CHAPTER 5

New Product Development

Overview

This chapter addresses four key issues: (1) early supply management and supplier involvement; (2) the process of designing and developing new products, with emphasis on supply management's role in the process; (3) several approaches to increasing supply management's role in the new product development process; and (4) a description of supply management professionals who interface successfully with engineers during the new product development process.

World-class firms excel at a crucial triad of activities: new product development, the design of the required production process, and development of the optimal supply chain. This chapter addresses the first member of this triad.

"Rapid changes in technology, the emergence of global industrial and consumer markets, increasing market fragmentation and product differentiation, and the increasing options for developing and producing products have increased the pressure on all firms to more effectively and efficiently develop new products."[1] In many progressive firms, the design of new products is conducted by a team representing a number of functional areas. Marketing, product planning, design engineering, reliability engineering, supply management, manufacturing engineering, quality, finance, field support, and, frequently, carefully selected suppliers and customers are involved, as appropriate. If effectively done, new product development (NPD) can be a source of competitive advantage for a firm and a competitive strategy for the internal and external partnerships of the supply chain.[2]

Anecdotal evidence indicates that the development of new products by such cross-functional teams and the use of concurrent engineering[3] have the potential of significantly improving three key objectives: time to market, quality, and total cost.[4] The turnaround of many troubled manufacturers during the past decade was the result of replacing departmental walls with teamwork among those who should be part of the design process. Supply management professionals and carefully selected suppliers are moving to earlier involvement in the new product development process because of the important contributions they can make in the areas of quality, cost, and timely market availability. This early involvement commonly is referred to as *early supply management involvement* and *early supplier involvement* (ESI). German authorities Arnold and Essig conclude that "by involving supply management and suppliers in the simultaneous engineering process (as members of cross functional teams) at an early stage, R&D gets the chance to increase efficiency... In fact, early supply management involvement helps to shorten engineering time and increase engineering quality."[5]

The lack of effective, cooperative teamwork among the functions just noted frequently has been accompanied by quality problems, cost overruns, forgone all-in-cost savings,[6] major scheduling problems, and new products that are late to enter the marketplace. Further, early recognition of problems is difficult or impossible in the absence of cooperative teamwork. Extensive redesign, rework, and retrofit operations are common when a company is operating in the traditional functional mode. Ultimately, the absence of teamwork results in products that are a continuing burden to the firm's long-term competitiveness.

Cost overruns and forgone cost savings frequently result when the designers (or the design team) fail to consider the supply base's design, manufacturing, quality, and cost capabilities. For example, during the early 1980s, design engineers at General Electric's Jet Engine Division frequently designed materials to be purchased from outside suppliers under the mistaken belief that the outside suppliers had the same manufacturing and process capabilities as GE. In fact, this was not the case; the outside suppliers frequently did not have the same equipment, processes, and quality capabilities. The results were cost growth and schedule slippages as the suppliers, using a trial-and-error process, attempted to meet GE's specifications. Frequently, it became apparent that those specifications could not be met and that a costly and time-consuming process of reengineering would be required.[7]

A similar example of costs resulting from the failure to consider supply implications during design involves IBM. In 1993, IBM's PC units' sales were just over $8 billion, with earnings of about $200 million (2.5%). By contrast, Compaq's profits were $462 million on sales of $7.2 billion (6.4%). According to *Business Week*, "At least one reason . . . seems clear, IBM still does not use common parts across its product families." Another contributor to lower profits was IBM's failure to shift away from pricey Japanese components as the value of the yen rose.[8] It was noted that IBM recognized that its supply management system had been the source of significant cost overruns and forgone dollar savings. In 1994, that recognition resulted in the appointment of a new Chief Procurement Officer: Mr. Gene Richter. Under Richter, three-time Purchasing Man of the Year, IBM procurement has undergone an incredible transformation and is now approaching "World Class" status.

Scheduling problems frequently result from late delivery of required parts. For example, earnings at Apple Computer fell nearly 30% in the third quarter of 1999, largely as a result of supply shortages. Apple received only 45% of the G4 chips its suppliers originally had promised. This, in turn, led to significant reductions in the sales of Apple's Power Mac G4 computers.[9] When supply considerations are not addressed during new product development, unique nonstandard components may be specified. Those components frequently require longer lead times than do standard items. The use of nonstandard items often leads to the inability of the manufacturer to react quickly to changes in market demand, frequently resulting in lost sales. To reduce reaction time to changes in demand, firms are replacing unique components with standard "commodity" ones. In addition to being more readily available, commodity components tend to be far less expensive than the unique items they replace.

The global marketplace and global competition, coupled with advanced communication systems, computers, and sophisticated software, have generated an environment where "time to market" and first to market have significant competitive advantages. Clearly, the need to reduce development time has forced companies to look for new methods to compete. The use of supply professionals and suppliers earlier in the product development cycle is a key way to reduce time to market. The advantages of an integrated approach to new product development no longer can be ignored.[10]

In the early 1990s, the Chrysler Viper went from concept to production in 36 months, in contrast to an industry norm of 60 months. Chrysler did not achieve that goal by itself; it got a lot of support from its suppliers. "They were as much a part of the Viper team as anyone . . . suppliers are an integral part of the team," said Dave Swietlik, the man in charge of procurement for the Viper program. "Their processes drive design."[11]

When a cross-functional team has the responsibility for the development of new products, a concurrent approach to the myriad of tasks involved is taken. This avoids the traditional (and time-consuming) passage of a project from concept development, to design, to manufacturing engineering, to supply management, to manufacturing, to marketing, to field support. That sequential approach requires even more time and personnel resources when changes have to be made in the product's design. The cross-functional team uses a concurrent approach in which the team members work together and collaborate throughout the process.

The Design Process[12]

Design is the progression of an abstract notion or idea to something that has a function and a fixed form. The desired levels of quality and reliability must be "engineered in" during the design phase of the new product. "Suppliers must have access to product design as early as humanly possible in the design process to assure optimal use of any special skills or processes they can contribute."[13] The design stage is also the optimum point at which the vast majority of the cost of making an item can be reduced or controlled. If costs are not minimized during the design stage, excessive cost may be built in permanently, resulting in expensive, possibly noncompetitive, products that fail to realize their profit potential.

The new product development process is a series of interdependent and frequently overlapping activities that transform an idea into a prototype and on to a marketable product. The process is much more fluid and flexible than is portrayed in the forthcoming flow diagrams in this chapter. As the original idea progresses through the development process, it is refined and constantly evaluated for technical and commercial feasibility. Trade-offs between the various objectives (price, cost, performance, market availability, quality, and reliability) are made throughout the process. These days, one hears a great deal about designing for manufacturability; however, invariably, the focus is on the firm's internal manufacturing process. However, when those responsible for design ignore the manufacturing process and technological capabilities of outside suppliers, problems with quality, time-to-market, configuration, control, and cost are inevitable. If optimal design performance is to be achieved, suppliers must be active from the beginning, when they can have a major impact on performance, time, cost, and quality. Selected suppliers should participate in feasibility studies, value engineering, and prototype, failure, and stress analysis, among other product development tasks.

There is a growing trend among manufacturers to develop an "envelope" of performance specifications for suppliers. For example, instead of determining the materials, manufacturing processes, and engineering drawings for a seat for one of its motorcycles, in the 1980s Kawasaki began specifying the environmental conditions and the maximum weight the seat had to withstand together with a drawing showing how the seat was to attach to the motorcycle frame. The suppliers' engineering and CAD/CAM[14] tools, not the buying firm's, were then dedicated to designing selected components. This approach allows engineers at the buying firm to focus on the development of more sophisticated core technologies and proprietary systems. The customer firm's engineers do not prepare engineering drawings for nonstrategic components. However, they review and approve the supplier's designs. That not only redirects critical engineering resources to higher-value activities but also places responsibility for manufacturability and quality with the supplier.

To involve suppliers effectively and early, manufacturing companies invite carefully selected suppliers' engineers into their own engineering departments. In a 1995 *Harvard Business Review* article, management guru Peter Drucker described William Durant as the inventor of the keiretsu, a set of companies with interlocking business relationships. Durant designed and built General Motors during the early 1900s. "Durant deliberately brought the parts and accessories makers into the design process of a new automobile model right from the start. Doing so allowed him to manage the total cost of the finished car as one cost stream."[15] Manufacturers should allow key suppliers to review the design of the entire subassembly before committing to it. Not only does this tease out new ideas, it also helps the supply partner understand the customer's real needs—and likely future needs.

Involving suppliers in the new product development process is more challenging than one might imagine. Handfield and Ragatz observe that, "Successful supplier integration initiatives result in a major change to the new product development process. Further, the new process must be formally adapted by multiple functions within the organization to be successful. One of the most important activities in the new development process is understanding the focal supplier's capabilities and design expertise, conducting a technology risk assessment, weighing the risks against the probability of success."[16]

The changing competitive environment requires that much more planning, coordination, and review take place during the design and development process than previously was the case. Complexity of product lines must be addressed. Lower levels of complexity result in higher schedule stability, a prerequisite to just-in-time manufacturing. Feasibility studies, computer simulations, prototype analysis, failure analyses, stress analyses, and value engineering all must be conducted in an effort to develop producible, defect-free products quickly at the lowest possible total cost.

The new product development process has undergone a tremendous change during the last several years. The process is described in Figures 5.1, 5.2, and 5.3 and is discussed next.[17]

The Investigation or Concept Formation Phase

There are several types of new product design. The first is the one used for a totally new product. This is the least common approach because completely new products are the exception. Most new product design is actually an adaptation or an expanded feature set for a previous design. Advancing technology, process improvements, and market expansion drive the majority of new product design activity. The process described is equally applicable to a totally new product or a "new and improved one."

Defining the New Product

The design and development process begins with the investigation phase. First, the product is defined. This function is normally performed with considerable marketing involvement. Intel carries marketing to its logical extreme: it emphasizes design ethnography, which focuses on understanding the customer and the culture in which a product is to be used.[18] The design and development process has been formally titled "customer focused product and process development" at some firms, or "quality function deployment" at others.[19] Marketing authority Regis McKenna is quoted as saying:

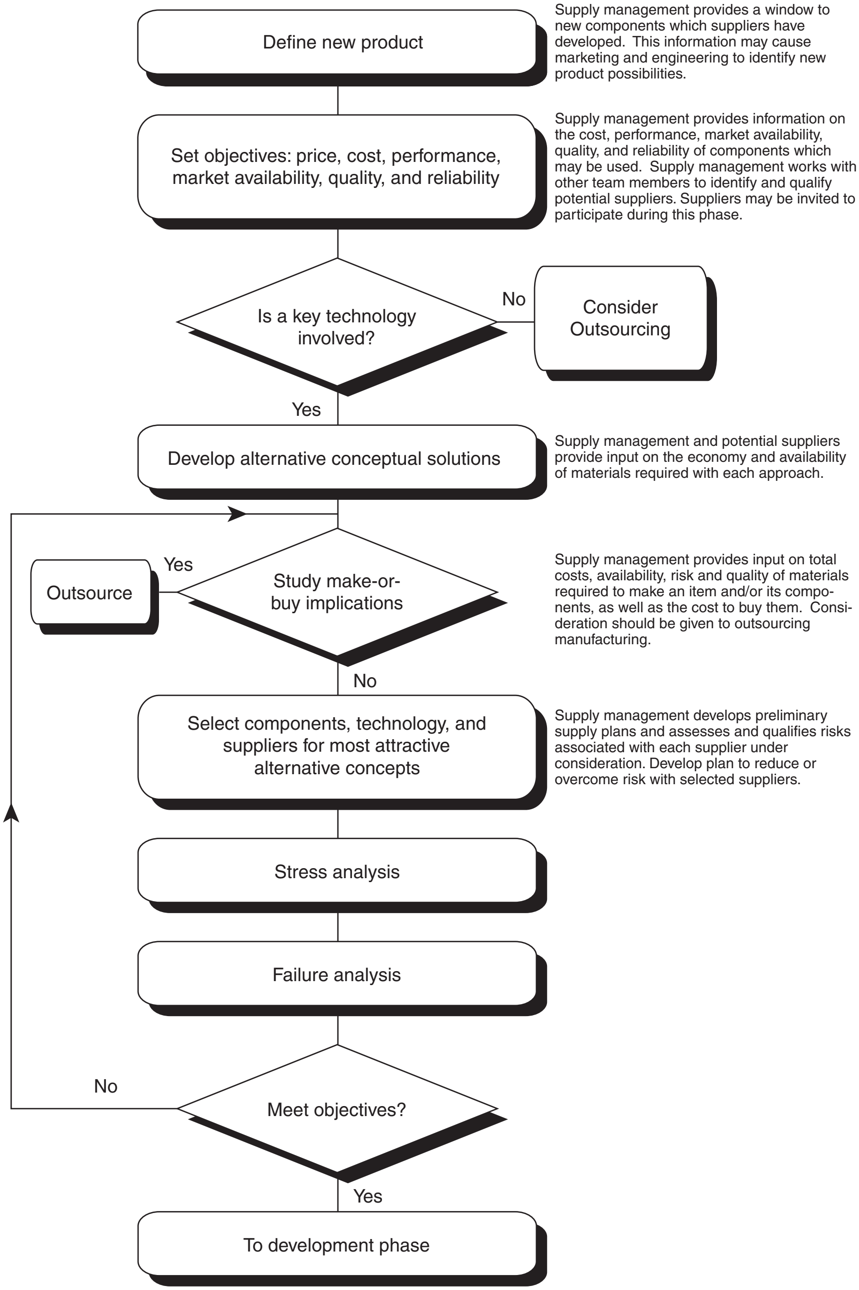

Figure 5.1 Team and supply management activities during new product development *(NPD) investigation phase*. Adapted from David N. Burt and Richard L. Pinkerton, *A Purchasing Manager's Guide to Strategic Proactive Procurement*. New York: AMACOM, 1996, 27.

> Companies need to incorporate the customer into product design. That means getting more and more members of an organization in contact with the customer-manufacturing and design people, as well as sales and marketing staff. You can, for example, have customers sitting in on your internal committee meetings.[20]

Designers can make up for some of the shortcomings of consumer input because they usually understand more about future technological possibilities and look at a longer timeline. They are also in a better position to know what competitors may offer. For example, consumers may desire a "user-friendly" personal computer that is easy to get started with, but the designer realizes the computer should also meet longer-term needs. Therefore, designers should have the freedom to create innovative product designs that not only meet current user requirements but are also up to the demands of future consumer expectations. This give-and-take requires a delicate balance between designers and consumers because research has shown a high correlation between inadequate feedback from users and the failure of new products containing technical innovations.[21]

One of a supply management professional's key responsibilities is to acquire, assimilate, digest, and share information concerning new or forthcoming developments in the supply markets for which he or she is responsible. Interviews with present and potential suppliers, visits to suppliers (with emphasis on their research and development and production activities), attendance at trade shows, weekly reviews of relevant literature, and discussions with colleagues at local supply chain management organizations and American Production and Inventory Control Society meetings help the professional remain current. Through such activities, the supply management professional will become aware of new products and new technologies that may be of interest. This information may help product managers in marketing and senior design personnel responsible for identifying and developing new products. While being careful to screen out inappropriate information, the buyer should share potentially attractive information with marketing and engineering.

Statement of Objectives

Next, a statement of needs, desires, and objectives is developed. Needs are based on marketing's perception or knowledge of what customers want (or the customer's direct input if the customer is a member of the design team), balanced against the company's objectives and resources. Needs that are potentially compatible with the firm's objectives (profit potential, sales volume, and so on) and resources (personnel, machines, and management) are considered for development. Product objectives, including performance, price, quality, and market availability, are established and become the criteria that guide subsequent design, planning, and decision making. A well-informed procurement professional is the key source of information on the cost, performance, market availability, quality, and reliability of supplier-furnished components that may be used in the new product.

Establishing a realistic target cost at this stage of the new product development process is mandatory at world-class firms. (Target Cost = Targeted Market Selling Price – Targeted Profit.)

Purchasing authority Lisa Ellram writes, "By establishing the target cost up front, purchasing, the supply base, designers, and marketing can all work toward a common goal in the value engineering, design for purchasing, and early supplier involvement processes."[22] The planned product lifecycle typically includes not only the original product but also several future products that will incorporate improvements in design, function, features, and so on. These new products are driven by advances in technology, design, or materials; competitive offerings; and customer expectations. These desired advances frequently are known at the time of the original product design, but they are not included in the design because the technology does not exist or requires additional development to be production-ready. This product feature design "wish list" is very important to the design engineer because he or she most closely understands the design trade-offs and compromises that were included in the original design. This "wish list" of technology requirements is extremely important. Unfortunately, most firms do not document these technical interests that eventually drive a subsequent iteration through their product development process. Not only should these data be documented, but they must become an important focus for a supply partner's R&D efforts. Quick development will drive new product offerings that add additional sales volume, frequently at premium prices, for both the manufacturer and supplier.

Key Technology

The development team should determine whether a key technology is involved. If it is not, the team may decide to have an outside supplier develop both the technology and the product.

Development of Alternatives

Alternative ways of satisfying these needs, desires, and objectives should be developed and then evaluated against the criteria established in the preceding step.

There is an unfortunate tendency to proceed with the first approach that appears to meet a need even though less obvious alternatives may yield more profitable solutions. Alternative approaches should be evaluated on the basis of suitability, producibility, component availability, economy, and customer acceptability.

- *Suitability* refers to technical considerations such as strength, size, power consumption, capability, maintainability, and adaptability. Engineering has primary responsibility for these issues.

- *Produceability* is the ease with which a firm can manufacture an item. In the past, designs needed to be changed to accommodate the firm's or its suppliers' ability to produce the item economically. Problems arose when the needed changes were implemented. Early manufacturing engineering involvement in the design is needed to ensure the produceability of items made internally, and early supplier involvement helps ensure the producability of items furnished by suppliers.
- *Component availability* is the time at which components are available, while component economy describes the cost of the item or service. Component availability and economy are the responsibility of purchasing.
- *Customer acceptability* is defined as the marketability of an item to potential customers.

The selection of components, technologies, and suppliers for the most attractive conceptual solutions is a complex process. At progressive firms such as GE, Hewlett-Packard, and Deere and Company, this selection process is a team effort, with design engineering providing the majority of the staffing and the team leadership.

Often, an engineer has a need that must be filled—a power transmission gear ratio, a structural component, a capacitance, a memory requirement. This need usually can be met in more than one way, and yet many times the engineer may not be aware of the options available. In such a case, a supply management professional may be able to offer suggestions. A gear, for example, might be machined of bronze or steel, die cast in aluminum or zinc, molded from plastic, or formed by powder metallurgy. All these options may meet engineering's constraints while offering a wide range of cost, availability, and reliability choices. Supply management and potential suppliers can provide information on the economy and availability of the materials and subassemblies to be purchased under each approach.

The Internet is playing an increasingly critical role in compressing development time. In 2000, Spin City began providing its customers a service that allowed customers to search electronically for current data sheets, free symbols, pricing, and availability for more than 1 million components. Electronics parts suppliers were able to communicate product and service information directly to the engineer's desktop in real time, reducing costs and development time.[23] Practiced by leading firms today, ESI is a key contributor to the product development process. With ESI, suppliers are carefully prequalified to ensure that they have both the desired technology and the right management and manufacturing capability. Before inviting an outside supplier to participate in the development of a new product, the cross functional development team will ask the following and related questions:

- Will the supplier be able to meet our cost, quality, and product performance requirements?
- Does the supplier have the required engineering capability?

- Will the supplier be able to meet our development and production needs?
- Does the supplier have the necessary physical process and quality capabilities required?
- Does the supplier have both the resources and the reputation of being able to overcome problems and obstacles as they arise?
- Is the supplier financially viable?
- Are the supplier's short- and long-term business objectives compatible with ours?
- If a long-term relationship appears desirable, are the technology plans of the two firms compatible?
- If a long-term relationship appears desirable, is it likely that we can build a trusting relationship?

When a component or subsystem is to be developed by an outside supplier under an ESI program, normally two or three potential suppliers will be requested to design and develop the required item. Potential suppliers are given performance, cost, weight, and reliability objectives and are provided information on how and where the item will fit (interface) in the larger system. These potential suppliers must develop quality plans during the design of the item to ensure that the item can be produced in the quality specified. Selection of the "winning" supplier is a team effort, with supply management, design engineering, reliability engineering, product planning, quality, manufacturing, finance, and field support participating. Performance, quality, reliability, and cost are all considered during the selection process. When a carefully crafted strategic alliance for the item or the commodity class (e.g., fasteners, resistors, safety glass) exists, the alliance supplier alone will be invited to design and develop the required item.

Early supply management and supplier involvement can reduce the well-known start-up problems that occur when the design and the supplier's process capability are poorly matched. Ideally, supplier suggestions will be solicited and the matching of design and manufacturing process will take place during the investigative phase of the design process. The support suppliers provide in the early stages of design is a critical factor in squeezing the material costs out of a product, improving quality, and preventing costly delays.

Make-or-Buy and Outsourcing Analysis

The make-or-buy and outsourcing issues should be addressed for all new items that can be either purchased or produced in-house. Every job release and every purchase request implies a decision to make or to buy. Supply management plays a key role in the make-or-buy process by providing information on the cost, quality, and availability of items. (For more on this critical issue, see Chapter 10.)

Select Components, Technologies, and Supplies

Several options may meet engineering's constraints while offering a wide range of cost, availability, and reliability choices. Supply management professionals and selected suppliers provide information on the availability of the materials and subassemblies to be purchased under each approach. The Internet allows engineers to check for component capability and product attributes in real time. The early involvement of quality engineers allows advanced quality planning to commence in a timely manner. Quality standards are developed to ensure that components and products that are being designed can be produced at the quality specified.

The selection of required standard components is facilitated by the availability of a current internal catalog of standard items and sources that have been prequalified.[24] The use of such a catalog simplifies the design engineer's job while supporting the efforts of engineering or materials management to standardize the items used. The use of standard materials, production processes, and methods shortens the design time and lowers the cost of designing and producing an item. In addition, standardization reduces quality problems with incoming materials, inventories, administrative expenses, inspection, and handling expenses, while achieving lower unit costs.

The selection of technologies is a complex issue due to inherent cost/benefit trade-offs and functional orientations. Engineers are eager to incorporate the latest technology. The marketplace often richly rewards those who are first to market with innovative products; therefore, there is a strong case for incorporating new technology or processes before they are perfected. The cost of such a decision can be high. Not only does such an approach result in a proliferation of components to be purchased and stocked, but it frequently results in the use of items whose production processes have not yet stabilized; quality problems, production disruptions, and delays frequently result, increasing project risk. Engineering, quality, supply management, and manufacturing personnel must ensure that both the costs and benefits of such advanced developments are properly considered. The design team should design new products to the requirements of the customer, not necessarily to the state of the art.

Stress Testing and Failure Analysis

Once candidate component and subsystem items have been identified, they are subjected to stress testing and failure analysis. Failures are caused by failure mechanisms, which are built into the item and then activated by stresses. Studying the basic stresses and the failure mechanisms they activate is fundamental to the design of effective reliability tests. The correct design approach is to find and eliminate the fundamental causes of failure. This means that the most successful stress tests are ones that result in failures. Successful tests are also tailored to look for particular failure mechanisms efficiently by selectively accelerating the tests.

Every failure has a cause and is a symptom of a failure mechanism waiting to be discovered. The tools of failure analysis are both statistical and physical; used together, they are a potent means for detecting the often unique fingerprint of the underlying source of the failure.

The Development Phase

Rapid advances in computer technology and software have made large-scale, complex computer simulations possible. Manufacturers typically conduct extensive computer simulations to identify interferences, fit issues, functionality, algorithmic logic accuracy, and so forth, before the development of prototypes. As the technology continues to advance, computer modeling and simulation may replace prototype development.

Despite these technical advances, breadboard or hardware prototypes commonly are developed so that the design team may conduct tests on the integrated system to eliminate performance and quality problems. The selected approach is reviewed in detail for feasibility and likely risk. Efforts are made to reduce risk to acceptable levels by developing and testing prototypes.

Prototypes

As shown in Figure 5.2, the first complete prototypes of the new product are designed, built, and tested. Documentation such as materials lists, drawings, and test procedures is created. It is not unusual to repeat this phase more than once, perhaps building the first prototype in the laboratory to test the design and the second prototype in manufacturing as a test of the documentation. The design should not exit this phase until a prototype has met all the design goals set for it, although it may not be possible to demonstrate the reliability goal because of the small number of prototypes available for testing.

Design Reviews

The design review is the point at which the new design can be measured, compared with previously established objectives, and improved. Supply management participates in design reviews and provides information on the effect of specifications and the availability of items that are standard production for, or are inventoried by, suppliers. The supply professional must ensure that the specification or other purchase description is complete, is unambiguous, and provides necessary information on how items furnished under it are to be checked or tested. He or she should be satisfied that the purchase description is written in terms relevant to and understandable by potential suppliers.

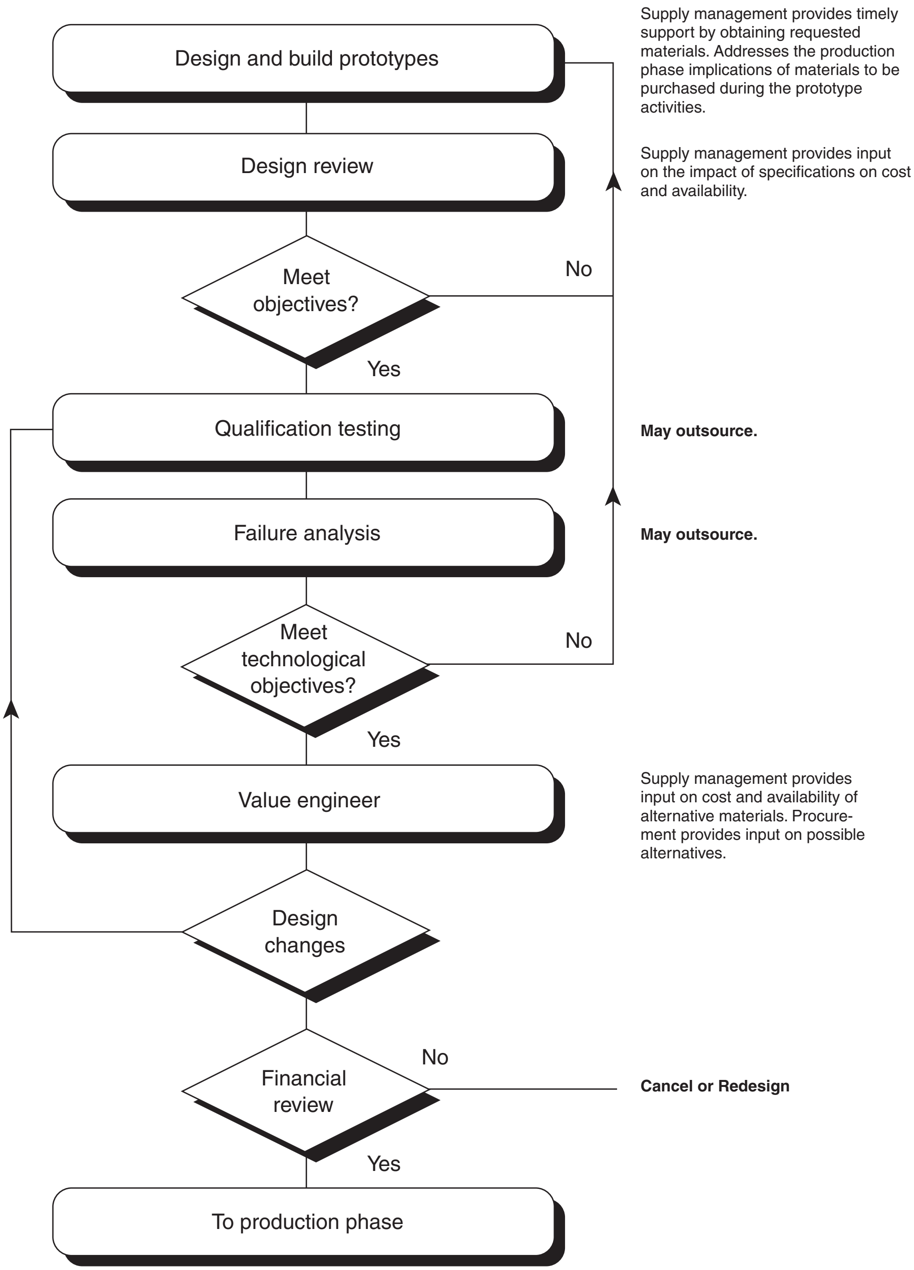

Figure 5.2 Team and supply management activities during new product development *(NPD) development phase*. Adapted from David N. Burt and Richard L. Pinkerton. *A Purchasing Manager's Guide to Strategic Proactive Procurement*. New York: AMACOM, 1996, 28.

Boeing provides an example of how computers have an impact on new product development. It can now design a commercial aircraft entirely by computer. It solves nearly all of its design issues through computer animation, avoiding the need to build physical prototypes. This approach reduces the cost of making design changes during production. The practice cut the time required to design the 777 by 50%.[25]

Qualification Testing

Qualification tests are conducted on the prototype equipment. There are two different types: (1) margin tests and (2) life tests. *Margin tests* are concerned with assuring that the threshold of failure—the combination of conditions at which the product just begins to malfunction—is outside the range of specified conditions for the product's use.

Life tests are intended to find patterns of failure that occur too infrequently to be detected by engineering tests on one or two prototypes. These tests differ from margin tests primarily in the number of units tested and the duration of the test.

Failure Analysis

The stress testing and failure analysis techniques described in the investigation phase are applied to the prototype.

Does the Prototype Meet Objectives?

The design team determines whether the prototype meets the objectives established in the investigation phase. If the prototype fails this analysis, the project reenters the design process and a new or upgraded prototype is developed.

Value Engineering

During World War II, many critical materials and components were difficult to obtain, and most manufacturers were required to incorporate numerous substitutions in their design and production activities. Harry Erlicher, then Vice President of Purchasing for the General Electric Company, observed that many of the substitutions required during that period resulted not only in reduced costs but also in product improvements. Consequently, Mr. Erlicher assigned to Larry Miles the task of developing a systematic approach to the investigation of the function/cost aspect of existing material specifications. Larry Miles not only met the challenge successfully but subsequently pioneered the scientific procurement concept General Electric called "value analysis (VA)."[26]

In 1954, the U.S. Navy's Bureau of Ships adopted a modified version of General Electric's VA concept in an attempt to reduce the cost of ships and related equipment. In applying the concept, the Navy directed its efforts primarily at cost avoidance during the initial engineering design stage and called the program "value engineering" (VE), even though it embodied the same concepts and techniques as GE's VA program. In an operational sense, however, the two terms typically are used synonymously in industry today—only the timing differs. Hence, throughout this book when the term "value analysis" is used, it carries the same conceptual meaning as the term "value engineering," except for the practical matter of timing.

Value Engineering vis-à-vis Value Analysis

As practiced in U.S. firms for many years, VA techniques were most widely used in programs designed to engineer unnecessary costs out of existing products. Finally, the more progressive firms began to follow the Navy's lead by establishing what they too called "value engineering" programs—programs that applied the VA concept during the early stages of the new product design process. Clearly, this is the first point at which it should be applied. This is where the greatest benefits are produced for both the firm and its customers.

What is the mix of VA and VE applications in American industry today? No one really knows. However, the number of both programs has grown markedly in the last decade, with VE programs setting the pace.

The VE concept finds its most unique use in two kinds of companies: those that produce a limited number of units of a very expensive product and those that mass-produce products that require expensive tooling. In these types of companies, VA of an item already in production is often impractical because it is too late to incorporate changes in the product economically. In manufacturing certain electronic instruments used in defense systems, for example, the production run is often so short that it precludes the effective use of VA after production has been initiated. In fact, the Federal Acquisition Regulations now stipulate that most major defense procurement contracts be subjected to VE studies before initial production.[27]

A somewhat different situation that produces similar operating results is used in firms that mass-produce automobiles. For example, in manufacturing the body panel for a car, once the design is fixed and the dies are purchased, it is normally too costly to change them even though VA studies subsequently may disclose design inefficiencies.

VE utilizes all the techniques of VA. In practice, it involves very close liaison work between the supply, production, and design engineering departments. This liaison is most frequently accomplished through the use of product design teams or supply and production coordinators who spend considerable time in the engineering department studying and analyzing engineering drawings as they are produced. Once coordinators locate problem areas, VA techniques are employed to alleviate them.[28]

VE is a systematic study of every element of cost in a material, item of equipment, service, or construction project to ensure that the element fulfills a necessary function at the lowest possible total cost. Ideally, the VE thought process is instilled in all members of the new product design team through appropriate training. (World-class firms provide 40–50 hours of VE training per year to those who would benefit!) The team members (including selected suppliers) apply VE as the product development project evolves. In some instances, value engineers are assigned to the development teams to ensure that these powerful tools are applied.

The inclusion of the VE step in Figure 5.2 is a safeguard: if VE thinking has been incorporated throughout the development process, a separate VE review may not be necessary. However, experience indicates that a VE review at the indicated point will result in significant savings and improved quality and performance. Two tools aid those involved in the VE process:

- Design analysis
- The VE checklist

Design Analysis

Design analysis entails a methodical step-by-step study of all phases of the design of a particular item in relation to the function it performs. The philosophy underlying this approach is not concerned with appraisal of any specific part per se. Rather, the appraisal focuses on the function that the part or the larger assembly containing the part performs. This approach is designed to lead the analyst away from a traditional perspective, which views a part as having certain accepted characteristics and configurations. Instead, it encourages the analyst to adopt a broader point of view and to consider whether the part performs the required function both as effectively and as efficiently as possible. Both quality and cost are objects of the analysis.

A technique many firms use in analyzing component parts of a subassembly is to dismantle, or "explode," the unit and then mount each part adjacent to its mating part on a pegboard or a table. The idea is to demonstrate visually the functional relationships of the various parts. Each component can thus be studied as it relates to the performance of the complete unit rather than as an isolated element. Analysis of each component in this fashion is done to answer four specific questions:

1. Can any part be *eliminated* without impairing the operation of the complete unit?
2. Can the design of the part be *simplified* to reduce its basic cost?
3. Can the design of the part be changed to permit the use of simplified or less costly *production methods*?
4. Can less expensive but equally satisfactory *materials* be used in the part?

Design simplifications frequently are more apparent than is possible under the original design conditions when viewed from the standpoint of the composite operation. (This in no way reflects unfavorably on the work done initially by the design engineer.) The discovery of such potential improvements is simply the product of an analysis with a substantially broader orientation than that of the original designer. An organized VE study usually utilizes a number of individuals with different types of backgrounds, experience, and skill impossible to combine in the person of a single designer. The resulting design changes often permit the substitution of standardized production operations for more expensive operations that require special setup work. In some cases, considering the volume of parts to be produced, an entirely different material or production process turns out to be more efficient than the one originally specified. Figure 5.3 shows the logic underlying a VE study.

The Value Engineering Checklist

Most companies develop some type of checklist to systematize the VE process. Literally hundreds of questions and key ideas appear on those lists. Some of the checklists are highly specialized for particular types of products. Illustrative of the more general questions is the following checklist.

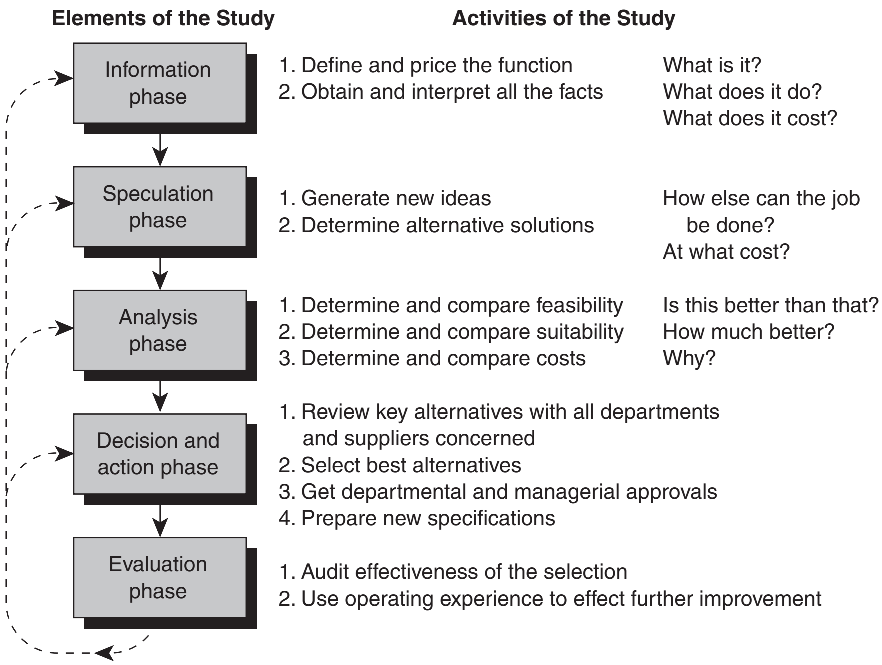

Figure 5.3 A generalized procedural model of the VE process.[29,30]

First, determine the function of the item, then determine:

1. Can the item be eliminated?
2. If the item is not standard, can a standard item be used?
3. If it is a standard item, does it completely fit the application, or is it a misfit?
4. Does the item have greater capacity than required?
5. Can the weight be reduced?
6. Is there a similar item in inventory that could be substituted?
7. Are closer tolerances specified than are necessary?
8. Is unnecessary machining performed on the item?
9. Are unnecessarily fine finishes specified?
10. Is "commercial quality" specified? (Commercial quality is usually more economical.)
11. Can you make the item less expensively in your plant? If you are making it now, can you buy it for less?
12. Is the item properly classified for shipping purposes to obtain the lowest transportation rates?
13. Can cost of packaging be reduced?
14. Are suppliers contributing suggestions to reduce cost?[31]

In using this or similar checklists, those involved evaluate the component under investigation with respect to each item on the checklist. When a question is found to which the answer is not entirely satisfactory, this becomes a starting point for more detailed investigation. The checklist focuses the analyst's attention on those factors that past experience has proved to be potentially fruitful cost-reduction areas.[32]

Viability

Before proceeding to production, a careful business analysis must be completed. In effect, the development team asks: "Will the product provide our firm's required return on its investment?"

The Production Phase

Manufacturing and Production Plans

In the production phase, as shown in Figure 5.4, the manufacturing plan and the procurement plan (frequently in the form of a bill of materials) are finalized. As a result of its early involvement in the design and specification development process, supply management also should have been able to develop contingency plans that will satisfy the firm's needs if the first source doesn't work out. The appropriate plans are now formalized and implemented.

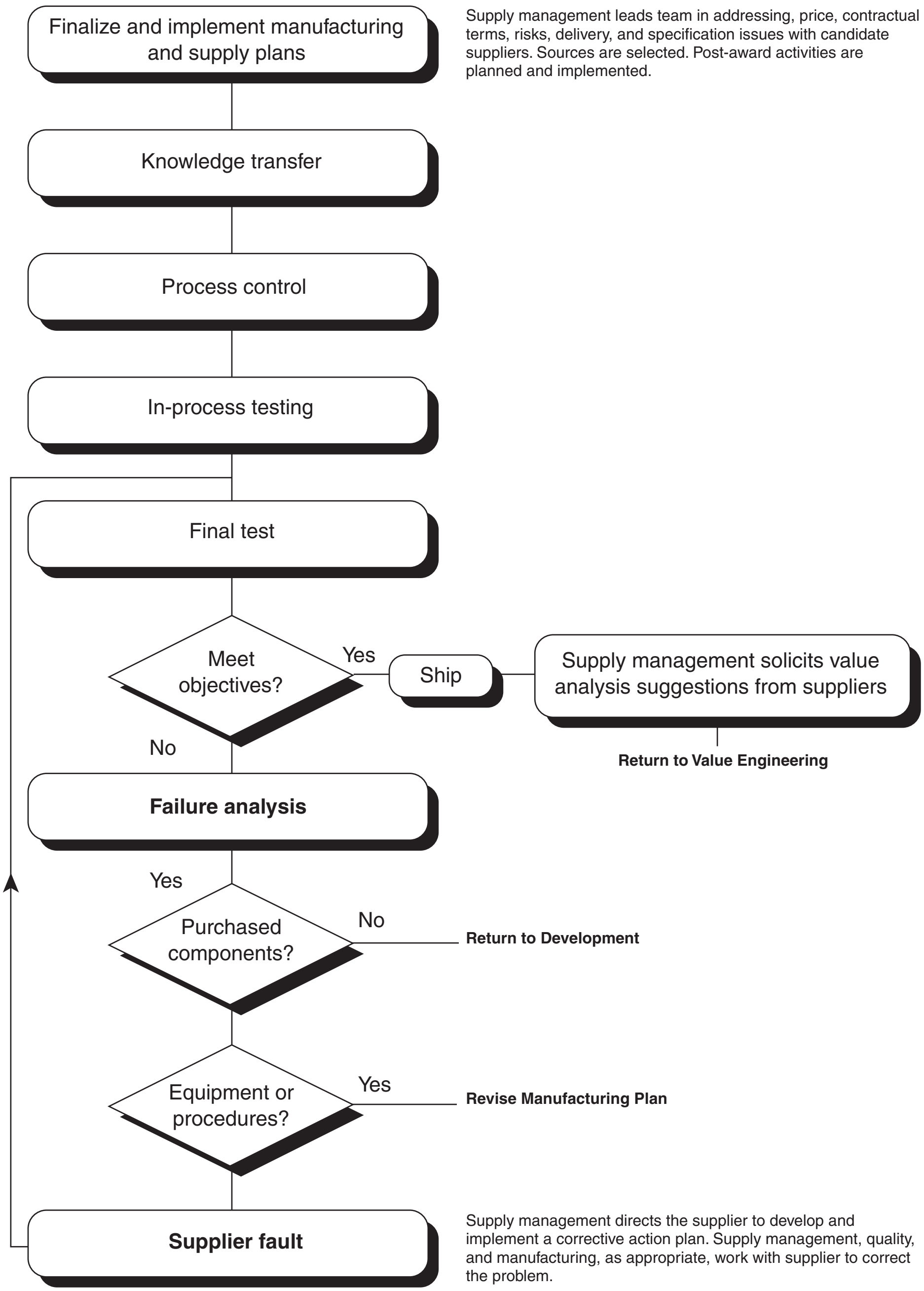

Figure 5.4 Team and supply management activities during new product development (NPD) production phase. Adapted from David N. Burt and Richard L. Pinkerton, *A Purchasing Manager's Guide to Strategic Proactive Procurement.* New York: AMACOM, 1996, 30.

Knowledge Transfer

Manufacturing engineering applies experience from similar projects and new developments from other manufacturers to the firm's production process. Manufacturing engineers also work with suppliers to share new and improved production techniques.

Process Control

Contrary to popular opinion, the design is not finished when the transfer from development to production takes place—quite the contrary. Unfortunately, changes at this stage of product development are very costly and tend not to be evaluated with the same thoroughness as the original alternatives. Finding a quick fix typically is the order of the day, preferably a fix that does not require extensive retooling or scraping. Still, there are some legitimate reasons why changes in the design occur after release to production. For example, there may be phenomena that occur so infrequently that they are not discovered until a large number of products are manufactured. Another reason for changes at this point is the pressure to develop new products in a shorter time. This time compression frequently results in concurrent engineering. This means that a new manufacturing process is developed simultaneously with a new product using that process, as opposed to the more traditional sequential approach. This is a risky approach, but one that is gaining popularity because it saves time and results in earlier new product release.

When manufacturing problems arise, whether in the buying firm or the supplier's manufacturing operations, there is a tendency to look for a quick fix. One type of solution is to adjust the manufacturing process to minimize the problems, rather than to change the design. Perhaps this approach is taken because the process documentation is internal and not shipped to the customer along with the product. More likely, such changes in manufacturing processes are made because the process is under the jurisdiction of production and consequently the change does not require design engineering's approval.

Such an approach can create problems. The situation can deteriorate to the point where there is a customized process for each product—nothing is standard and the process is out of control most of the time. When design rules and process parameters are both being varied at the same time, the situation quickly becomes too complex to understand or control, and quality suffers.

The correct solution is to optimize the process, get it under control, and keep it that way. Then the designs can be modified so that they fit the standard process, producing stable and predictable yields day after day.

In-Process and Final Testing

There are two objectives for in-process testing: (1) to adjust or calibrate the performance in some way and (2) to eliminate defects before much value is added to the product. Final product testing ensures that the item meets its performance objectives.

Every failure has a cause and is a symptom of a failure mechanism waiting to be discovered. For example, if failure analysis identifies a purchased component as the source of the failure, further analysis is required to determine whether: (1) faulty equipment or procedures are to blame or (2) the problem resides with the supplier. Failure analysis also may identify a latent defect in the product's design, requiring redesign.

Engineering Change Management

Any changes in components or the product itself may have profound effects on its cost, performance, appearance, and acceptability in the marketplace. Changes, especially at the component or subassembly level, can have a major impact on manufacturing. Unless changes in the configuration of an item or its components are controlled, manufacturers may find themselves in trouble. They may possess inventories of unusable raw materials or subassemblies. They may possess materials that require needlessly expensive rework to be adapted to a new configuration. They may produce an end item that will not meet the customer's needs. Uncontrolled changes generally mean that quality and reliability requirements have been compromised without appropriate retesting.

Engineering change management, a discipline that controls engineering changes, has been developed to avoid such problems.[33] How often engineering change management is required is a matter of managerial judgment, but for most modern technical items, engineering change management is a necessity. In some cases, it will be imposed on the manufacturer by its customer. When engineering change management is used, changes are controlled and recorded. Marketing and all activities involved in the purchase, control, and use of purchased materials are told of any proposed changes to the item's characteristics. These organizations then comment on the effect of the proposed change. Such control and coordination is especially important when production scheduling and the release of purchase orders are controlled by a material requirements planning system.

There are many ways to organize an engineering change management group. Ideally, an engineering change management board is established with engineering, manufacturing, marketing, production planning, inventory management, and supply management represented. When there is a materials management organization in the firm, a senior representative of production planning and inventory control is a logical candidate to chair this board. It is crucial that supply management and the function responsible for materials control be involved in the review of proposed engineering changes for three reasons: (1) to provide input on the purchased material's implications of a proposed change, (2) to discuss the timing of proposed changes in order to minimize costs associated with unusable incoming materials, and (3) to be aware of forthcoming changes so that appropriate action can be taken with affected suppliers.

Adherence to this or a similar design process is key to the firm's success in the development of new products. Product quality, cost, and availability all must receive proper attention. Engineering, manufacturing, marketing, quality assurance, and supply management all have vital roles to play in the design process.

How to Expand Supply Management's Contributions

This chapter has described the design and development process. In too many firms, the design engineer attempts to address not only the technical and functional issues of design and development, but also manufacturing considerations, marketing implications, and the commercial considerations of economy and availability. Many of these individuals enjoy interacting with suppliers on both technical and commercial issues, and most believe they are serving their employer's best interests even when making sourcing and specifications decisions that turn out to be sub-optimal in the long run.

It is important to note that the effectiveness of early supplier involvement appears to be a function of the industry involved. Researchers McGinnis and Vallopra found that "supplier involvement is not a panacea for every new product development effort." They also found that the potential for supply management's

> …contribution to new product development is substantial. These potentials can be realized if the supply management staff has the abilities to successfully participate in (and lead) multi-functional teams; has the skills needed to identify, screen, and select suppliers to include in new product development; and the competence to manage, control, and coordinate supplier involvement in a multi-functional team environment.[34]

Supply management professionals have their work cut out for them. They must develop and maintain cooperative relations with engineering that protect the profitability of the firm. Early supply management involvement is an essential ingredient of the program to maximize a firm's profitability.

Supply management professionals must understand the orientation and dedication of the typical design engineer. Obviously, an ability to speak the engineer's language (i.e., *engineeringese*) is very helpful. In a study conducted by one of the authors, it was found that supply management personnel who think in the same manner as engineers have a much higher success rate when dealing with engineers than do other individuals. Such thought processes can be identified through established testing procedures.

Whenever feasible, supply professionals should provide advice on the commercial implications of designs under consideration in a positive and constructive manner. They must learn to co-opt their engineering counterparts by providing value and service. Supply management then is seen as a partner who takes care of business problems, thereby allowing engineers to concentrate on technical issues. Several successful approaches to obtaining the desired level of supply management input during the design process are described now.

Design or Project Teams

When the importance of a project or program warrants, a dedicated project team is the ideal means of ensuring early supply management involvement. These teams are often referred to as cross-functional design teams.

Materials Engineers

Individuals with an engineering background are good candidates for supply management positions whose responsibilities require involvement with design engineering. Some supply management organizations divide buying responsibilities into two specialties: (1) materials engineering and (2) the supply management activities of sourcing, pricing, and negotiating. The materials engineer is responsible for coordinating with design engineering, for prequalifying potential sources (usually with the assistance of quality assurance), and for participating in value management.

Co-Location

This approach calls for the placement of members of the supply management staff in locations where design engineering and development work is done. These individuals are available to collaborate with design engineers and others by obtaining required information from prospective suppliers and advising designers on the procurement implications of different materials and suppliers under consideration. When Harley-Davidson opened its product design center in 1997, it co-located design engineering, supply management, manufacturing, marketing, and key supplier personnel. Cross-functional teams are the order of the day. The result? Faster to market, reduced total cost, and improved quality.[35]

Supply Management Professionals Who Interface Successfully with Engineers

The supply professional is the key to successful early supply management involvement in the new product development process. Management directives, policies, and procedures supporting early supply management involvement all help. But it is only when design engineers realize that the early involvement of a supply professional is a productive asset, and not a nuisance or an infringement on their territory, that early supply management involvement makes its full contribution.

A supply management professional who recognizes the importance of being involved early in the process must acquire the necessary skills and knowledge to be seen and accepted as a contributor. Courses in the development and interpretation of engineering drawings, as well as in a wide variety of technologies, can be taken via correspondence, night school, or a few degree-granting programs.[36] Sales personnel love to talk and will gladly help a willing listener gain technical insight into their products. Visits to suppliers' operations provide further insight and understanding.

The design and development of new products is one of a manufacturing firm's most crucial activities. Profitability and even survival are affected. Supply management and the firm's suppliers have major contributions to make during this process. An increasing number of successful firms involve supply management and suppliers up front because of contributions they can make in the areas of quality, cost, and time to market.

Appendix

Simon Croom of the Warwick Business School, Coventry, U.K., and the University of San Diego establishes the need for two types of competencies during product development: operational and relational. He defines operational competencies as those related to the design, manufacture, and delivery of a product. Relational competencies are involved in communication, interaction, problem resolution, and relationship development. Croom demonstrates the importance of relational competencies in achieving successful collaborative product development.[37]

European researchers Finn Wynstra, Bjorn Axelsson, and Arjan van Weele argue that authors in the fields of purchasing, procurement, and supply management have failed to identify many of supply management's activities in product development. These highly respected researchers identify 21 supply management activities related to product development. The interested reader is encouraged to review their provocative articles contained in the summer 1999 and autumn 2000 issues of the *European Journal of Purchasing and Supply Management.*

Handfield, Ragatz, Petersen, and Monczka address the complex issue of evaluating the capabilities of suppliers that are being considered for early involvement in new product development. The interested reader is encouraged to review this insightful article.[38]

Charles Fine, author of *Clockspeed*, advocates that firms design their supply chains strategically and concurrently with their products and production process.

> When firms do not explicitly acknowledge and manage supply chain design and engineering as a concurrent activity to product and process design and engineering, they often encounter problems late in product development, or with manufacturing launch, logistical support, quality control, and production costs. In addition, they run the risk of loosing control of their business destiny.[39]

We agree with Dr. Fine.

Endnotes

1. Michael McGinnis and R. Vallopra, "Purchasing and Supplier Involvement: Issues and Insights Regarding New Product Success," *The Journal of Supply Chain Management*, Summer (1999): 4–15.
2. John E. Ettlie and Paul A. Pavlou, "Technology-Based New Product Development Partnerships," *Decision Sciences,* 37(2)(2006): 117–147.
3. Concurrent engineering is a process in which functional specialists execute their parts of the design as a team concurrently instead of in separate departments serially.
4. Charles O'Neal, "Concurrent Engineering with Early Supplier Involvement: A Cross-Functional Challenge," *International Journal of Purchasing and Materials Management*, Spring (1993): 3–9.
5. Personal interview with Dr. Uli Arnold and Dr. Michael Essig, Stuttgard, Germany, July 1999.
6. "All-in-cost" is a summation of purchase price, incoming transportation, inspection and testing, storage, production, lost productivity, rework, process yield loss, scrap, warranty, service and field failure, and customer returns and lost sales associated with the purchased item. The term "all-in-cost" is similar to "total cost of ownership" and simply "cost." All recognize that the purchase price of an item is merely one component of the total cost of buying, owning, and using a purchased item.
7. Personal interview with Gene Walz, Materials Manager, General Electric, Jet Engine Division, June 1983.
8. Ira Sager, "IBM: There's Many a Slip. . . ," *Business Week*, June 27, 1994, 26–27.
9. "Apple Net May Fall Up to 30% in Quarter," *Wall Street Journal*, September 21, 2000.
10. Chong Leng Tan and Michael Tracey, "Collaborative New Product Development Environments: Implications for Supply Chain Management," *The Journal of Supply Chain Management,* 43(3)(2007): 2–15.
11. Ernest Raia, "The Chrysler Viper: A Crash Course in Design," *Purchasing*, February 20, 1992, 48.

12. Portions of this section are based on *Proactive Procurement*: *The Key to Increased Profits, Productivity, and Quality* by David N. Burt, Englewood, NJ: Prentice Hall, (1984) and *Proactive Procurement* by David N. Burt and Richard L. Pinkerton (New York: AMACOM, 1996).
13. John A. Carlisle and Robert C. Parker, *Beyond Negotiation*: *Redeeming Customer-Supplier Relationships*, (Chichester, UK: John Wiley & Sons, 1989): 127.
14. Computer-assisted design/computer-assisted manufacturing.
15. Peter F. Drucker, "The Information Executives Truly Need," *Harvard Business Review* Jan-Feb (1995): 56.
16. Robert B. Hanfield and Gary L. Ragatz, "Involving Suppliers in New Product Development," *California Management Review* Fall (1999): 60.
17. Some world-class firms prepare a report at the end of a new product development project to document the major lessons learned—ones that can be applied to future projects.
18. Peter Tarasewich and Saresli Nair, "Designing for Quality," *Industrial Management*, Jul-Aug (1999): 18.
19. The interested reader is referred to "The House of Quality" by John R. Hauser and Don Clausing, *Harvard Business Review*, May-June (1988): 63–67.
20. Interview with Regis McKenna by Anne R. Field, "First Strike," *Success*, October 1989, 48.
21. Peter Tarasewich and Suresh K. Nair, "Designing for Quality," *Industrial Management*, Jul/Aug (1999): 18.
22. Lisa Ellram, "Cost Reduction: Match the Tool to the Purchase," *Purchasing Today*, October (1998). For more insight into this process, see "Purchasing and Supply Management's Participation in the Target Cost Process," by Lisa M. Ellram, *The Journal of Supply Chain Management*, Spring (2000): 39–51.
23. Personal interview: Pat Guerra, CEO, Spin City, October 10, 2000.
24. This catalog is developed and maintained by the joint efforts of design engineering, reliability engineering, supply management, and manufacturing engineering. It reflects the technical and commercial implications of the items included. The catalog typically classifies components as low, medium, or high risk, in an effort to dissuade design engineers from using high-risk components in new products. The internal catalog is in contrast to a supplier's catalog, which, while simplifying the engineer's efforts to describe an item, places the firm in an unintentional sole-source posture.
25. "The Economy," *Fortune Magazine*, October 2, 2000.
26. The classic book on value engineering and analysis is *Techniques of Value Analysis & Value Engineering*, 2nd ed., by Lawrence D. Miles, McGraw-Hill, 1972. This book is still the best on the subject.

27. For an interesting discussion of how the Department of Defense utilizes value engineering, see "DOD Honors ASD Value Engineering Program," *Skywriter*, August 1991, 7.
28. For a complete discussion of this topic, see D. W. Dobler, "How to Get Engineers and P.A.'s Together," *Purchasing World*, November (1980): 48–51; D. N. Burt, *Proactive Procurement*, (Englewood Cliffs, NJ: Prentice-Hall), 1984, chap. 2; and David N. Burt and Richard L. Pinkerton, *A Purchasing Manager's Guide to Proactive Procurement*, (AMACOM, 1996), chap. 11.
29. Most items perform more than one function—usually a basic function plus several supporting functions. Experience has shown that often the basic function constitutes 20 to 25% of the cost of the item and supporting functions account for the rest of the cost. Consequently, it is important to clearly identify these two types of functions. Use of the FAST (function analysis system technique) diagram approach provides an easy way to organize functions and subfunctions in their logical relationships. Details are available in Carlos Fallon, *VA,* Wiley Inter-Science Publishers, 1991; and Gary Long, *VA/VE Workshop Workbook,* Society of American Value Engineers, September 24, 1993, Phase One and Phase Two.
30. The development of alternative materials and processes is the most challenging, but perhaps the most stimulating phase of VE. Creativity and brainstorming should be encouraged and supported. Professor Alvin Williams and his colleagues suggest a number of other techniques that readers may find helpful. For details see Alvin J. Williams, Steve Lacey, and William C. Smith, "Purchasing's Role in Value Analysis: Lessons from Creative Problem Solving," *The International Journal of Purchasing and Materials Management,* Spring (1992): 37–41.
31. Basic Steps in Value Analysis, a pamphlet prepared under the chairmanship of Martin S. Erb by the Value-Analysis-Standardization Committee, Reading Association, NAPM, Tempe, AZ, 4–18.
32. For an interesting list of suggestions, see Dave A. Lugo, "Boost Your Creativity with Divergent Thinking and Checklists," *NAPM Insights*, May (1994): 12.
33. Engineering change management controls the changes to a product's design—specifically, its form, fit, and function.
34. Michael A. McGinnis, "New Product Development with and without Supplier Involvement: Factors Affecting Success in Manufacturing and Nonmanufacturing Organizations," Purchasing 2000 Conference, Richard Ivey School of Business, 455–461.
35. Personal interviews with Leroy Zimdars, former Director of Product Purchasing, Harley-Davidson, 1997 and 1998.
36. A small but growing number of universities now offer an integrated procurement and engineering management program.

37. Simon R. Croom, "The Dyadic Capabilities Concept: Examining the Process of Key Supplier Involvement in Collaborative Product Development," *European Journal of Purchasing* & *Management*, 7(2001): 29–37.
38. Robert B. Handfield, Gary L. Ragatz, Kenneth J. Petersen, and Robert M. Monczka, "Involving Suppliers in New Product Development," *California Management Review*, 42(1)(1999): 59–82.
39. Charles H. Fine, *Clockspeed* (Cambridge, MA: Da Capo Press, 1998) 133.

Suggested Reading

Tan, Chong Leng, and Michael Tracey. "Collaborative New Product Development Environments: Implications for Supply Chain Management." *The Journal of Supply Chain Management* 43(3)(2007): 2–15.

Crawford, Merle, and Anthony Di Benedetto. *New Products Management*, 7th ed. New York: McGraw-Hill, 2003.

Parker, Delvon B., George A. Zsidisin, and Gary L. Ragatz. "Timing and Extent of Supplier Integration in New Product Development: A Contingency Approach." *Journal of Supply Chain Management* Jan. (2008): 71–83.

Ettlie, John E., and Paul A. Pavlou. "Technology-Based New Product Development Partnerships." *Decision Sciences* 37(2)(2006): 17–147.

Kahn, Kenneth B., Ed. *PDMA Handbook of New Product Development*, 2nd ed. Hoboken, NJ: John Wiley & Sons, 2005.

Karol, Robin, and Beebe Nelson. *New Product Development for Dummies*. Hoboken, NJ: Wiley, 2007.

Lakemond, Nicolette, Christian Berggren, and Arjan vanWeele. "Coordinating Supplier Involvement in Product Development Projects: A Differentiated Coordination Typology." *R* & *D Management* 36(1)(2006): 55–66.

McGinnis, M.A., and R.M. Vallopra. "Purchasing and Supplier Involvement in Process Improvement: A Source of Competitive Advantage." *The Journal of Supply Chain Management* 35(3)(1999): 42–50.

Nellore, Rajesh. "The Impact of Supplier Visions on Product Development." *The Journal of Supply Chain Management* 37(1)(2001): 27–36.

Petersen, K.J., R.B. Handfield, and G.L. Ragatz. "Supplier Integration into New Product Development: Coordinating Product, Process and Supply Chain Design." *Journal of Operations Management* 23(3-4)(2005): 371–388.

Rainey, David L. *Product Innovation*: *Leading Change Through Integrated Product Development*. Cambridge, U.K.: Cambridge University Press, 2005.

Rogers, D.S., D.M. Lambert, and A.M. Knemeyer. "The Product Development and Commercialization Process." *International Journal of Logistics Management* 15(1) (2004): 43–56.

Kono, Toyohiro, and Leonard Lynn. *Strategic New Product Development for the Global Economy*. Basingstoke, Palgrave Macmillan, 2007.

Schilling, M.A., and C.W. Hill. "Managing the New Product Development Process: Strategic Imperatives." *Academy of Management Executive* 12(3)(1998): 67–81.