two primary metrics for the program manager are contract cost and profit. Historically, suppliers were not contacted until after the project had been fully designed by the subcontractor. The supplier contracts were then awarded to the bidder who could provide the technology at the lowest price, in order to control overall program costs. The cost of the supplier relationship, historically, was seen to be the cost of the components. Thus, in the time of reduced budgets, many managers continue to take a short-term cost view. They would prefer to simply hand designs to suppliers, and ask them to build them. Encouraging the program managers to invest time and money during the early stages of the contract, working with suppliers and purchasing agents to design products, is a difficult culture change. Proving to them that there are long term benefits to investing this initial time, in terms of product cost, quality and delivery, is also difficult, given that many defense contractors are just beginning to do this. The benefits are still difficult to see, as this company has not been able to fully measure the impact of involving the supplier in this type of relationship. This is due in part to the fact that there are limited base cases to compare these new relationships to, given that the subcontractor's projects vary. Another problem that the company is having is the timing of the proposals. In order to have the suppliers involved in the design stage, they need several months to be able to approach and work with them. Often, they may not have this much time before a proposal is due.

To deal with the changing customer environment, the company's supply chain management efforts includes several major initiatives. As in the auto industry, these efforts have focused on improving suppliers' up front involvement in design, reducing the need to inspect quality in through supplier certification programs, and providing feedback to suppliers about their products, so that it and the supplier may be improved. These are described in more detail below.
The most critical first link to the suppliers is created by the company's use of integrated product development teams. These multi-functional teams consist of design engineering, manufacturing, purchasing, quality and the program office, and are ideally convened at the proposal stage of a contract. With this team, the subcontractor can identify for each contract the items that will be outsourced as early as possible. The team can then determine the appropriate target price for these items, based on pricing analysis. With this information, purchasing can approach suppliers early in the process to determine if they have the capabilities to design and produce a particular item for the target price. By involving the suppliers at this stage, management can take advantage of their design expertise, and submit a bid that realistically portrays the costs that they will incur to build the product. Management has also utilized computer aided design capabilities to ease the transfer of design data between the company and suppliers at this stage.

To reduce administrative efforts relating to suppliers, the subcontractor has developed several programs. Two of these relate to the reduction of paperwork associated with outsourcing materials. For example, the company has created an electronic data interchange program with suppliers for parts with a recurring demand. The supplier must have a history of reliability with the company to qualify. These suppliers are automatically notified by the company's computer system to ship more goods when the company's inventories reach a certain level. Another program is for products that have a relatively large volume, with a commodity type product. In this case, the company will contract with a supplier for a certain price over a certain period. When the company requires any of these goods, they will order them under this agreement. This allows the company to receive a reduced price based on the volume across contracts. It also reduces the time spent negotiating pricing for each individual contract.

Other efforts to reduce the time and cost associated with handling suppliers include supplier grading and certification programs. With supplier grading, the company maintains an approved supplier listing to simplify supplier selection. Suppliers on this list must have a reasonable grading, based on their having provided quality products in the past, having met delivery schedules, and provided reasonable pricing. The subcontractor maintains on-line information about the supplier's performance, including problems and corrective actions. These quality problems are communicated to the suppliers so that the problems can be addressed. In order for a supplier to become certified by the company, they must have the requisite business and quality systems, manufacturing capabilities and financial stability. When suppliers become certified, they are allowed to ship their
product directly to the subcontractor's manufacturing floor, without it having to be inspected by the company's quality people. This is a significant cost saving for the company. However, there are also risks associated with not inspecting product, that must be weighed against the benefits. In order to become certified, the supplier's processes must meet the company's standards initially. They then must continue to provide quality product. Periodic audits are conducted by the subcontractor, as well as self-audits by the suppliers. The goal of these efforts is to reduce the company's need to verify conformance after the product is built, rather than focus on building it in initially.

The company is also using strategic and financial analysis to define their supplier relationships. First, they are performing make/buy analysis at the company, to determine which products they should be outsourcing in the long run. This aids in the product teams' decision making process during the proposal phase. Secondly, they are using cost/benefit analysis to determine the optimal number of shipments per year for certain products. This has been termed 'modified JIT.' The company is also recognizing that their supplier management program should focus on the balancing of risks and rewards. That is, they need to ensure maximum quality, while reducing the cost of supply management in the long run. They recognize that investing money up front in improving supplier processes and in getting suppliers involved in the product design can save significant costs over time.

To implement a quality focus in the production line, the company has sent its workers to quality and statistical process control training. Additionally, they have trained over 700 suppliers in total quality management. The employees are active in quality improvement teams which address quality issues. The goal, again, is to build quality in, and to continue to improve the products and processes over time.

These supply chain efforts have resulted in benefits to the company. They have reduced the number of suppliers to approximately 800. The inspection of incoming product has been reduced to 40%. They have certified approximately 700 suppliers, representing 95% of the dollar value of supplier product purchased. The entire workforce has been trained in TQM methodology, focused on building quality in and problem solving through quality teams. Integrated product teams are being used on the majority of new programs, allowing them to take advantage of expertise within the company and within the supplier community in setting the course for the program. The implementation of lean supply relationships across the entire company is slowly taking place. As one purchasing
manager stated, "We have pockets of success, and are aggressively pursuing cultural consistency throughout every program and every supplier."

To gain a deeper understanding of the implementation of and results of these supplier initiatives, I have examined two specific programs in more detail. The efforts made, and the results, are described below.

Examination of Programs

I reviewed two defense contractor programs and their supplier initiatives. The first supplier relationship, scenario A, involved the design and manufacture of a mechanical assembly from a black box design (performance specifications) for a defense system. The second relationship, scenario B, involved the redesign of an electronic assembly for an defense system. In both cases, the subcontractor and the supplier were involved in joint efforts to reduce product cost. The subcontractor and the supplier have also collaborated during the entire product life cycle to ensure that improvements are made to quality, cost and timely delivery.

Mechanical Assembly:

Scenario A involved a contract that would last for a five year period. During the proposal phase, the company created a multi-functional team to determine how to best approach the contract. First, the team developed a win strategy based upon system cost. They then determined how much each component would have to be priced at in order to support the total system cost. They quickly evaluated which components should be built in-house, and which should be built by a supplier (make/buy analysis).

The team identified a mechanical subassembly, which, based on their delivery needs and pricing, they thought could be better built by a supplier. They would need approximately five subassemblies delivered each month, depending on their customer's demand. The subcontractor had not designed the subassembly, but knew what they needed it to do. Using their supplier grading system, and their past experience with suppliers, they approached several mechanical suppliers during the proposal phase to determine if they could build this entire black box component. Previously, a similar component might have been assembled as a "make", with many suppliers providing the sub-components to the subcontractor. The subcontractor examined the incumbents' facilities, capabilities, and
quality systems. They also asked the suppliers to meet target pricing levels over the life of the contract. The price of the assembly would be expected to decline over time. An additional issue was that the company and the supplier would have seven months to design and begin production: the proposal was to be submitted in the first quarter of that year, with the first delivery of the system to be made in the third quarter. Only one of the suppliers met these conditions for the mechanical assembly, and agreed to meet the pricing constraints.

When the defense subcontractor was awarded the contract, they were ready to move quickly, as they already had their suppliers in place. In order to meet the short delivery time frame, engineers worked directly with the supplier's engineers during the design phase. Computer aided design capabilities were critical to the quick turnaround achieved. With the direct involvement of the engineers, the company was able to reduce the number of sign-offs required for engineering revisions to two. This improved turnaround time when deficiencies were discovered. Turnaround time was also improved by having just one supplier responsible for the entire subassembly. The subcontractor then had a single point of contact to deal with when problems were found, rather than several. Additionally, because the supplier was certified for quality by the company, product was eventually able to bypass the subcontractor's receiving inspection, and go directly to the factory floor for assembly.

The company is now in the fifth year of the contract. Through this relationship, they were able to reduce the cost of the assembly by over 50% per unit during the life of the contract. By using the supplier's in-house design capabilities, the subcontractor also avoided significant internal costs. More critically, the subcontractor was able to achieve the 7 month design and delivery time frame set by their customer. The supplier has continued to meet quality requirements through their certified process. They have also met all monthly delivery schedules.

There are other benefits from this relationship that have not been quantified. By working more closely together, the company and the supplier were able to identify problems earlier in the process than they would have otherwise. When problems were found, they were able to resolve them more quickly by working jointly. This saved time and money that would have been spent on scrap, revisions and expediting. Management also stated that there are longer term benefits to the relationship. By having their engineers work directly with their suppliers, the engineers increased their understanding of the supplier's
needs. It also increased the engineers' awareness of the value of designing to cost. These
lessons can be applied to future contracts.

The supplier also gained significantly from this relationship. They have improved their in-
house capabilities, in terms of computer skills, design techniques and product scope. For
example, prior to this project, they would have contracted to build only a component of
the assembly, rather than the entire product. By working with the engineers, they gained
an appreciation for the customer's needs, and gained a sense of purpose by having their
customer work with them on site. Through the subcontractor's certification program,
they have enhanced their product quality. The supplier's efforts have improved their
reputation both inside and outside of the subcontractor. They have had positive press at
the subcontractor and within the community regarding their progress. As a result, the
supplier has been awarded follow-on work from the subcontractor. They have also
increased the scope of their work for other contractors, based on their successes. They
cite that trust and mutual investment has been the key to the relationship with the
subcontractor. That is, both parties needed to invest in the other party in order for the
relationship to work. Doing so has built a mutual dependence and trust that has had
great impact on both companies.

When asked for an example of mutual problem solving relating to a supplier defect found
at the company site, subcontractor management was unable to think of an example. The
purchasing manager stated "Historically, we at American companies have managed by
exception. Through our relationship with this supplier, we were able to resolve most
issues before they even became problems. By changing our focus, we have had
insignificant problems at this supplier during this acquisition."

The benefits of the relationship are unquestionable. The supplier also cites some
concerns about the relationship. Although the supplier has agreed to pricing terms for
the assembly, they have no long term contract guarantee for the assembly from the
subcontractor. Subcontractor management stated that this is common because they
themselves have no certainty about the volume of systems that their customer will ask
them to produce. They said that the supplier's risk is lessened inasmuch as the supplier
owns the design to the assembly. The supplier also stated that while they have benefited
significantly from the relationship, they still feel that the subcontractor continues to focus
primarily on cost. That is, even though they have invested time and money in the design
and production phases, management is still asking them to reduce the price of the
subassembly, regardless of the fact that the commodity metal that the supplier uses for the majority of the assembly has significantly increased in cost. This is also a concern since the supplier feels that they can best profit from this type of relationship where the volumes of production are large. Given the uncertainty with the primary contract, they cannot be sure if they will profit on the assembly over the life of the agreement. As the company is a large portion of the supplier's business, however, the supplier continues to hope that their investment in the relationship with the subcontractor will pay in the long run.

Electronic Assembly:

Scenario B involved the redesign of an electronic assembly. In this case, the company had had the contract work for the system for over 15 years. Each year, the customer would determine the level of volume for the product, and flow down that requirement to the subcontractor. The volume level has varied from 100 to 300 systems per year.

Approximately 8 years ago, the company decided that an electronic assembly used in this particular system was a good candidate to be made externally. This determination was based on the subcontractor's skill and their desire to build capabilities, as compared to the opportunities to obtain better and cheaper products outside. This particular component was small in size, and would have a relatively steady expected volume. Through a bidding process, the contract for the electronic assembly was awarded to a supplier. This supplier was provided with the subcontractor's existing design, and told to build it to specifications.

The supplier built the part as required, and delivered on time. The subcontractor continued to be awarded the work from their customer, and passed the work onto the supplier. After a while, however, the subcontractor decided that they needed the cost of the component to come down. Since this was a sole sourced item, they felt that they needed a competitive process to ensure that the cost of the product was appropriate. They approached their customer, and asked for funding to obtain alternative sourcing. This funding was granted, and the company identified three new suppliers who could make the part. After a bidding process, one of these suppliers was chosen. This supplier was added to the drawing, so that the subcontractor had three sources for the part: itself, the first supplier, and the new second supplier. When the next contract was awarded to the company, they put the electronic assembly out to the two suppliers to bid. The
second supplier came in with a lower bid, and was awarded the work. They were handed the subcontractor's design and told to build it to specifications.

When the time for the next bidding process came, the first supplier won the bid from the second supplier. They continued to build the product to specifications, and make on-time deliveries. One manager at the subcontractor dubbed this process "bid and build, bid and build."

When the next bidding process occurred, the second supplier proposed to make a substantial price decrease, by redesigning the existing product over time. The company decided to work with this supplier, to redesign the assembly, because this component was a large cost of the product, and it was critical technically. They agreed to work closely with this supplier because the supplier had the appropriate technology, design capabilities and problem solving skills. Like the mechanical assembly supplier, in the previous case discussed, they were able to provide one-stop shopping for the component. They also promised significant cost reductions. Subcontractor management stated that they did not invest this time in building a relationship for other component parts for this contract, because they were not as sophisticated or expensive.

The supplier would achieve a price reduction for the component by reducing their costs in three phases. In the first phase, the supplier would deliver based on the existing design. In the second phase, the supplier would focus on process improvements to reduce the product cost. In the third, and final phase, the supplier would completely redesign the product, to achieve further cost improvements. The subcontractor is currently in the second phase of this contract. According to management, the supplier is on target in terms of their commitment.

The company stipulated that the supplier would need to become certified for this assembly, so that the company would not need to inspect the product at the supplier's facility. This was the first time that the subcontractor had been willing to accept this important technological assembly without source inspection. To get the supplier to this level, the company's quality engineers worked with the supplier to baseline their processes, and to identify where improvements were required. Over a four month period, from the issuance of the first purchase order to the required delivery date, the company and the supplier worked together to get the process in-line. This would improve their quality to a level where the customer would not have to inspect the parts at their
facilities. The result was that the supplier has now met all delivery dates and has had no part failures.

The supplier stated that this was an opportunity that they would not have had several year ago. That is, prior to this arrangement, most of their defense customers would hand them exact specifications for a component. This left the supplier with little opportunity to improve upon the design or process, and thereby improve the product and their profits. Now, the supplier and the subcontractor are moving toward 'performance' specifications where possible, which allow the supplier to get involved early on. This benefits both the supplier and customer. The customer benefits from the supplier's expertise and his ability to reduce costs. The supplier benefits from the ability to redesign the product to improve their cost and profit position.

Both the supplier and subcontractor management said that this relationship is a major paradigm shift, requiring significant culture change. Historically, the customer-supplier relationship was bargaining based. The customer held all the cards. He would hand the supplier product specifications, and expect them to be delivered on time. The customer's purchasing manager called this a "What have you done for me lately" attitude. In turn, this supplier stated that most suppliers usually told the customer about production and delivery problems only after the delivery date had been missed. In contrast, in this current relationship, the supplier has been very honest and vocal about production problems. This honesty has resulted in the subcontractor providing engineering help to the supplier. It also allowed the subcontractor to work around any potential delays, and to reschedule other suppliers. In turn, any problems that the subcontractor discovered at their site were immediately communicated to the supplier. Using conference calls, the company's engineers worked with the supplier to resolve the issues quickly.

The supplier is currently providing 'modified JIT' delivery. That is, based on the volumes stipulated in the yearly contract, the supplier is providing delivery to the company monthly. The volumes requested per month might vary from 2 to 20. In order to improve their process, the supplier negotiated with the subcontractor to smooth production to 10 units per month. The supplier indicated that they are currently producing at a level "to optimize their production costs and minimize holding costs." That is, their production systems are not fully synchronized with the company's production needs, so that they may be holding some levels of inventory.
As an example of the benefits of this relationship between the supplier and the subcontractor, the subcontractor purchasing manager provided the following story. During the product ramp up, the subcontractor purchasing manager, supplier sales manager and supplier engineers would hold twice weekly conference calls to ensure that the product was moving ahead. During one of these conversations, the program manager at the supplier informed the subcontractor that they were having problems with their inventory; the product had failed testing the day before, and they were not sure why. The subcontractor's manager said that they would schedule a conference call with the company engineers the next day to discuss the detailed analysis of the situation. By working with the supplier, they discovered that the problem was with a sub-component from another supplier. While the part was apparently within the product specifications, it was failing once assembled. The supplier talked to their sub-supplier, and told the company that the supplier was willing to fix the problem. However, it would take two months for the parts to get to the supplier.

This notified the subcontractor that they would have delivery problems to their customer, if nothing was done. Historically, the subcontractor would have attacked the supplier for this problem. Also, in the past, they probably would not have found out about the problem until it was too late to do anything. Instead, the company tried to rectify the situation. They first set out to determine if one of their manufacturing centers might have some of the parts in stock. It turned out that another site had some that they were willing to loan to the supplier. However, they did have the total needed for the delivery date. The subcontractor then questioned whether they had any prior relationship with the sub-supplier, that might give them some leverage in terms of production and delivery. It turned out that they did. As a result, the company was able to use the parts from its other site, and get the rest of the parts from the sub-supplier more quickly. By working together, the supplier and the company were able to meet the customer delivery deadline.

The supplier stated that the relationship between himself and the company was critical to success. That is, the trust between them is critical to their achieving production, quality, delivery and profit goals. For example, the supplier stated that design to cost objectives were critical to meeting the needs of the subcontractor. By sharing this information up front, both the supplier and the company were able to buy in to a situation fully informed about the other’s needs. The supplier felt that both he and the subcontractor invested in the relationship up front. He invested the time and design costs, initially, and was willing to lose money on the initial phases of the contract, with the expectation of recouping these
losses over the life of the contract. The company invested in him by helping the design team, and in helping their production process become quality certified.

As with the mechanical assembly supplier, this supplier has no long-term volume commitment. He has provided the subcontractor with a three year quote. Similar to the mechanical assembly supplier, he knows that if he is honest with the contractor, and keeps his price down, he will keep the business. He owns the assembly design, and knows that the lead time for the company to ramp up with a new supplier would be significant.

As a result of this process, the subcontractor was able to reduce the price of the component significantly. When they initially created the dual sourcing situation, management was able to decrease the price of the component by 30%. With the second supplier's arrangement to redesign the assembly, the price was reduced significantly again. The company has also benefited by getting an improved quality product for a reduced cost. By working with the supplier to resolve problems early and quickly, they have also saved time and money in production. The supplier has gained other work for unrelated projects from the company based on their current relationship.

As with the mechanical supplier, it is clear that the supplier is not currently profiting from the sales on a per unit basis, to the degree that he could. The supplier believes that he will profit in the later years of the contract, and, he expects to gain future follow-on work from the customer. It is also clear that the subcontractor is a significant portion of the supplier's business, and this influences the relationship to some extent.
Conclusion

Based on these cases and their supplier initiatives, the defense subcontractor I reviewed is making strides toward implementing and adapting the techniques of lean supply. There are pockets of success. But, as this statement implies, there is still work to be done. In conclusion, I will review the success of their efforts relative to lean supply. I will then consider the keys to this success and the lessons learned.

As described previously, the elements of the lean supply, as exemplified by the Japanese automotive industry, are as follows.

- Pre-selection of supplier
- Supplier input into component design
- Supplier assignment of entire component
- A contractual framework for mutual benefit
- Use of value engineering
- Frequent deliveries of supplier product
- Mutual problem solving
- Outsourcing of non-core components

In order to evaluate the success of this defense subcontractor, I will consider their efforts relative to these elements.

- Pre-selection of supplier
  The subcontractor has instituted practices which allow it to monitor its key suppliers so that pre-selection is simplified. It has significantly reduced its supplier base, and has created a supplier grading system to manage its suppliers and track their performance. This past history was used in the first case, in the mechanical assembly, to identify an appropriate group of suppliers for the bidding process. These suppliers were reviewed during the proposal phase of the process, so that the supplier could get involved in the design of the product. The subcontractor has also instituted certification practices, whereby selected suppliers are qualified to ship direct to the factory floor. They have invested the effort to get these suppliers to this quality level, and continue to invest this time with occasional audits, in order to simplify the supplier process. The subcontractor is also using integrated product development
teams which allow them to consider involving the suppliers early in the product life cycle.

- Supplier input into component design
  As mentioned previously, the mechanical assembly supplier was selected during the proposal phase. They were given black box specifications, and worked with the subcontractor's engineers to design a quality part to a target price. The same was true of the electronic assembly supplier. Although they were given specifications to build an existing part, in order to meet ongoing customer needs, they were given the opportunity to redesign the product over time. This would provide both the supplier and the subcontractor with an improved product and reduced cost.

- Supplier assignment of entire component
  In both the cases described, the suppliers were given an entire assembly to design and manufacture. This was identified as being a departure from previous work that they had done. This is also compatible with the subcontractor's transition to a systems integrator. By assigning entire assemblies to suppliers, the subcontractor limits the assembly problems that it will find at their site, and reduces their supplier coordination effort. This is similar to the lean tiering system.

- A contractual framework for mutual benefit
  In both the cases, the suppliers shared cost information with the subcontractor. This information was shared in order to design to a target cost, with the aid of the subcontractor's engineers. Both supplier's have contracted to reduce costs over time, based on improvements in design and production. The subcontractor also agreed to work with both suppliers to get them certified. They have improved their quality to such a level that the subcontractor is willing to forgo in-house inspection. Again, this differed dramatically from previous situations, where the supplier had either won a bid, or had been given a set price by the supplier. In those cases, little information about actual costs was disclosed, and limited efforts were made toward continuous improvement.

On the other hand, these suppliers were not given a contractual commitment by the subcontractor. As discussed, the subcontractor itself has little security regarding the level of production that its customer will require it to produce. There is a sense of mutual commitment, or dependency, in that, in both cases, the supplier owns the
design drawings. Lead time and switching costs for the subcontractor also result in greater dependency in the relationship.

- **Use of value engineering**
  As discussed, in both cases, the product was designed to meet a target cost based on the subcontractor's determination of its customer's price. Both suppliers have agreed to a declining cost curve over the life of the contract, based on mutual efforts to continuously improve.

- **Frequent deliveries of supplier product**
  In both cases, the supplier is delivering product monthly, based on the subcontractor's needs. While this may not appear to be just-in-time, as defined in the automotive industry, this is a significant improvement over past practices. In the past, product was delivered quarterly, and then, it had to wait for inspection. With monthly delivery, the subcontractor and supplier are able to reduce their inventory level, while allowing for variation in their job shop processes. With the certification process, the subcontractor is able to use the delivered product immediately.

- **Mutual problem solving**
  As discussed in the cases, both suppliers have worked closely with the subcontractor to ensure mutual success. This occurred during the design phase, to ensure that the product met specifications at a target cost and quality level. It also occurred during production, in handling problems found during manufacturing. Mutual effort was also evident in the subcontractor's assistance in getting the supplier's processes certified.

- **Outsourcing of non-core components**
  Both cases had evidence that management had considered which components they should be making in-house on a strategic level. After this determination, they approached suppliers to fulfill the component needs.

In addition to the lean supply criteria described above, management's practices are also consistent with the partnering literature reviewed previously. They have assessed their own internal expertise and criteria before making external decisions about suppliers. They have used make-buy analysis to determine which parts should be outsourced. Finally, they have considered which components in a contract are critical ones, requiring
a higher level of commitment and involvement by suppliers. They have thus recognized that not every supplier requires the investment necessary to become a full-fledged partner. In selecting these key suppliers, they have considered the suppliers' technological capabilities, management expertise and reliability.

It appears that this defense subcontractor has had great success in moving towards a comprehensive and beneficial supply chain program. In the effort of continuous improvement, however, I will make the following comments.

The key to success in the supply chain arena, as demonstrated by the Japanese automotive industry and the American adaptations, is collaboration for mutual benefit. Historically, we saw that the American business focus was on a bargaining-based relationship with suppliers. This history is especially relevant for the defense industry, with its extreme focus on cost and competition, at the primary contractor level. Thus, creating and benefiting from a comprehensive supply chain management program will require a radical culture change for the contractor and its customers. For the contractor to fully benefit from these programs, its key decision makers will need to recognize that there is benefit to involving suppliers up front, as soon as possible. This recognition is already happening, as the industry moves toward using commercial product where possible. But recognition does not always translate into action, or filter down to the people at the front line, making decisions. Thus, getting customer representatives and program managers to recognize and implement supply chain programs is critical. This recognition is key, since they will make the decision as to whether to involve the suppliers up front. It is this up front involvement, we have seen, which is critical to improving quality, cost and cycle time.

As the major focus of the customer continues to be on cost, and as consolidation in the industry continue to occur, contractors will need to improve their efforts to provide a more competitive product at better prices. We have seen that relationships with suppliers can aid in this effort. Convincing program managers and customers that an initial investment in time and money with suppliers will significantly save costs and reduce problems later on is critical. This has been hard to do, in the past, since limited data has been collected about the comprehensive benefits associated with the supply chain efforts. It is the collection of this data that may be needed to prove the value of these efforts to the true die-hards, in order to change the culture of the system.
We have also seen that there is danger in these supplier efforts in merely trying to mimic the Japanese tenets. For example, in the contractor's job shop environment, trying to achieve the Japanese concept of just-in-time delivery may be more expensive than the value it brings. Defense contractors must also consider government military specifications in designing their product. They therefore will not be able to allow suppliers complete freedom in designing product, as in the auto industry. These issues show that adaptation of the lean supply techniques to the defense environment is critical to achieving the maximum benefit at the minimum cost. Another danger in this industry is in simply trying to achieve the results of the lean system. For example, it is easy to reduce the supplier base and their product prices by pushing the suppliers to invest in the partnership, without providing a respective commitment to them. This, in essence, relies on the historical bargaining-based power relationship. This type of relationship may result in short-term benefits, but, in the long-term, it is less effective than a mutually rewarding alliance.

The cases I have examined show that the contractor in the defense industry can maximize his benefits by treating the supplier as more than a subcontractor. The benefits include reduced costs, quality and cycle time. These examples show that the company does indeed have pockets of success. In order to increase the number of successes to a broader, company level, one needs to understand why these particular examples of supply chain management were effective. Management was able to achieve these benefits in these cases for several reasons. First, they considered the value of the supplier to be greater than simply supplying parts. They also had enough time during the proposal phase to select the supplier, early in the process, so that the supplier had time to contribute their design and manufacturing expertise. Next, they were able to provide the supplier with performance specifications, rather than a pre-designed system. In this way, the supplier could design or redesign the system to improve quality, cost and manufacturability. Because the subcontractor was able to involve the supplier relatively early in the process, they were able to define a relationship framework initially. This framework set the stage for mutual responsibility and benefit from continuous improvement and problem solving. Finally, because these cases involved products that had relatively significant expected volumes, for current and follow-on programs, there was benefit to both the supplier and subcontractor in fostering a longer term relationship. Understanding these issues is key to increasing the supplier success stories at the company.
The lessons learned from these cases is that it is critical to get the supplier involved in the product process as soon as possible. This requires that both parties buy into the relationship and define their roles early on. In doing this, both parties assume the rights to mutual benefit from mutual effort, as well as the sharing of associated risks. Thus, the contractor must realize that achieving all of the benefits of a supplier relationship requires that the he assume some risks as well. By committing to the relationship, the contractor recognizes the value the supplier will provide in the long run, rather than focusing on short term cost implications.
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