Chapter Eight
MATERIALS AND PURCHASED PARTS
(MANUFACTURING)

INTRODUCTION

Purchased materials and parts make up a significant portion of the cost of the typical military aircraft, usually about 50 to 70 percent of the cost value stream at the prime level. Organizations that have adopted lean manufacturing attempt to maximize the quality and performance and reduce the costs of purchases, by rationalizing the supply base and carefully partnering with the most important suppliers. Supplier partners help with product design by participating on IPTs and work to support their customers through such techniques as just-in-time delivery to maintain inventory at the lowest possible levels. In this chapter, we describe the characteristics of lean Purchasing and Supplier Management (PSM) in more detail and discuss implementation of lean PSM in the defense aircraft industry, which was for the most part at the early stages. Evidence on particular implementation efforts and findings regarding expected cost savings close the chapter. The full CCDR definition of materials and purchased parts (manufacturing) can be found in Appendix C.

LEAN PSM—A NEW PROCUREMENT STRATEGY

The lean manufacturing model focuses a great deal of attention on efficient operations within the factory, but internal processes are only part of the lean enterprise story. With more than half of the cost stream of a typical aircraft being purchased rather than produced in-house, to implement lean, aircraft manufacturers need to adopt a system of best practice procurement as part of the strategy to reduce
cost and improve quality. Every consideration that applies to the value of using lean production within an organization also applies to its use throughout the value chain as a whole. Lean PSM encourages a buyer to look beyond its own boundaries and work with its suppliers to introduce lean production in their production processes as well.

Lean PSM offers two avenues for cost savings. First, proper in-house management of purchasing offers cost saving opportunities through a reduction of people and other in-house resources required to find and certify new suppliers, manage ongoing suppliers, and deal with problems in the supply chain. Second, and with even greater potential for cost reduction and quality improvement, the lean model offers specific guidelines for improved supplier performance based on developing trusting partnerships. Prime contractors and suppliers can work together to improve supplier quality and delivery and reduce costs. Research on best commercial firms shows that the firms have found dramatic savings by focusing attention on suppliers. AMR cut its cost of purchased material by 20 percent over five years (Avery, 1998); Honda of America cut the same costs by 17 percent over four years (Nelson, 1998). Best practice purchasing offers a stark contrast to much of the traditional supplier-prime procurement in aerospace, characterized by more arms-length, short-term relationships with an emphasis on low cost rather than other factors, such as past performance or fewer defects.

What exactly is lean or best practice PSM? Notionally, traditional purchasing views the supplier only as a source of risk, high costs, or quality problems. Tough negotiations are needed to keep the prices down, and relentless inspection is required to ensure part quality. Best practice/lean PSM views suppliers as a source of benefits, as a critical piece of the value chain, as partners in the manufacture of the final product. Trusting, but realistic, relationships and willing supplier implementation of lean obviate much of the need for harsh punitive actions on the part of the prime.

A list of features of traditional and lean PSM demonstrates the contrast and the shift in mindset that lean requires. It should be stated up-front that all aspects of the “traditional” procurement model are not necessarily what has prevailed historically in the defense aircraft industry. In fact, prime contractors have a long history of working
with suppliers as the only way to capture the technical expertise held by these other organizations. There has never been a solid wall separating the companies.

Table 8.1 offers a sense of how the lean production system approaches procurement, with a “straw-man” traditional procurement model offered for contrast. Lean’s potential benefits are substantial but require restructuring of how goods and services are procured by the purchasing firm.

One first step on the way to gaining the benefits from lean PSM is to reduce the overall number of suppliers and work more closely with

<table>
<thead>
<tr>
<th>Traditional Procurement</th>
<th>Lean Supplier Management</th>
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<tbody>
<tr>
<td>Many suppliers</td>
<td>Fewer suppliers, tiered structure</td>
</tr>
<tr>
<td>Outsourcing of individual parts assembled at prime</td>
<td>Outsourcing of components, parts produced at lower tiers, assembled at the first tier</td>
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<tr>
<td>Little concept of value stream</td>
<td>Attention toward the creation of flexible production networks</td>
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<tr>
<td>Arm’s-length relationships, no commitment</td>
<td>Closer relationships, long-term commitments</td>
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<tr>
<td>Supplier MilSpec Qualification</td>
<td>Supplier certification</td>
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<td>Traditional negotiation, win-lose philosophy</td>
<td>Gainsharing, win-win philosophy</td>
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<tr>
<td>Limited information exchange</td>
<td>Two-way intensive information exchange, emphasis on joint problem-solving, developing new technology</td>
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<tr>
<td>Infrequent deliveries of batch-produced products</td>
<td>JIT production and delivery, synchronized production operations</td>
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<tr>
<td>Inspection of incoming parts</td>
<td>Inspection/qualification of suppliers’ processes</td>
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<tr>
<td>Selection based on price</td>
<td>Selection based on best value (performance plus price)</td>
</tr>
<tr>
<td>Build-to-print: parts designed at prime, blueprints thrown over wall for supplier to build</td>
<td>Build to performance specification or requirement: early and continuing supplier involvement in design and development</td>
</tr>
<tr>
<td>Suppliers not given assistance to resolve problems or improve; substitution of another supplier</td>
<td>Commitment to continuous improvement, working with suppliers to improve their processes</td>
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the best ones. Each supplier maintained as a source costs money, including the investment in managing the supplier and keeping the supplier actively on the books. (These in-house supplier management costs are normally captured in the material-handling fee that prime contractors add on to the cost of purchases, which is passed on to the government as part of material costs.)

Although it may seem counterintuitive, cutting the number of suppliers offers a number of avenues for cost reduction. This is counterintuitive because a greater number of suppliers offers more opportunities for competition. However, having many suppliers means that the prime can invest fewer resources in each supplier for helping improve supplier performance, improve quality, and reduce cost. Cutting the number of suppliers allows investments of time and resources to be focused on particular supplier relationships. Firms chosen as partner suppliers are generally given the understanding that the partnership will be ongoing so long as certain requirements of price and performance are met. Suppliers, in turn, invest time and energy to build better and cheaper products faster because they have confidence that they can reap the rewards of those efforts over a longer period. First-tier suppliers in turn can devote resources and management attention to improving the performance of subtier suppliers. The Toyota model includes a check on self-serv ing behaviors by suppliers; while the car manufacturer may sole source a component for a particular automobile model (Asanuma, 1985), it maintains at least two sources of that component across all its lines to maintain competition (Richardson, 1993). This may not be possible with the low volumes typical in aerospace, but investing in trusting partnerships with a reduced number of suppliers can keep costs down and performance high.

Two mechanisms can cut suppliers: reducing the number of suppliers offering the same part and moving to a tiered structure. In this case, first-tier top-level suppliers consolidate parts from second-tier suppliers into larger subassemblies.

Note that in best practice PSM, not all suppliers are treated as partners. Given the limits on resources, customers should focus their efforts on suppliers who contribute more to the final product or who would be harder to replace because of their expertise, design, quality, or some other factor. The expense of developing close partnership
ties means that potential for improvements—or the uncertainties—have to be significant for this investment to be made. In an example pertinent to aerospace, there may not be a lot of suppliers with the ability to make composite substructures using the resin transfer molding process, so the payoffs of developing a true partnering relationship with that supplier would be more significant than working with a supplier providing, say, rivets and fasteners.

The notional chart division in Figure 8.1 makes some suggestions about strategy.

Suppliers not in the upper right quadrant can still be managed in a lean way. For example, automated procurement, purchase cards, and e-commerce can cut transaction costs with arm’s-length sup-

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**Figure 8.1—Strategies of Supplier Management**

<table>
<thead>
<tr>
<th>Suppliers of unique products</th>
<th>Strategic suppliers of critical products</th>
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<tbody>
<tr>
<td>Develop closer ties, try to develop new sources of supply, consolidate purchases to gain leverage (specialized parts)</td>
<td>Focus proactive PSM efforts in this category (major subsystems), form partnerships and strategic alliances</td>
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</tbody>
</table>

<table>
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<tr>
<th>Generics suppliers</th>
<th>Important commodities suppliers</th>
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<tr>
<td>Arms-length, transaction-based relationships, look for low-cost supplier (office supplies)</td>
<td>High value means work with these, but low risk means can negotiate (computers)</td>
</tr>
</tbody>
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1A similar matrix first appeared in Kraljic (1983) and then more recently in Bensaou (1999), Tang (1999), and many others.
pliers. Proactive PSM attempts to migrate suppliers into the partner category, devolving responsibility for design and integration on them as trust increases. Consolidating contracts (i.e., getting partner suppliers to take on the low-volume but high-risk work or the high-volume, low-risk work) is another way to try to get cost and performance improvements from closer ties.

SPECIFIC PRACTICES OF LEAN PSM

A number of specific tools and management techniques have grown up to help firms reduce costs of procured goods and services after the supplier base has eroded. One starting point is the formal analysis of supplier performance to determine who to keep buying from, who to develop a partnering relationship with, who to provide assistance to, and who to stop buying from.

Supplier Qualification and Certification

Lean PSM practices put significant emphasis on quality of purchased parts. As part of this, customer firms generally qualify suppliers as acceptable bidders and certify existing suppliers’ processes. For qualification, suppliers have to prove that they meet certain standards, for example, having ISO-9000 approval. (Another benchmark, AS-9000, is providing a core set of standards that should help support lower-cost supplier qualification in the aerospace and defense industry in the same way that QS-9000 has done in the American auto industry.) Certification of suppliers is generally a longer-term process by which suppliers win ratings depending on their performance, quality, and delivery. The best suppliers may have special privileges. Many prime aircraft manufacturers have complex qualification and certification programs that have helped improve supplier quality and delivery over the past few years.

Long-Term Relationships

Part and parcel of developing and maintaining trusting relationships with suppliers is offering them implicit or explicit promises of continued business so long as their performance continues to meet or exceed expectations. Explicit promises may consist of agreements to
buy all of a particular item needed during a year or agreements to buy a certain amount in a year or even promises to buy a certain amount over a multiyear period. Often, such promises as these can generate volume discounts from suppliers. The stronger the agreement, the larger the discount. Five percent or so reductions from long-term agreements (LTAs) was one number offered by contractors during data collection.

The term “multiyear contracts” refers to a different kind of promise in defense manufacturing. Because of uncertainties about their own sales, defense contractors often cannot offer firm multiyear contracts to their subcontractors. Because of its general unwillingness to commit to procurements beyond the current budget, Congress will not authorize multiyear agreements unless certain savings targets are met (the exact percentage has varied) or for particular exceptional instances. (Acquisition reform has begun to ease some of these limitations.) Contractual, multiyear purchase commitments by primes to suppliers over a number of years could generate additional savings on top of LTA savings, as suppliers reward their customers for this sales security and for the ability to amortize investments in cost-reduction activities, processes, or manufacturing technology insertion over a larger, stable quantity. Suppliers might not be able to cover the costs of improvements in one year, so they may not be willing or able to make the required investment without firm commitments for multiyear purchases. These are dependent on the ability of the prime contractors to get firm multiyear agreements from DoD and to “flow down” termination liability coverage, at least to key suppliers.

Communications with Suppliers

Lean PSM suggests that formal communication programs that reach out to suppliers offer a number of benefits. For example, newsletters are commonly used to let suppliers know of changes in PSM programs. Supplier councils that meet on a regular basis offer another avenue for communication and provide the opportunity for the customer to get feedback on its practices. The customer can learn if its demands are symptomatic across the supply base or put unique pressures on its suppliers. It is also a way to get some insight into
industrywide best practices as suppliers share (nonproprietary) knowledge on practices gained from working with other firms.

**Electronic Data Interchange (EDI) with Suppliers**

EDI with suppliers is another example of how digital technology has altered industry practices and led to greater efficiencies. The traditional procurement function involved a tremendous volume and time-consuming exchange of paper. Product blueprints, orders, and change orders were sent to suppliers. Suppliers sent paperwork with parts including invoices. Customers sent back paper checks for payment.

Digital technology has allowed the automation of these functions and cut costs dramatically in the process. The term EDI refers to the original systems used to link customers and suppliers. These were often expensive systems that were proprietary to each customer, so that a supplier might need to learn different systems for each customer. Proprietary systems have been replaced by linkages taking place over the Internet, which has reduced the cost and complexity of the linkages. The Internet is also the avenue for other tools that may save money, such as reverse auctions for parts.

Whatever they are called, electronic linkages with suppliers have enabled closer partnering between different organizations. At several sites, for example, suppliers can access the customers’ databases to get information on production schedules so that they can plan their own production and delivery schedules accordingly. This was cited by suppliers as important for their ability to efficiently schedule their production of parts and to avoid unexpected rush orders, which disrupted their production lines and increased costs.

**Continuous Improvement Kaizen Events at Suppliers**

Lean practice calls for conscious efforts at continuous improvements in cost and quality. As part of partnering relationships with suppliers, customers often offer considerable assistance to their suppliers to become more efficient. These outreach programs can involve a considerable investment by the customer as engineers and other experts are sent to suppliers for days or weeks for quick or lengthy
kaizen events. Savings generated by these efforts are ideally shared between the partnering firms so both parties have an interest in making them work.

Examples of aircraft manufacturers holding kaizen events at their suppliers are relatively new, although the events that have occurred have resulted in claimed cost savings. It may be that since implementation of lean is relatively new, these firms are focused on leaning their own internal operations first.

**Target Costing**

The Toyota model of lean production generated an alternative method of setting prices of suppliers. The traditional way is to add up resource inputs and add a profit—the cost-plus model. Suppliers with the lowest bids are chosen to keep costs of the final product down even if their performance is not the best. The Toyota model is market driven. Here, prices are generated by first determining the required target price of the final product based on knowledge of the market. Then the prime will work backward to reduce its own internal costs and establish costs of purchased parts to meet this price. Companies select best performing suppliers and work with them to reduce costs so that their target price can be met. Often, they develop planned-ahead reductions in cost of suppliers’ inputs as part of a continuous improvement strategy. Note that DoD’s policy of CAIV is something of a move toward the target costing model. CAIV requires trade-offs of requirements in weapons systems in order to meet target prices.

Lean procurement tends to substitute longer-term relationships for competition—it reduces the number of suppliers and deepens the relationship between the buyer and each supplier. A deeper relationship allows the buyer to transfer design and QC responsibilities to each supplier. As these responsibilities transfer, target pricing becomes a useful tool for informing each supplier of what the buyer wants and expects. Target pricing provides a vehicle for an ongoing discussion between buyer and seller about where the costs lie in the provider’s process and how they might most effectively be reduced through process adjustments and product redesigns. Target pricing also supports a kind of benchmarking that emulates ongoing com-
petition by forcing a supplier in a long-term relationship to be responsive to changes in the outside market.

**Just-in-Time (JIT) Delivery**

JIT delivery from suppliers offers many benefits to customers, particularly reduced inventory costs. JIT means that suppliers deliver components to customers exactly when customers need to incorporate those components into the final product. The signal to deliver can be sent electronically, or via an empty container or a message card (kanban) sent back to the supplier. Savings to the prime manufacturer come from lower in-house inventory waiting to be worked on, reduced floor space (since the inventory does not need to be stored), reduced labor costs of managing inventory, reduced chance of inventory becoming obsolete and being scrapped, and speedier identification of quality problems at suppliers with faster addressing of problems and lower rework or scrapping costs.

In the lean manufacturing model, JIT delivery requires very close linkages between suppliers and customers so that costs and waste are minimized throughout the production chain. Attention to quality and machine maintenance is critical. In the Toyota automobile manufacturing model, suppliers are located very close to their customers, to minimize travel time between the two factories. Suppliers can make deliveries as often as every hour. When the supplier finishes its components, it immediately kits and ships them to the customer.

However, in actual practice, this is much more difficult to achieve and may have some negative side effects. JIT deliveries have contributed to Japan’s heavy traffic (Cusumano, 1994). In the United States, geographic distances between plants tend to be much larger. In the automobile industry, there is some concentration of plants, but aerospace manufacturers have an entirely different set of constraints. They face political pressure when it comes to plant locations, so suppliers of different parts on any particular aircraft may be

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2 More information on the costs associated with inventory can be found in the discussions on Direct Manufacturing (Chapter Six) and Overhead, General, and Administrative Costs (Chapter Nine).
located in dozens of states. This presumably increases congressional support and funding for weapons systems but probably is not the least costly way to manufacture products. Transportation costs mean that it may be more cost effective for suppliers to make fewer and larger deliveries. This is economically justifiable given the geographic constraints but means that inventory costs are not reduced as much as they could be.3 (In any case, the majority of inventory costs lie in work in progress within manufacturing facilities, rather than on the highways in transit. This complication is an example of the different conditions U.S. aerospace manufacturers face, problems they will have to solve themselves rather than by blindly copying the lean auto production model.)

JIT delivery may be required by customers, but unless inventories are reduced throughout the production chain, only a small portion of possible savings can be captured. Ideally, suppliers themselves will only produce their components to order, building a component right before the customer needs it, so that they do not have any finished-goods inventory waiting to be shipped out. (Sending components out immediately reduces costs of holding inventory and also reduces the likelihood of damaged or obsolete goods.) In actual practice, when customers demand JIT delivery, they rarely offer assistance to their suppliers in implementing lean production, so the suppliers must improve their own production processes to be able to manufacture the item right before it is shipped. What often occurs is simply a transfer of inventory locations. Instead of the customer holding inventory on site and using it as needed, the supplier holds the inventory and delivers it only as needed. Generally, companies farther down the supply chain have lower overhead costs so this still saves a small amount, but the cost savings from completely integrating suppliers into pull production are not generated. (These potential savings are the same ones as described in Chapter Six on direct manufacturing.)

3In aerospace, the issue is even more complex. High volumes in the automobile industry mean that those subcontractors very likely produce parts only for automobile manufacturers and hence would benefit from being close to their customers. Aerospace subcontractors often deliver only a small percentage of their output to aerospace customers, so they would want to be closer to their higher-volume customers instead.
In low-volume long production runs typical in the aerospace industry, two further issues generate deviation from the ideal typical lean production model. Low numbers of final products mean that a supplier may only be producing a few hundred or less of any particular item. It may make most economic sense to produce the entire annual or lifetime quantity of a particular part at once rather than throughout the year or production lifetime. Again, the supplier may end up holding the inventory. Similarly, changes in technology may make some parts of the airplane obsolete in the commercial industry before the production run of the aircraft is complete years later. Unless the prime contractor buys the whole batch up front, it may not be able to buy the part at all later on. Again, economic trade studies can help determine the most efficient way to produce, store, and deliver parts. This way may or may not match that suggested by a lean production model based on a high volume consumer product. Spear and Bowen (1999) provide a reality check to the lean model in their report that, contrary to popular belief, Toyota itself does hold inventory when circumstances require it. However, Toyota also does not consider costs per batch or production lead times as fixed. Consistent effort to cut costs and lead times may help single-piece production go from uneconomic to being the best, most efficient outcome—and this should be the goal.

Examples of JIT delivery were offered at different plants, mostly as a part of small pilot projects. Savings from this particular practice were not quantified. Indeed, as has been discussed, while this may be a lean practice in the high-volume automobile industry, it is not clear to what extent this practice is germane to defense aerospace.

**Supplier Management of Inventory at Customer**

A related practice seen at several plants was the supplier ownership and management of certain kinds of inventory at the prime contractor. Until the prime contractor actually used the part, integrating it onto the final product, the supplier owned and managed the inventory. This only applied to suppliers of such commodities as fasteners and such equipment wear parts as drill bits. On some production lines, suppliers check fastener bins and refill them as needed. In another example, suppliers stock vending machines with wear parts. Production employees then take parts as needed by flashing their
coded ID for inventory control. (This has the side benefit of reducing inventory "shrinkage" from lost or stolen parts.) Information on what has been used is sent automatically to the supplier, who can refill the vending machine when stocks get low.

**Supplier Kitting**

One lean PSM practice is supplier kitting of parts, instead of the prime contractor putting kits together and giving them to the production workers or not using kits at all. (Refer to Figure 6.3b for an example.) If a supplier sells a group of parts for a particular product, it can package them in kits of parts needed for individual products. For example, a supplier of fasteners can package all the related fasteners required for a particular assembly. Suppliers can also create kits, integrating their parts with kits or parts from other suppliers and then send these integrated kits to the prime contractor. These can be organized by major assembly or product type, so all the parts required for one platform, or for a large assembly, such as a landing gear door, can be in one container. Then further kitting of parts can occur if the prime contractor takes parts and/or kits of parts from different suppliers and consolidates them into one integrated unit.

The greatest potential for savings here is if the subcontractor builds and kits individual parts only at a signal from the prime contractor (rather than to an internal, independent production schedule) and then delivers these kits directly to the prime’s factory floor right before they are needed. This reduces the costs of inventory throughout the system. It requires extremely close attention to first-time quality through careful process control throughout the production chain.

**SUMMARY RESULTS ON IMPLEMENTATION OF LEAN PSM**

We found evidence that all the major aerospace companies had programs intended to reduce their costs through proactive supplier management. Purchased goods and services are typically the largest area of cost concentration within manufacturing firms, so they have been subject to some level of attention everywhere. Levels of implementation did vary, and current efforts tended to be driven by direct cost issues rather than quality or delivery issues. (Prime con-
tractors did report significant and successful efforts in the early 1990s to improve the quality and delivery to schedule performance of their suppliers.)

A common plan was to centralize procurement across different plants of one company and leverage the total amount spent in a particular industrial sector or with a particular contractor. Generally, a large percentage of purchased goods and services comes from a small percentage of the supplier base. Although a few suppliers contribute a high volume and value of goods and services, the majority of suppliers “on the books” sell tiny amounts to their aerospace customers. Managing these suppliers can be expensive, particularly if quality problems develop. These suppliers can be unresponsive to demands of their aerospace customers if aerospace companies are a small percentage of their customer base. Hence, consolidation of contracts across corporate sectors or industry sectors may generate the kind of volumes with any particular supplier to get the attention that the customer wants.

One aircraft prime’s final product cost consisted of about 50 percent purchased materials. Three-quarters of the cost of goods purchased was spent at less than 3 percent of the company’s suppliers, and inventory made up almost three-quarters of the company’s total assets. The company hoped to reduce the supplier base and create partner suppliers, with JIT delivery helping to cut inventory. Also, it hoped to improve the quality of supplier inputs, as rejects and variability were significant costs. It wanted to reduce cycle time by managing lead times of suppliers. Finally, it wanted to reduce the percentage of company personnel staffing the procurement function. The company thought it could save about 4.5 percent on parts with further effort. Savings through 1998 came from outsourcing, personnel efficiencies, group and corporate purchasing agreements, revised contracting methods, and similar efforts. The company saved about three-quarters of its initial target during the summer of 1998 and did better than expected during the final target date of 1999. Future estimates indicate that the company expected to save 1 percent of its total spending in 2000, a figure rising to about 6 percent by 2004.

A second research site was just beginning its implementation of improved supplier management in the summer of 1998 and had no
initial savings results to share. The company expected to get savings of 20 percent of total procurement. This number is somewhat more doubtful, particularly since literature on best practice purchasing and supply management generally lists about 5 percent savings as typical, although further savings are not unusual in plants committed to the best practices and working on an ongoing basis with their suppliers. Certainly, 20 percent may be possible in some purchased goods and services categories, but in other categories it may be difficult to get any savings at all. This may be particularly true of commodities with clear market prices, where aerospace makes up only a small percentage of sales.

To summarize, lean supplier management may indeed result in real savings, both directly from reduced cost of materiel and indirectly from such outcomes as higher-quality goods requiring less rework or returns, from JIT inventory with supplier partners, and potentially reduced workload at the prime. Close partnering with suppliers can result in savings as both parties take advantage of the opportunity to learn. Further savings from long-term agreements or multiyear procurements are also possible. Research indicates that savings of about 5 percent are probably achievable in the next several years, provided the manufacturer has a strong, consistent effort to implement the lessons from best practice PSM. Without such commitment, these savings have little chance of being generated.