Innovative Inventory and Production Management Techniques

LEARNING OBJECTIVES

After completing this chapter, you should be able to answer the following questions:

1
What are the most important relationships in the value chain,
and how can these relationships be managed to benefit the company?

2
Why are inventory management and inventory costs so significant to the firm?

3
How do push and pull systems of production control work?

4
How do product life cycles affect product costing and profitability?

5
How does target costing influence production cost management?

6
What is the just-in-time philosophy and how does it affect production and accounting?

7
What are flexible manufacturing systems and how do they relate to computer-integrated manufacturing?

8
How can the theory of constraints help in determining production flow?

9
(Appendix) How are economic order quantity, reorder point, and safety stock determined and used?

INTRODUCING

In the three-quarters of a century since "Madame" Beatrice Alexander founded the Alexander Doll Co. in 1923, little girls have been unwrapping Madame Alexander dolls at Christmastime. These charming collectibles with hand-painted faces and decorative costumes are modeled either after the fictional Cinderella or the real Elizabeth Taylor, and cost from $40 to $600.

During the 1950s through the 1980s the Alexander Doll Co. prospered under the direction of its founder, but under new management in 1995, the company was struggling so much financially that it filed bankruptcy. However, the company was purchased by the Kaizen Breakthrough Partnership, L.P. (KBP) an investment partnership formed by Gefinor Group, an international merchant bank, in partnership with TBM Consulting Group, Inc., which specializes in helping clients implement *kaizen.* KBP saw an opportunity to use the *kaizen* process to turn Alexander Doll Co. around.

Beginning with the company's small production line for dolls, TBM set up a cross-functional team of 10 Alexander employees to evaluate problems with the production line. The team observed 25 operations and measured each with a stopwatch.

Operations had been spread out over three floors, causing extra handling that wasted time and damaged the dolls. The batch process that had been used caused hundreds of dolls in various stages of completion to collect at each operation.

"We physically moved the operation [within the building] and combined everything in one location," says William Schwartz, director of Alexander Doll and a vice president of TBM. The distance each doll traveled from the beginning to the end of the process was reduced from 630 feet to 40 feet. The time that was required to complete a doll went from 90 days to 90 minutes. The number of unfinished doll pieces was reduced from 29,000 to 34. The square footage used for the line was reduced from 2,010 to 980. And productivity increased from eight dolls per person per day to 25.

SOURCES: Robert Maynard, "A Company Is Turned Around Through Japanese Principles," *Nation's Business* (February 1996), p. 9; and Alex Taylor III, "It Worked for Toyota. Can It Work for Toys?" *Fortune* (January 11, 1999), p. 36.

In recent years, some people have questioned whether some segments of American industry are as productive and efficient as their counterparts in Japan, Germany, or other parts of the world. Many U.S. companies are concentrating on ways to improve productivity and utilization of available technology. These efforts are often directed toward reducing the costs of producing and carrying inventory. Consider the following comments regarding the role of information technology in creating economic value for American business:

> *Federal Reserve Chairman Alan Greenspan gave unexpected support to "New Economy" theorists in a speech at the Gerald R. Ford Foundation in Grand Rapids [September 8, 1999]. Information technology, he said, "has begun to alter, fundamentally, the manner in which we do business and create economic value." By enabling businesses to remove "large swaths of unnecessary inventory, real-time information is accelerating productivity growth and raising living standards. This has contributed to the greatest prosperity the world has ever witnessed."* [1]

The amount spent on inventory may be the largest investment, other than plant assets, made by a company. Investment in inventory, though, provides no return until that inventory is sold. This chapter deals with ways for companies to minimize

[1] George Melloan, "Global View: America's 'New Economy' Is Technology," *The Wall Street Journal Interactive Journal* (September 21, 1999), p. 1. Permission conveyed through the Copyright Clearance Center.

their monetary commitments to inventory. These techniques include the just-in-time (JIT) inventory philosophy and its accounting implications, flexible manufacturing systems (FMS), and computer-integrated manufacturing (CIM). The appendix to this chapter covers the concepts of economic order quantity (EOQ), order point, safety stock, and Pareto inventory analysis.

IMPORTANT SETS OF RELATIONSHIPS IN THE VALUE CHAIN

1

What are the most important relationships in the value chain, and how can these relationships be managed to benefit the company?

Every company has a set of upstream suppliers and a set of downstream customers. In a one-on-one context, these parties can be depicted by the following model:

Upstream Supplier ←→ The Company ←→ Downstream Customer

It is at the interfaces of these relationships where real opportunities for improvements exist. By building improved cooperation, communication, and integration, the entities within the value chain can treat each other as extensions of themselves. In so doing, they can enjoy gains in quality, throughput, and cost efficiency. Non-value-added activities can be reduced or eliminated and performance of value-added activities can be enhanced. Shared expertise and problem solving can be very beneficial. Products and services can be provided faster and with fewer defects, and activities can be performed more effectively and reliably with fewer deficiencies and less redundancy. Consider the following opportunities for improvement between entities:

- improved communication of requirements and specifications,
- greater clarity in requests for products or services,
- improved feedback regarding unsatisfactory products or services,
- improvements in planning, controlling, and problem solving, and
- shared managerial and technical expertise, supervision, and training.

All of these opportunities are also available to individuals and groups within an organization. Within the company, each employee or group of employees has both an upstream supplier and a downstream customer that form the context of an intraorganizational value chain. When employees see their internal suppliers and customers as extensions of themselves and work to exploit the opportunities for improvement, teamwork will be significantly enhanced. Improved teamwork helps companies in their implementation of pull systems, which are part of a just-in-time work environment. Greater productivity benefits all company stakeholders. The impact of greater productivity is addressed in the following quote:

> [From 1994 to 1999], productivity growth [in the U.S.] averaged about 2% a year, up from the 1% average annual rate during the 20 years ending in 1993. The faster productivity rises, the more employers can afford to raise wages and benefits without raising prices or squeezing profits.[2]

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[2] Alejandro Bodipo-Memba, "Productivity Grew at Slower, 3.5% Rate in First Quarter Than First Estimated," *The Wall Street Journal* (June 9, 1999), p. A2.

BUYING OR PRODUCING AND CARRYING INVENTORY

In manufacturing organizations, one basic cost is for raw material. Although possibly not the largest production cost, raw material purchases cause a continuous cash outflow each period. Similarly, retailers invest a significant proportion of their assets in merchandise purchased for sale to others. Profit margins in both types of organizations can benefit from reducing or minimizing inventory investments, assuming that demand for products could still be met. The term *inventory* is used in this chapter to refer to any of the following: raw material, work in process, finished goods, indirect material (supplies), or merchandise inventory.

Good inventory management relies largely on cost-minimization strategies. As indicated in Exhibit 16–1, the basic costs associated with inventory are (1) purchasing/production, (2) ordering/setup, and (3) carrying/not carrying goods in stock. The **purchasing cost** for inventory is the quoted purchase price minus any discounts allowed, plus shipping charges.

For a manufacturer, *production cost* refers to the costs associated with purchasing direct material, paying for direct labor, incurring traceable overhead, and absorbing allocated fixed manufacturing overhead. Of these production costs, fixed manufacturing overhead is the least susceptible to cost minimization in the short run.

purchasing cost

EXHIBIT 16–1

Categories of Inventory Costs

Purchasing
  Quoted price
− Discounts allowed
+ Shipping charges

PRICE $

or

Production
  Direct material
+ Direct labor
+ Traceable overhead
+ Allocated fixed overhead

Ordering
• Invoice preparation
• Goods receipt and inspection
• Payment
• Forms
• Clerical processing

or

Setup
• Labor time
• Machine downtime

Carrying
• Storage
• Handling
• Insurance
• Property taxes levied on inventory cost or value
• Losses from obsolescence, damage, and theft
• Opportunity cost of invested capital

or

Not Carrying (Stockout)
• Lost customer goodwill
• Lost contribution margin
• Ordering and shipping charges from filling special orders
• Setup costs for rescheduled production

An exception is that management is able to somewhat control the fixed component of unit product cost through capacity utilization measures within the context of product demand in the short run. Most efforts to minimize fixed manufacturing overhead costs involve long-run measures.

Purchasing/production cost is the amount to be recorded in the appropriate inventory account (Raw Material Inventory, Work in Process Inventory, Finished Goods Inventory, or Merchandise Inventory).
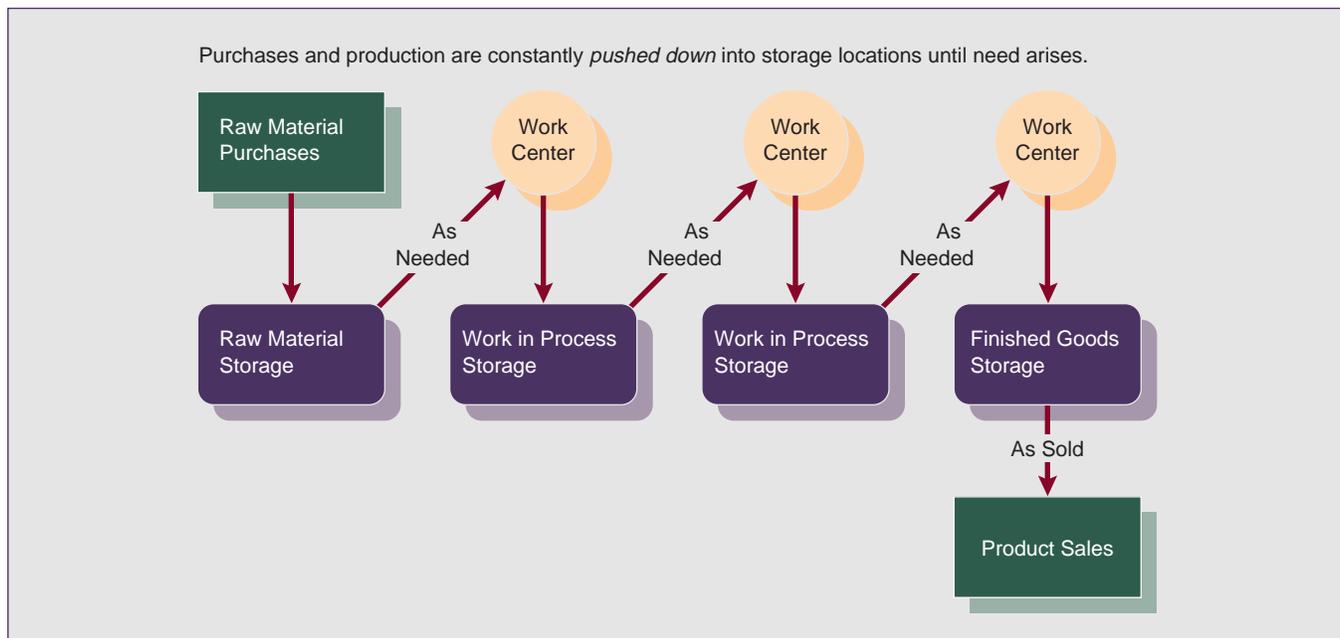
The two fundamental approaches to producing inventory are push systems and pull systems. In a traditional approach, production is conducted in anticipation of customer orders. In this approach, known as a **push system** (illustrated in Exhibit 16–2), work centers may buy or produce inventory not currently needed because of lead time or economic order or production quantity requirements. This excess inventory is stored until it is needed by other work centers.

To reduce the cost of carrying inventory until needed at some point in the future, many companies have begun to implement **pull systems** of production control (depicted in Exhibit 16–3). In these systems, parts are delivered or produced only as they are needed by the work center for which they are intended. Although some minimal storage must exist by necessity, work centers do not produce to compensate for lead times or to meet some economic production run model.

Discussion of matters such as managing inventory levels and optimum order size is presented in the Appendix to this chapter.

3

How do push and pull systems of production control work?

push system

pull system

EXHIBIT 16–2

Push System of Production Control

Purchases and production are constantly *pushed down* into storage locations until need arises.

PURCHASING TECHNIQUES

ordering cost

Incremental, variable costs associated with preparing, receiving, and paying for an order are called **ordering costs** and include the cost of forms and a variety of clerical costs. Ordering costs are traditionally expensed as incurred by retailers and wholesalers, although under an activity-based costing system these costs can be traced to the ordered items as an additional direct cost. Retailers incur ordering costs for their entire merchandise inventory. In manufacturing companies, ordering costs are incurred for raw material purchases. If the company intends to produce

Product sales dictate total production. Purchases and production are *pulled* through the system on an as-needed basis.

Product Sales

(4) FG

I request for FG

Work Center — II request for WIP → **Work Center** — III request for WIP → **Work Center** — IV request for WIP → **Raw Material Purchases**

(3) WIP   (2) WIP   (1) RM

→ Information flow that creates (pulls) demand at each successive operation

← Physical production flow in which raw material (RM) and work in process (WIP) flow successively through work centers until completed (FG)

rather than order a part, direct and indirect **setup costs** (instead of ordering costs) are created as equipment is readied for each new production run. Setup necessitates costs for changing dies or drill heads, recalibrating machinery, and resetting tolerance limits for quality control equipment. For decision analysis purposes, only the direct or incremental setup costs are relevant.

setup cost

Information Technology and Purchasing

Advances in information technology have greatly improved the efficiency and effectiveness of purchasing. Bar coding and electronic data interchange (EDI) are expected to reduce procurement costs from "an average $9.50 per transaction to $1.87."[3]

Bar codes are groups of lines and spaces arranged in a special machine-readable pattern by which a scanner measures the intensity of the light reflections of the white spaces between the lines and converts the signal back into the original data.[4] The bar code can be used as a simple identifier of a record of a product in a database where a large amount of information is stored, or the bar code itself may contain a vast amount of information about the product.

bar code

Manufacturers can use bar codes to gain information about raw material receipts and issuances, products as they move through an assembly area, and quality problems. Bar codes have reduced clerical costs, paperwork, and inventory, and simultaneously made processing faster, less expensive, and more reliable.

Because the need for prompt and accurate communication between company and supplier is essential in a pull system, many companies are eliminating paper and telephone communication processes and relying instead on **electronic data interchange** (EDI). EDI refers to the computer-to-computer transfer of information in virtual real time using standardized formats developed by the American National Standards Institute. In addition to the cost savings obtained from reduced paperwork and data entry errors, EDI users experience more rapid transaction processing and response time than can occur using traditional communication channels. Workers and teams of workers can also reduce the time required to perform

electronic data interchange

http://www.ansi.org/

[3] Joseph McKendrick, "Procurement: The Next Frontier in E-Businesss," *Midrange Systems* (Spring House: July 19, 1999), pp. 27ff.
[4] Mark Rowh, "The Basics of Bar Coding," *Office Systems* (April 1999), pp. 44ff.

activities and consume fewer resources by cooperating and conferring on cross-functional interface activities as discussed in the next section.

Advances in Authorizing and Empowering Purchases

vendor-managed inventory

http://www.kraft.com
http://www.motts.com
http://www.walmart.com

An extension of EDI is **vendor-managed inventory** (VMI), a streamlined system of inventory acquisition and management. A supplier can be empowered to monitor EDI inventory levels and provide its customer company a proposed e-order and subsequent shipment after electronic acceptance. Electronic transfer of funds from the buyer's bank is made when the goods are received.[5] The accompanying News Note describes how the supplier, not the buying entity, is responsible for managing and replenishing inventory.

procurement card

http://www.american express.com
http://www.mastercard .com
http://www.visa.com

The process of conducting business transactions over the Internet, known as e-commerce, has made possible the use of **procurement cards** (p-cards). These are given to selected employees as a means of securing greater control over spending and eliminating the paper-based purchase authorization process. The card companies, American Express, MasterCard, and Visa, increase the buying entity's assurance by tightly controlling how each p-card is used, states Ellen Messmer, "right down to the specific merchant dealt with, the kind of item purchased and the amount spent." She further says, "One of the main reasons corporate bean-counters love p-cards is that American Express, MasterCard and Visa promise to deliver detailed transaction information—sometimes directly into companies' back-end enterprise resource planning systems—on every purchase."[6]

open purchase ordering

Companies are also currently decreasing their order costs significantly by using **open purchase ordering**. A single purchase order—sometimes known as a blanket purchase order—that expires at a set or determinable future date is prepared to authorize a supplier to provide a large quantity of one or more specified items. The goods will then be requisitioned in smaller quantities as needed by the buyer over the extended future period.

NEWS NOTE   GENERAL BUSINESS

Vendor-Managed Inventory

Throughout the supply chain, vendor-managed inventory (VMI) is a way to cut costs and keep inventory levels low. Its practitioners range from food manufacturers like Kraft Inc. in New York and Mott's USA in Stamford, Conn., to chain-store wizard Wal-Mart Stores, Inc., in Bentonville, Ark.

VMI lets companies reduce overhead by shifting responsibility for managing and replenishing inventory to vendors. "If you're smart enough to transfer the ownership of inventory to your vendors, your raw materials and work-in-process inventory comes off your balance sheets. Your assets go down, and you need less working capital to run your business," says Ron Barris, global leader of supply-chain management for the high-tech industry at Ernst & Young LLP.

In VMI, the vendor tracks the number of products shipped to distributors and retail outlets. Tracking tells the vendor whether or not the distributor needs more supplies. Products are automatically replenished when supplies run low, and goods aren't sent unless they're needed, consequently lowering inventory at the distribution center or retail store. Suppliers and buyers use written contracts to determine payment terms, frequency of replenishment, and other terms of the agreement.

SOURCE: Jacqueline Emigh, "Vendor-Managed Inventory," *Computerworld* (August 23, 1999), pp. 52ff. Reprinted with permission.

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[5] Jacqueline Emigh, "Vendor-Managed Inventory," *Computerworld* (August 23, 1999), pp. 52ff.
[6] Ellen Messmer, "The Good, the Bad, and the Ugly of P-Cards," *Network World* (August 23, 1999), pp. 42ff.

A variation of the annual blanket purchase order is a long-term open purchasing arrangement in which goods are provided at fixed or determinable prices according to specified requirements. These arrangements may or may not involve electronic procurement cards.

Inventory Carrying Costs

Inventory **carrying costs** are the variable costs of carrying one inventory unit in stock for one year. Carrying costs are incurred for storage, handling, insurance, property taxes based on inventory cost or value, and possible losses from obsolescence or damage. In addition, carrying costs should include an amount for opportunity cost. When a firm's capital is invested in inventory, that capital is unable to earn interest or dividends from alternative investments. Inventory is one of the many investments made by an organization and should be expected to earn a satisfactory rate of return.

carrying cost

Some Japanese managers have referred to inventory as a liability. One can readily understand that perspective considering that carrying costs, which can be estimated using information from various budgets, special studies, or other analytical techniques, "can easily add 20 percent to 25 percent per year to the initial cost of inventory."[7]

Although carrying inventory in excess of need generates costs, a fully depleted inventory can also generate costs. A **stockout** occurs when a company does not have inventory available when requested internally or by an external customer. The cost of having a stockout is not easily determinable, but some of the costs involved might include lost customer goodwill, lost contribution margin from not being able to make a sale, additional ordering and shipping charges incurred from special orders, and possibly lost customers.

stockout

For a manufacturer, another important stockout cost is incurred for production adjustments arising from not having inventory available. If a necessary raw material is not on hand, the production process must be rescheduled or stopped, which in turn may cause additional setup costs before production resumes.

UNDERSTANDING AND MANAGING PRODUCTION ACTIVITIES AND COSTS

Managing production activities and costs requires an understanding of product life cycles and the various management and accounting models and approaches to effectively and efficiently engage in production planning, controlling, decision making, and performance evaluation.
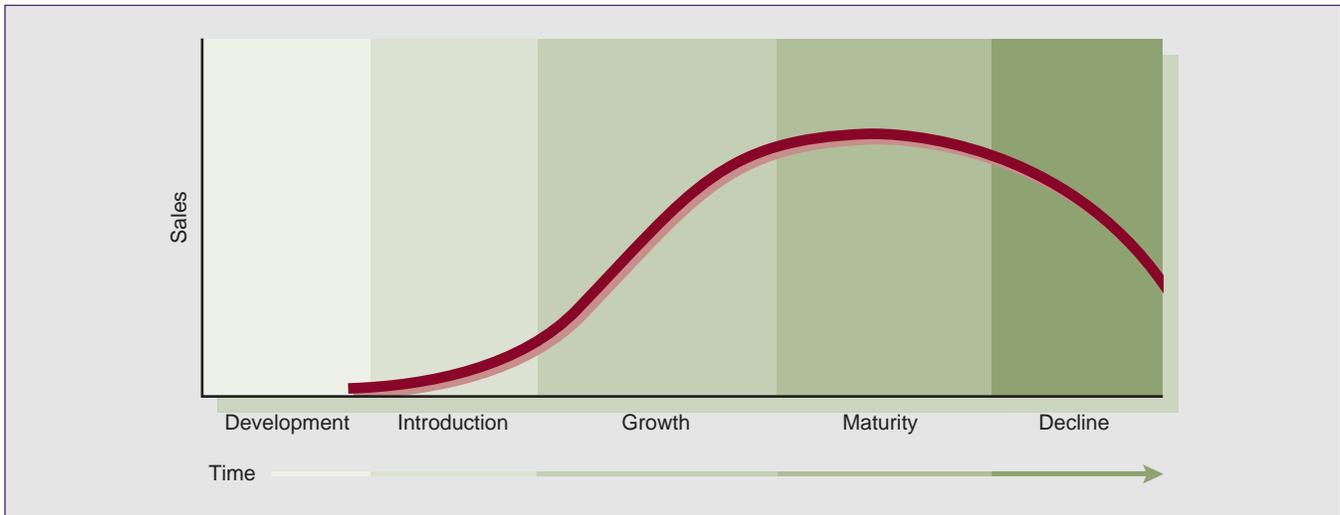
Product Life Cycles

Product profit margins are typically judged on a period-by-period basis without consideration of the product life cycle. However, products, like people, go through a series of sequential life-cycle stages. As mentioned in Chapter 1, the product life cycle is a model depicting the stages through which a product class (not necessarily each product) passes from the time that an idea is conceived until production is discontinued. Those stages are development (which includes design), introduction, growth, maturity, and decline. A sales trend line through each stage is illustrated in Exhibit 16–4. Companies must be aware of where their products are in their life cycles, because in addition to the sales effects, the life-cycle stage may have a tremendous impact on costs and profits. The life-cycle impact on each of these items is shown in Exhibit 16–5.

4

How do product life cycles affect product costing and profitability?

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[7] Bill Moseley, "Boosting Profits and Efficiency: The Opportunities Are There," *(Grant Thornton) Tax & Business Adviser* (May–June 1992), p. 6.

EXHIBIT 16–4

Product Life Cycle

EXHIBIT 16–5

Effects of Product Life Cycles on Costs, Sales, and Profits

LIFE CYCLE AND TARGET COSTING

From a cost standpoint, the development stage is an important one that is almost ignored by the traditional financial accounting model. Financial accounting requires that development costs be expensed as incurred—even though most studies indicate that decisions made during this stage determine approximately 80 to 90 percent of a product's total life-cycle costs. That is, the materials and the manufacturing process specifications made during development generally affect production costs for the rest of the product's life.

Stage	Costs	Approach to Costing	Sales	Profits
Development	No production costs, but R&D costs very high	Target costing (explained later in this section)	None	None; large loss on product due to expensing of R&D costs
Introduction	Production cost per unit; probably engineering change costs; high advertising cost	Kaizen costing (explained in next section of this chapter)	Very low unit sales; selling price may be high (for early profits) or low (for gaining market share)	Typically losses are incurred partially due to expensing of advertising
Growth	Production cost per unit decreases (due to learning curve and spreading fixed overhead over many units)	Kaizen costing	Rising unit sales; selling price is adjusted to meet competition	High
Maturity	Production cost per unit stable; costs of increasing product mix begin to rise	Standard costing (explained in Ch. 10)	Peak unit sales; reduced selling price	Falling
Decline	Production cost per unit increases (due to fixed overhead being spread over a lower volume)	Standard costing	Falling unit sales; selling price may be increased in an attempt to raise profits or lowered in an attempt to raise volume	May return to losses

Although technology and competition have tremendously shortened the time required in the development stage, effective development efforts are critical to a product's profitability over its entire life cycle. Time spent in the planning and development process often results "in lower production costs, reduced time from the design to manufacture stage, higher quality, greater flexibility, and lower product life cycle cost."[8] All manufacturers are acutely aware of the need to focus attention on the product development stage, and the performance measure of "time-to-market" is becoming more critical.

Once a product or service idea has been formulated, the market is typically researched to determine the features customers desire. Sometimes, however, such product research is forgone for innovative new products, and companies occasionally ignore the market and simply develop and introduce products. For example:

> [E]very season Seiko "throws" into the market several hundred new models of its watches. Those that the customers buy, it makes more of; the others it drops. Capitalizing on the design-for-response strategy, Seiko has a highly flexible design and production process that lets it quickly and inexpensively introduce new products. [The company's] fast, flexible product design process has slashed the cost of failure.[9]

http://seikousa.com

Because many products can now be built to specifications, companies can further develop the product to meet customer tastes once it is in the market. Alternatively, flexible manufacturing systems allow rapid changeovers to other designs.

After a product is designed, manufacturers have traditionally determined product costs and set a selling price based, to some extent, on costs. If the market will not bear the resulting selling price (possibly because competitors' prices are lower), the firm either makes less profit than hoped or attempts to lower production costs.

In contrast, since the early 1970s, a technique called target costing has been used by some companies (especially Japanese ones) to view the costing process differently. **Target costing** develops an "allowable" product cost by analyzing market research to estimate what the market will pay for a product with specific characteristics. This is expressed in the following formula:

5

How does target costing influence production cost management?

target costing

$$TC = ESP - APM$$

$$\text{where } TC = \text{target cost}$$
$$ESP = \text{estimated selling price}$$
$$APM = \text{acceptable profit margin}$$

Subtracting an acceptable profit margin from the estimated selling price leaves an implied maximum per-unit target product cost, which is compared to an expected product cost. Exhibit 16–6 compares target costing with traditional Western costing.

If the expected cost is greater than the target cost, the company has several alternatives. First, the product design and/or production process can be changed to reduce costs. Preparation of cost tables helps determine how such adjustments can be made. **Cost tables** are databases that provide information about the impact on product costs of using different input resources, manufacturing processes, and design specifications. Second, a less-than-desired profit margin can be accepted. Third, the company can decide that it does not want to enter this particular product market at the current time because it cannot make the profit margin it desires. If, for example, the target costing system at Olympus (the Japanese camera company) indicates that life-cycle costs of a product are insufficient to make profitability

cost table

[8] James A. Brimson, "How Advanced Manufacturing Technologies Are Reshaping Cost Management," *Management Accounting* (March 1986), p. 26.
[9] Williard I. Zangwill, "When Customer Research Is a Lousy Idea," *The Wall Street Journal* (March 8, 1993), p. A10. Permission conveyed through the Copyright Clearance Center.
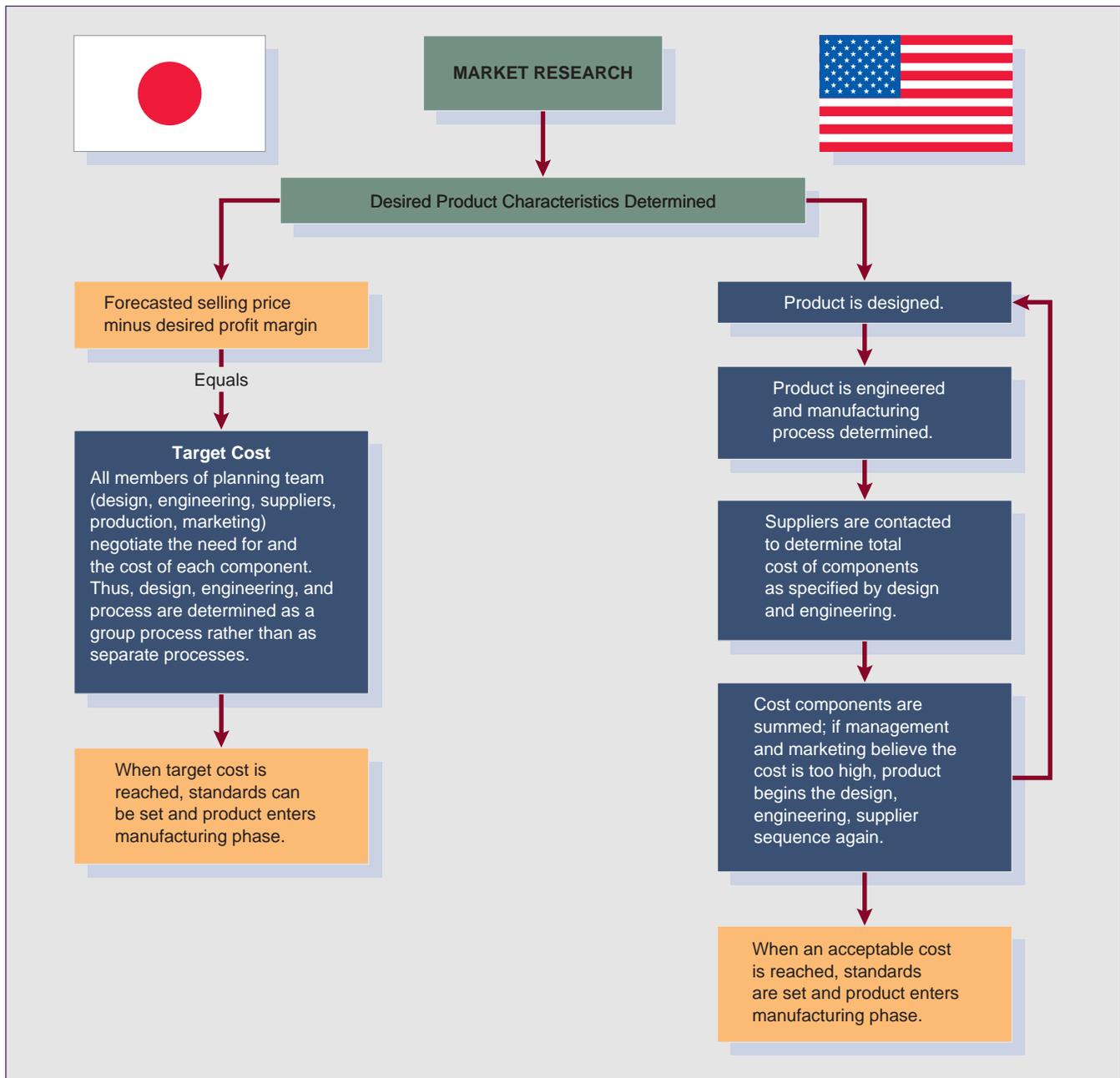
EXHIBIT 16–6

Developing Product Costs

value engineering

acceptable, "the product is abandoned unless there is a strategic reason, such as maintaining a full product line or creating a 'flagship' product, for keeping the product."[10]

Value engineering is an important step in successful product development. It involves a disciplined search for various feasible combinations of resources and methods that will increase product functionality and reduce costs. Multidisciplinary teams using various problem-solving tools such as brainstorming, Pareto analysis, and engineering tools seek an improved product cost-performance ratio considering such factors as reliability, conformance, and durability. Cost reduction is considered the major focus of value engineering.[11]

[10] Robin Cooper, *When Lean Enterprises Collide* (Boston: Harvard Business School Press, 1995), p. 159.
[11] Eric Meng, "The Project Manager's Toolbox," *PM Network* (1999), pp. 52ff.

Target costing can be applied to services if they are sufficiently uniform to justify the modeling effort required. Assume that a print shop wants to offer its customers the opportunity to buy personalized picture calendars and other similar personalized documents with photographs. A market survey indicates that the metropolitan area could sustain an annual 500-order volume and that customers believe $18 is a reasonable fee per service. The print shop manager believes that a reasonable profit for this service is $8 per customer order. Thus, the shop has an allowable target cost of $10 per order. The manager will invest in the equipment necessary to provide the new service if he or she believes the indicated volume suggested by market research is sufficient to support the effort.

If a company decides to enter a market, the target cost computed at the beginning of the product life cycle does not remain the final focus. Over the product's life, the target cost is continuously reduced in an effort to spur a process of continuous improvement in actual production cost. **Kaizen costing** involves ongoing efforts for continuous improvement to reduce product costs, increase product quality, and/or improve the production process after manufacturing activities have begun. These cost reductions are designed to keep the profit margin relatively stable as the product price is reduced over the product life cycle. Exhibit 16–7 compares target and kaizen costing.

kaizen costing

In designing a product to meet an allowable cost, engineers strive to eliminate all nonessential activities from the production process. Such reductions in activities will, in turn, reduce costs. The production process and types of components to be used should be discussed among appropriate parties (including engineering,

	Target Costing	**Kaizen Costing**
What?	A procedural approach to determining a maximum allowable cost for an identifiable, proposed product assuming a given target profit margin	A mandate to reduce costs, increase product quality, and/or improve production processes through continuous improvement efforts
Used for?	New products	Existing products
When?	Development stage (includes design)	Primary production stages (introduction and growth; possibly, but not probably, maturity)
How?	Works best through aiming at a specified cost reduction objective; used to set original production standards	Works best through aiming at a specified cost reduction objective; reductions are integrated into original production standards to sustain improvements and provide new challenges
Why?	Extremely large potential for cost reduction because 80% to 90% of a product's lifelong costs are embedded in the product during the design and development stages	Limited potential for reducing cost of existing products, but may provide useful information for future target costing efforts
Focus?	All product inputs (material, labor, and overhead elements) as well as production processes and supplier components	Depends on where efforts will be most effective in reducing production costs; generally begins with the most costly component and (in the more mature companies) ends with overhead components

EXHIBIT 16–7

Differences between Target and Kaizen Costing

management, accounting, and marketing) in recognition of the product quality and cost desired. Suppliers also may participate in the design phase by making suggestions for modifications that would allow regularly stocked components to be used rather than more costly special-order items.

Properly designed products should require only minimal engineering changes after being released to production. Each time an engineering change is made, one or more of the following problems can occur and create additional costs: production documents must be reprinted; workers must relearn tasks; machine setups must be changed; and parts in stock or currently ordered may be made obsolete. If costs are to be affected significantly, any design changes must be made early in the process—preferably before production begins.

Using target costing requires a shift in the way managers think about the relationships among cost, selling price, and profitability. The traditional attitude has been that a product is developed, production cost is identified and measured, a selling price is set (or a market price is met), and profits or losses result. In target costing, a product is developed, a selling price and desired profit amount are determined, and maximum allowable costs are calculated. When costs rely on selling prices, all costs must be justified. Unnecessary costs should be eliminated without reducing quality.

During the product introduction stage, costs can be substantial and are typically related to engineering changes, market research, advertising, and promotion. Sales are usually low and prices are often set in relationship to the market price

substitute good

of similar or **substitute goods** if such goods are available.

The growth stage begins when the product has been accepted by the market and begins to show increased sales. Product quality also may improve during this life-cycle stage, especially if competitors have improved on original production designs. Prices are fairly stable during the growth stage because many substitutes exist or because consumers have become "attached" to the product and are willing to pay a particular price for it rather than buy a substitute.

In the maturity stage, sales begin to stabilize or slowly decline and firms often compete on the basis of selling price. Costs may be at their lowest level during this period, so profits may be high. Some products remain at this stage for a very long time.

The decline stage reflects waning sales. Prices may be cut dramatically to stimulate business. Production cost per unit generally increases during this stage because fixed overhead is spread over a smaller production volume.

LIFE-CYCLE COSTING

Customers are concerned with obtaining a quality product or service for a perceived "reasonable" price. In making such a determination, the consumer views the product from a life-cycle perspective. When purchasing a car, one would investigate not only the original purchase price but also the cost of operation, cost of maintenance, length of warranty period, frequency and cost of repairs not covered by warranty, and projected obsolescence period.

From a manufacturing standpoint, because product selling prices and sales volumes change over a product's life cycle, target costing requires that profitability be viewed on a long-range rather than a period-by-period basis. Thus, producers of goods and providers of services should be concerned about planning to maximize profits over a product or service's life cycle. Therefore, revenues must be generated in excess of total (not just the current period) costs for a product to be profitable.

For financial statement purposes, costs incurred during the development stage must be expensed in the period. However, the research and development (R&D) costs that result in marketable products represent a life-cycle investment rather than a period expense. Capitalization and product allocation of such costs for managerial

purposes would provide better long-range profitability information and a means by which to determine the cost impact of engineering changes on product design and manufacturing process. Thus, companies desiring to focus on life-cycle costs and profitability will need to change their internal accounting treatments of costs.

    Life-cycle costing is the "accumulation of costs for activities that occur over the entire life cycle of a product, from inception to abandonment by the manufacturer and consumer."[12] Manufacturers would base life-cycle costing expense allocations on an expected number of units to be sold over the product's life. Each period's internal income statement using life-cycle costing would show revenues on a life-to-date basis. This revenue amount would be reduced by total cost of goods sold, total R&D project costs, and total distribution and other marketing costs. If life-cycle costing were to be used externally, only annual sales and cost of goods sold would be presented in periodic financial statements. But all preproduction costs would be capitalized, and a risk reserve could be established "to measure the probability that these deferred product costs will be recovered through related product sales."[13] The risk reserve is a contra asset offsetting the capitalized preproduction costs. This contra asset represents the estimated portion of the preproduction costs expected to be unrecoverable through future related product sales.

    Life-cycle costing is especially important in industries that face rapid technological or style changes. If substantial money is spent on development, but technology improves faster or customer demand diminishes more rapidly than that money can be recouped from total product sales, was the development investment worthwhile? Periodic external financial statements may make a product appear to be worthwhile because its development costs were initially expensed. But, in total, the company may not even have recovered its original investment. Thus, over the product or service life cycle, companies need to be aware of and attempt to control the total costs of making a product or providing a service. One way of creating awareness is to evaluate all activities related to a product or service as value-added or non-value-added at relatively frequent intervals.

life-cycle costing

Just-in-Time Systems

Just-in-time (JIT) is a philosophy about when to do something. The "when" is as needed and the "something" is a production, purchasing, or delivery activity. The JIT philosophy is applicable in all departments of all types of organizations. JIT's three primary goals are as follows:

1. elimination of any production process or operation that does not add value to the product/service,
2. continuous improvement in production/performance efficiency, and
3. reduction in the total cost of production/performance while increasing quality.

These goals are totally consistent with and supportive of the total quality management program discussed in Chapter 8. The elements of the JIT philosophy are outlined on the next page in Exhibit 16–8.

    Because JIT is most commonly discussed with regard to manufacturing or production activities, this is a logical starting point. Just-in-time manufacturing originated in Japan where a card, or **kanban** (pronounced "kahn-bahn"), was used to indicate a work center's need for additional components. A **just-in-time manufacturing system** attempts to acquire components and produce inventory units only as they are needed, minimize product defects, and reduce cycle/setup times for acquisition and production.

6

What is the just-in-time philosophy and how does it affect production and accounting?

just-in-time

kanban
just-in-time manufacturing system

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[12] Callie Berliner and James A. Brimson (eds.), *Cost Management for Today's Advanced Manufacturing* (Boston: Harvard Business School Press, 1988), p. 241.
[13] Dennis E. Peavy, "It's Time for a Change," *Management Accounting* (February 1990), p. 34.

EXHIBIT 16–8

Elements of a JIT Philosophy

- Quality is essential at all times; work to eliminate defects and scrap.
- Employees often have the best knowledge of ways to improve operations; listen to them.
- Employees generally have more talents than are being used; train them to be multiskilled and increase their productivity.
- Ways to improve operations are always available; constantly look for them, being certain to make fundamental changes rather than superficial ones.
- Creative thinking doesn't cost anything; use it to find ways to reduce costs before making expenditures for additional resources.
- Suppliers are essential to operations; establish and cultivate good relationships with suppliers and use, if possible, long-term contracts.
- Inventory is an asset that generates no revenue while it is held in stock. Thus, it can be viewed as a "liability"; eliminate it to the extent possible.
- Storage space is directly related to inventories; eliminate it in response to the elimination of inventories.
- Long cycle times cause inventory buildup; keep cycle times as short as possible by using frequent deliveries.

Production has traditionally been dictated by the need to smooth operating activities over a period of time. Although allowing a company to maintain a steady workforce and continuous machine utilization, smooth production often creates products that must be stored until future sales arise. In addition, although smooth production works well with the economic order quantity (EOQ) concept (see the Appendix to this chapter for a discussion of EOQ), managers recognize that EOQ is based on estimates and therefore a stock of parts is maintained until they are needed. Traditionally, companies filled warehouses with products that were not currently in demand, while often failing to meet promised customer delivery dates. One cause of this dysfunctional behavior was management preoccupation with spreading overhead over a maximum number of products being produced. This obsession unwittingly resulted in much unwanted inventory, huge inventory carrying costs, and other operations problems to be discussed subsequently.

Thus, raw material and work in process inventories historically were maintained at levels considered sufficient to cover up inefficiencies in acquisition and/or production. Exhibit 16–9 depicts these inefficiencies or problems as "rocks" in a stream of "water" that represents inventory. The traditional philosophy is that the water level should be kept high enough for the rocks to be so deeply submerged that there will be "smooth sailing" in production activity. This technique is intended to avoid the original problems, but in fact, it creates a new one. By covering up the problems, the excess "water" adds to the difficulty of making corrections. The JIT manufacturing philosophy is to lower the water level, expose the rocks, and eliminate them to the extent possible. The shallower stream will then flow more smoothly and rapidly than the deep river.

CHANGES NEEDED TO IMPLEMENT JIT MANUFACTURING

Implementation of a just-in-time system in a manufacturing firm does not occur overnight. It took Toyota over 20 years to develop the system and realize significant benefits from it. But JIT techniques are becoming better known and more easily implemented and it is now possible for a company to have a system in place and be recognizing benefits in a fairly short time.
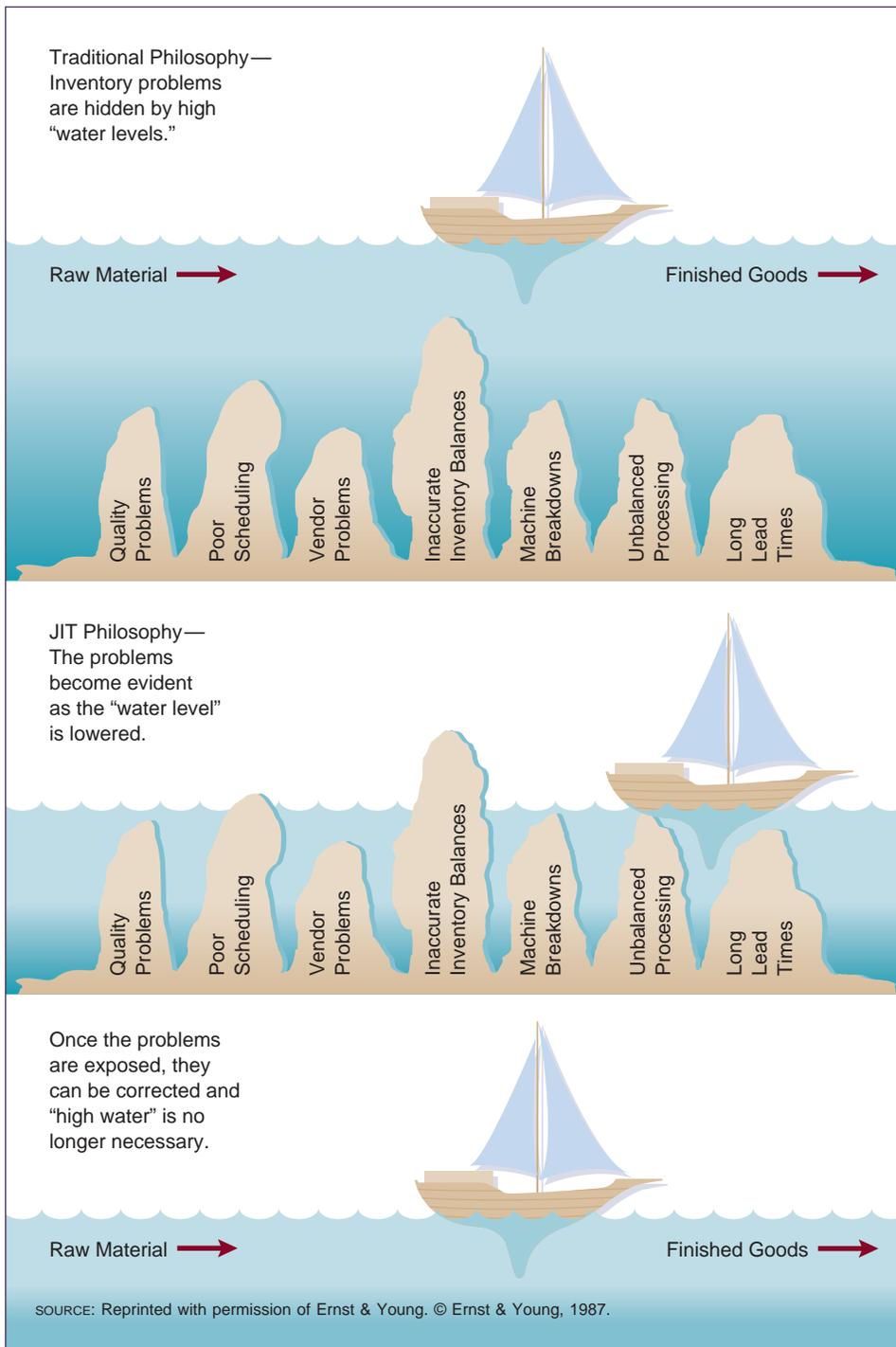
In a world where managers work diligently to produce improvements of a percentage point or two, some numbers just do not look real. One success story among many involves Johnson Control's Automotive Systems Group, which successfully adopted just-in-time manufacturing, with its Lexington, Tennessee, plant achieving 100 percent on-time delivery for three years, during which sales rose 55 percent.

http://www.toyota.com
http://www.johnson
controls.com

> *The key to Johnson Controls JIT program is process standardization. John Rog, purchasing manager of supplier manufacturing development at JCI, says*

Traditional Philosophy—Inventory problems are hidden by high "water levels."

Raw Material →   Finished Goods →

Quality Problems — Poor Scheduling — Vendor Problems — Inaccurate Inventory Balances — Machine Breakdowns — Unbalanced Processing — Long Lead Times

JIT Philosophy—The problems become evident as the "water level" is lowered.

Quality Problems — Poor Scheduling — Vendor Problems — Inaccurate Inventory Balances — Machine Breakdowns — Unbalanced Processing — Long Lead Times

Once the problems are exposed, they can be corrected and "high water" is no longer necessary.

Raw Material →   Finished Goods →

SOURCE: Reprinted with permission of Ernst & Young. © Ernst & Young, 1987.

that all their plants rely heavily on such Toyota-inspired strategies as visual management, kanban, and poka-yoke. JCI has also adopted the Japanese idea of the "five S's," namely, sort, stability, shine, standardize, and sustain, which intend to bring order and uniformity to the plant floor. Finally, JCI has created a training program to help its supply base enforce JIT, kaizen, lean manufacturing, and other manufacturing strategies.[14]

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[14] Tim Minahan, "JIT Moves Up the Supply Chain," *Purchasing* (September 1, 1998), pp. 46ff.

The most impressive benefits from JIT, though, are normally reached only after the system has been operational for 5 to 10 years. JIT is not easy and takes time and perseverance. Further, JIT must have strong backing and resource commitment from top management. Without these ingredients, considerable retraining, and support from all levels of company personnel, implementation of JIT will not succeed.

JIT and activity-based management (ABM) are similar because they are both aimed at reducing operating and producing costs and the time, space, and energy necessary for effective and efficient operations and production. Both processes center on the planning, control, and problem solving of activities. Also, both include quality and continuous improvement as prime considerations.

For just-in-time production to be effective, certain modifications must be made in purchasing, supplier relationships, distribution, product design, product processing, and plant layout. JIT depends on employees and suppliers being able to compress the time, distance, resources, and activities, and to enhance interactions needed to produce a company's products and services. The methods currently being used successfully by many companies are discussed next.

Purchasing Considerations   When applying JIT to purchasing, managers must first recognize that the lowest quoted purchase price is not necessarily the lowest cost. Suppliers should be screened to systematically consider other factors. If other costs such as the failure costs of poor quality (machine downtime, labor idle time, rework, and scrap) are considered, the lowest price could become the most expensive. Additionally, the vendor willing to quote the lowest price may not be willing to make frequent small-quantity deliveries, sign a long-term contract, or form a strategic alliance with the JIT firm.

Long-term contracts are negotiated with suppliers, and continuance of those contracts is based on delivery reliability. Vendors missing a certain number of scheduled deliveries by more than a specified number of hours are dismissed. Vendor agreements are made in which components are delivered "ready for use" without packaging, eliminating the need for the JIT manufacturer to unpack components; other agreements may specify that goods will be received from suppliers in modular form, so that less subassembly work is required in the assembly plant.

Suppliers may be requested to bar code raw material sent to a JIT company so that inventory management techniques are improved. Bar coding allows raw material inventory records to be updated more quickly, raw material received to be processed more precisely, work in process to be tracked more closely, and finished goods shipments to be quickly made—all with incredible accuracy.

http://www.ab.com

Although bar codes on purchased goods will improve recordkeeping and inventory management, even that would not be necessary if the ideal JIT purchase quantity of one unit could be implemented. Such a quantity is typically not a feasible ordering level, although Allen-Bradley and other highly automated, flexible manufacturers can produce in such a lot size. Thus, the closer a company can get to a lot size of one, the more effective the JIT system is. This reduction in ordering levels means more frequent orders and deliveries. Some automobile companies, for example, have some deliveries made every two hours! Thus, vendors chosen by the company should be located close to the company to minimize both shipping costs and delivery time. The ability to obtain suppliers close to the plant is easy in a country the size of Japan. Such an objective is not as readily accomplished in the United States where a plant can be located in New Jersey and a critical parts vendor in California. However, air express companies help to make just-in-time more practical.

Vendor Certification   The optimal JIT situation would be to have only one vendor for any given item. Such an ideal, however, creates the risk of not having alternative sources (especially for critical parts) in the event of vendor business failure,

production strikes, unfair pricing, or shipment delays. Thus, it is often more feasible and realistic to limit the number of vendors to a few that are selected and company certified as to quality and reliability. The company then enters into long-term relationships with these suppliers, who become "partners" in the process. Vendor certification is becoming more and more popular. For example, Allen-Bradley, a world-class electronics manufacturer, has been named the preferred automation controls supplier to Ford's Automotive Components Group network of more than 30 manufacturing plants worldwide.

Vendor certification requires substantial efforts on the purchasing company's part, such as obtaining information on the supplier's operating philosophy, costs, product quality, and service. People from various areas must decide on the factors by which the vendor will be rated; these factors are then weighted as to relative importance. Rapid feedback should be given to potential suppliers so that they can, if necessary, make changes prior to the start of the relationship or, alternatively, to understand why the relationship will not occur.

Factors commonly considered include supplier reliability and responsiveness, delivery performance, ability to service, ability of vendor personnel, research and development strength of supplier, and production capacity of supplier. Evaluations of new and infrequent vendors are more difficult because of the lack of experience by which the purchasing company vendor analysis team can make informed judgments.

Forming partnerships with fewer vendors on a long-term basis provides the opportunity to continuously improve quality and substantially reduce costs. Such partnerships are formal agreements in which both the vendor and the buying organization commit to specific responsibilities to each other for their mutual benefit. These agreements usually involve long-term purchasing arrangements according to specified terms and may provide for the mutual sharing of expertise and information. Such partnerships permit members of the supply chain to eliminate redundancies in warehousing, packaging, labeling, transportation, and inventories.

Product Design Products need to be designed to use the fewest number of parts, and parts should be standardized to the greatest extent possible. For example, at Harley-Davidson, engines and their components were traditionally designed without regard for manufacturing efficiency. Harley was making two similar crankpins, one with an oil hole drilled at a 45-degree angle, and the other at a 48-degree angle. (A crankpin is a cylindrical bar that attaches a connecting rod to a crank in an engine.) Repositioning the machines to make these different crankpins required about two hours. Engineers designed a common angle on both parts and common tools for drilling the holes, which cut changeover time for that process to three minutes.[15]

Another company discovered that it used 29 different types of screws to manufacture a single product. Downtime was excessive because screwdrivers were continuously being passed among workers. Changing to all of the same type screws significantly reduced production time.

Parts standardization does not have to result in identical finished products. Many companies (such as Ford Motor Company) are finding that they can produce a great number of variations in finished products from just a few basic models. Many of the variations can be made toward the end of the production process so that the vast proportion of parts and tasks are standardized and are added before the latter stages of production when the variations take place. Such differentiation can be substantially aided by flexible manufacturing systems and computer-integrated manufacturing, as discussed later in this chapter.

Products should be designed for the quality desired and should require only a minimal number of engineering changes after the design is released for production. Approximately 80 to 90 percent of all product costs are established when the

[15] John Van, "Leaks No Longer Stain Harley-Davidson Name," *Chicago Tribune* (November 4, 1991), Sec. 1, p. 6.

product design reached by the production team is only 25 to 50 percent complete. An effective arrangement for a vendor–purchaser partnership is to have the vendor's engineers participate in the design phase of the purchasing company's product; an alternative is to provide product specifications and allow the vendor company to draft the design for approval.

If costs are to be significantly affected, any design changes must be made early in the process. When an engineering change is made, one or more of the following activities occurs, creating additional costs: The operations flow document must be prepared again; workers must learn new tasks; machine dies or setups must be altered; and parts currently ordered or in stock may be made obsolete. Regardless of whether a company embraces JIT, time that is spent doing work that adds no value to the production process should be viewed as wasted. Effective activity analysis eliminates such non-value-added work and its unnecessary cost.

From another point of view, good product design should address all concerns of the intended consumers, even the degree of recyclability of the product. For example, an automobile plant may be equipped to receive and take apart used-up models, remanufacture various parts, and then send them back into the marketplace. Thus, companies are considering remanufacturing as part of their design and processing capabilities.

Product Processing   In the production processing stage, one primary JIT consideration is reduction of machine setup time. Reduction of setup time allows processing to shift between products more often and at a lower cost. The costs of reducing setup time are more than recovered by the savings derived from reducing downtime, WIP inventory, and material handling as well as increasing safety, flexibility, and ease of operation.

Most companies implementing rapid tool-setting procedures have been able to obtain setup times of 10 minutes or less. Such companies use a large number of low-cost setups rather than the traditional processing approach of a small number of more expensive setups. Under JIT, setup cost is considered almost purely variable rather than fixed, as it was in the traditional manufacturing environment. One way to reduce machine setup time is to have workers perform as many setup tasks as possible while the machine is on line and running. All unnecessary movements by workers or of material should be eliminated. Teams similar to pit-stop crews at auto races can be used to perform setup operations, with each team member handling a specialized task. Based on past results, it appears that with planning and education, setup times can be reduced by 50 percent or more.

Another essential part of product processing is the institution of high-quality standards because JIT has the goal of zero defects. Under just-in-time systems, quality is determined on a continual basis rather than at quality control checkpoints. Continuous quality is achieved by first ensuring vendor quality at point of purchase. Workers and machines (such as optical scanners or chutes for size dimensions) are used to monitor quality while production is in process. Controlling quality on an ongoing basis can significantly reduce the costs of obtaining good quality. The JIT philosophy recognizes that it is less costly not to make mistakes than to correct them after they are made. Unfortunately, as mentioned in Chapters 8 and 10, quality control costs and costs of scrap are frequently buried in the standard cost of production, making such costs hard to ascertain.

Standardizing work is an important aspect of any process. This means that every worker conducts work according to standard procedures, without variation, on time, every time. Such standard procedures are devised to produce the most efficient way to conduct the tasks to which they relate. Planning, supervising, and training are more efficiently and effectively conducted when work has been standardized. Standard work also provides the ability to improve processes. As Dr. W. Edwards Deming so aptly demonstrated during his many courses on TQM, it is nearly impossible to improve an unstable process because there is too much variation in it to ascribe cause and effect to modifications that might be made.

Plant Layout Traditionally, manufacturing plants were designed in conformity with functional areas, and machines of like type and workers of specialized skills were placed together. For a JIT system to work effectively, the physical plant must be conducive to the flow of goods and organization of workers and to increasing the value added per square foot of plant space. Manufacturing plants should be designed to minimize material handling time, lead time, and movement of goods from raw material input to completion of the finished product.

This goal often means establishing S-shaped or U-shaped production groupings of workers or machines, commonly referred to as **manufacturing cells**, arranged to address the efficient and effective production processes to make a particular product type. A manufacturing cell is depicted in Exhibit 16–10. This streamlined design allows for more visual controls to be instituted for problems such as excess inventory, production defects, equipment malfunctions, and out-of-place tools. It also allows for greater teamwork and quicker exchange of vital information.

The informational arrows show how production is "pulled" through a system as successive downstream work centers issue their kanbans to acquire goods or services needed from their upstream suppliers in order to produce the goods or services demanded by their downstream "customers." Many pull systems today use electronic means such as computer networks to send requests for goods or services to upstream workstations.

Exhibit 16–11 illustrates the flow of three products through a factory before and after the redesign of factory floor space. In the "before" diagram, processes were grouped together by function and products flowed through the plant depending on the type of processing needed to be performed. If the company uses JIT and a cellular design, substantial storage is eliminated because goods should only be ordered as needed. Products also flow through the plant more rapidly. Product 2 can use the same flow as Product 1, but skip the cell's grinding process.

When plant layout is redesigned to incorporate manufacturing cells, an opportunity arises for workers to broaden their skills and deepen their involvement
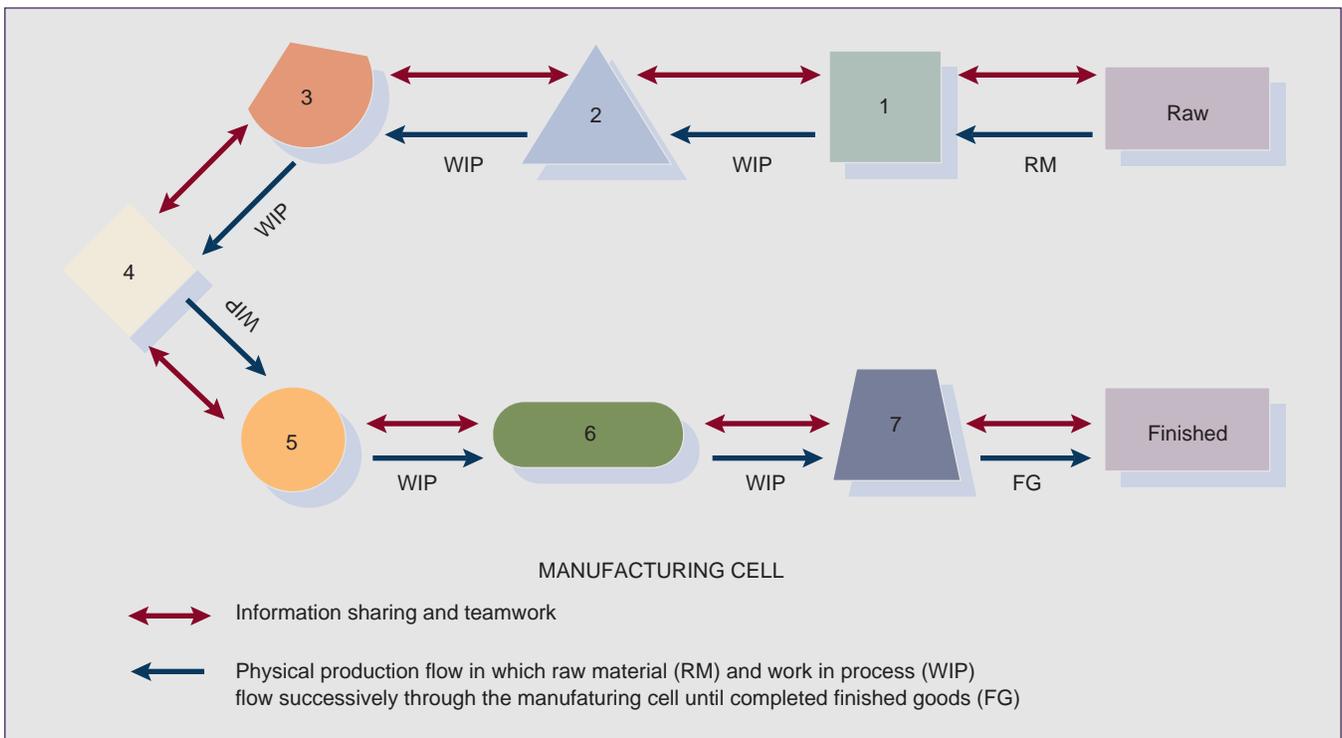
manufacturing cell

Depiction of a Manufacturing Cell

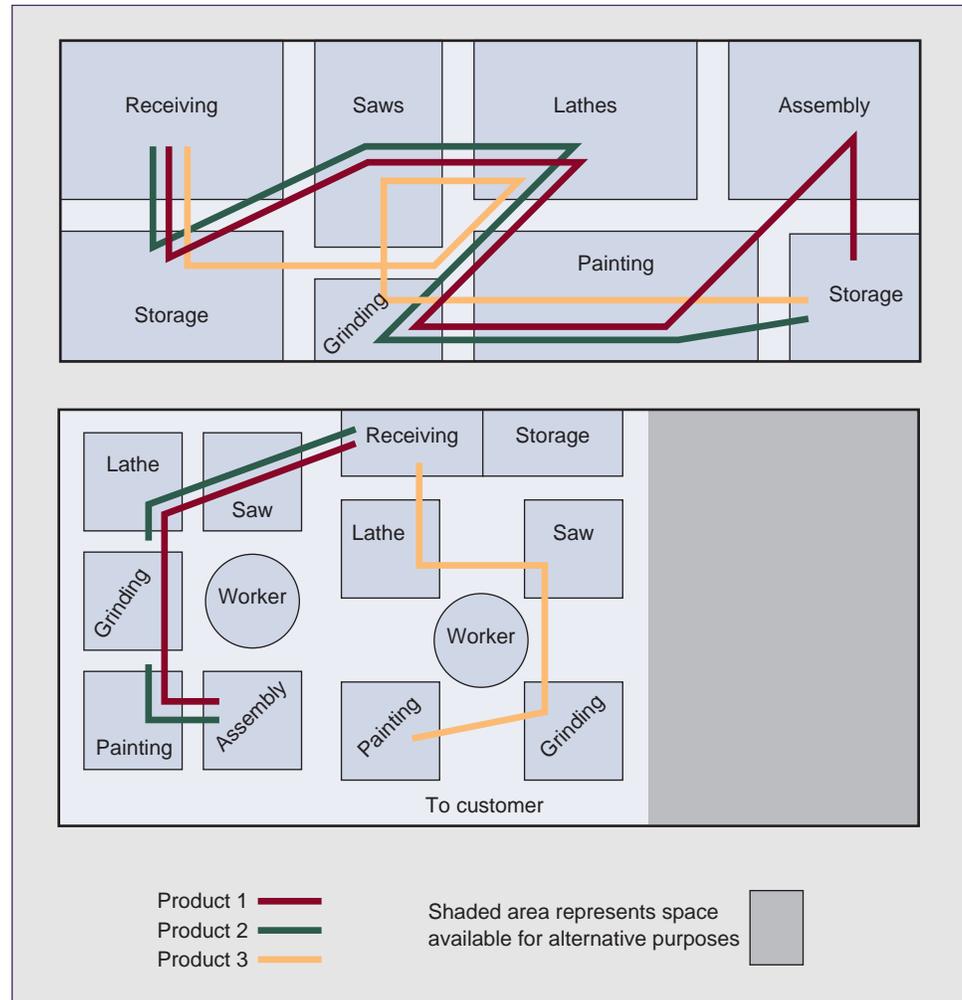MANUFACTURING CELL

Information sharing and teamwork

Physical production flow in which raw material (RM) and work in process (WIP) flow successively through the manufaturing cell until completed finished goods (FG)

multiprocess handling

in the process because of **multiprocess handling**. Workers are multiskilled, trained to monitor numerous machines, and therefore more flexible and less bored because they are performing a variety of tasks. The ability to oversee an entire process may prompt employee suggestions on improvement techniques that would not have been visible had the employee been working on a single facet of the process.[16]

Although highly automated equipment may run without direct labor involvement, it will still require monitoring. Some equipment stops automatically when a given situation arises. The "situation" may be positive (a specified quantity of production has been reached) or negative (a quality defect has been indicated).

autonomation

Toyota refers to the usage of such equipment in a factory environment as **autonomation** to distinguish it from automated factories in which the machinery is not programmed to stop when specified situations arise. Because machines "know" the certain conditions they are expected to sense, workers are able to oversee several machines concurrently. A worker's responsibility may be to monitor all machines operating in a single manufacturing cell.

[16] The average American company receives about one suggestion per year from every six eligible employees. On the other hand, Japanese companies receive an average of 32 suggestions. [John Tschohl, "Be Bad: Employee Suggestion Program Cuts Costs, Increases Profit," *The Canadian Manager* (Winter 1998), pp. 23–24.]

THE LOGISTICS OF THE JIT ENVIRONMENT

A certain degree of logistical assistance is developing in the JIT environment in the areas of information technology (IT), new support services, and new value-chain relationships. Such advancements can enhance the effectiveness and efficiency of companies employing JIT. These can be viewed in overriding support systems, in the preproduction stage, during production, and after production.

Overriding Support Systems JIT can be employed within the context of more comprehensive management models such as the TQM (discussed in Chapter 8) and six-sigma method. The **six-sigma method** is a high-performance, data-driven approach to analyzing and solving the root causes of business problems. Four steps for a successful application of the six-sigma method follow: first, an initial team determines what the organization knows about its customers and competitors; second, an executive action planning workshop is conducted to develop a vision of how six sigma can assist the organization to achieve its business goals; third, improvement workshops are held to familiarize personnel with methods and strategy and how they will be combined into the unit's business plan to push improved performance; and fourth, team-leader training is conducted for application of just-in-time.[17]

six-sigma method

The **Internet business model** has become the new orthodoxy, and it is transforming cost and service equations across the corporate landscape. It involves (1) few physical assets, (2) little management hierarchy, and (3) a direct pipeline to customers. In this environment, electronic commerce is transforming supply-chain integration and delivering cost savings.[18]

Internet business model

Christopher Gopal, national director of Ernst and Young's supply-chain and operations consulting says:

http://www.ey.com

> *Web-based technology allows the sharing of information, not just one-to-one—but one-to-many—and even many-to-many. . . . It is not simply a case of providing access to a Web site, but creating "extranets" where key customers and suppliers have access to "virtual private networks" that enable collaborative planning, forecasting, and replenishment. It is like traditional one-to-one customer/supplier scheduling, but now it has gone to one-to-many—and the supplier can turn around and do the same thing with all of its suppliers. It is basically linking the entire supply chain.[19]*

Supply-chain management is the cooperative strategic planning, controlling, and problem solving by a company and its vendors and customers to conduct efficient and effective transfers of goods and services within the supply chain. A recent report on supply-chain management by ARM Research Inc., Boston, notes three levels of business-to-business relationships in e-commerce: transactional, information-sharing, and collaboration. The report discusses these as follows:

supply-chain management

> *Transactional relationships include the use of EDI to automate such things as purchase orders and invoices. At the information-sharing level, firms might exchange production schedules or details on the status or orders. At the highest level—collaboration—information is not just exchanged and transmitted, but the buyer and seller also jointly develop it. Generally this information deals with future product plans and needs. . . . However, unlike an information-sharing relationship, information is not shared on an FYI-basis, since either trading partner may change it until both parties agree.[20]*

[17] Jerome A. Blakeslee, Jr., "Implementing the Six Sigma Solution," *Quality Progress* (July 1999), pp. 77ff.
[18] Nuala Moran, "E-Commerce Based Procurement Solutions for the Chemical Industry Eliminating Paper Trail," *Chemical Week* (August 18, 1999), pp. S9ff.
[19] John H. Sheridan, "Pushing Production to New Heights," *Industry Week* (September 21, 1998), pp. 43ff. Reprinted with permission from *Industry Week.* Copyright Penton Media, Inc., Cleveland, Ohio.
[20] Ibid.

Logistical Support in the Preproduction Stage In addition to the IT improvements in product design for manufacturability that will be discussed subsequently, simulation software is available to develop production systems that can enhance financial performance. The benefits of improving processes based on such simulations include greater throughput, reduced inventory levels, and further cost savings from reduced run time and setup time. Analyzing the important interaction and dependence that exist in production systems through software simulation can help answer questions such as these: (1) How many items can the system produce? (2) What will result if the equipment is rearranged? (3) Can delivery dates be met?[21]

A new standard for Open Buying on the Internet (OBI) is being developed by the on-line industry to establish guidelines for information flow between customers and suppliers, methods of communications and security procedures, and the format and content of on-line purchase orders, invoices, and other purchasing documents. The standard is intended to help a manufacturer communicate with all its suppliers in a more uniform and efficient way.[22]

Transportation analysis and arrangements can be enhanced to make the acquisition of materials and parts a more efficient and effective process. This involves the use of computer software and working more closely with material and logistics suppliers to gather essential information to guide decisions to improve transportation.[23]

Logistical Support during Production Companies are replacing the batch processing systems that supported traditional labor-intensive assembly-line production runs with on-line, real-time systems that can monitor and control production. These systems permit computer-controlled robots to move material and perform assembly and other manufacturing tasks.

just-in-time training

Although industry is moving toward automation, humans will not soon be entirely replaced. **Just-in-time training** systems map the skill sets employees need and deliver the training they need just as they need it.[24]

In the near future, workers unfamiliar with some tasks may be able to get just-in-time training whenever and wherever needed. The accompanying News Note describes this worker support.

focused factory arrangement

Focused factory arrangements are often adopted to connect a vendor more closely to a JIT manufacturer's operations. Such an arrangement means that a vendor agrees to provide a limited number of products according to specifications or to perform a limited number of unique services for the JIT company. The supplier may be an internal division of the same organization or an external party. Focused factory arrangements may also involve relocation or plant modernization by the vendor, and financial assistance from the JIT manufacturer may be available to recoup such investments. In addition, the vendor benefits from long-term supply contracts.

Major reliance on a single customer can be difficult, especially for small vendors. A decline in the business of the primary customer or demands for lower prices can be disastrous for the focused factory. To maintain customers, some companies are submitting to vendor certification processes.

Postproduction Logistical Support Real-time information processing software for inventory management of finished goods can better serve the customer, minimize errors, and yield savings in labor, transportation, capital, and carrying costs.[25]

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[21] Mike C. Patterson, "A Simulation Analysis of Production Process Improvement," *Journal of Business Education* (November 1998), pp. 87ff.

[22] Mike Bielen, "Commerce on the Information Highway," *Chemical Market Reporter* (July 21, 1997), pp. 16ff.

[23] Peter Bradley, "A New Strategy for Managing Transportation," *Purchasing* (July 13, 1995), pp. 76ff.

[24] Anonymous, "Movement toward JIT Training," *Industry Week* (May 4, 1998), p. 13.

[25] Anonymous, "Improving Productivity and Customer Service: Real Time Intelligent Information Processing Reaps Gains from Warehouse Inventory Management," *Plant* (October 23, 1995), pp. 16–17.

Wearable Computer Gives Workers Just-in-Time Help

Georgia Tech Research Institute (GTRI) researchers have developed a prototype system that integrates job performance support software with wireless communication to create a wearable computer. The hands-free system, called Factory Automation Support Technology (FAST), is designed to support mobile employees while they perform their job functions.

Researchers' challenge in developing the system was to create a lightweight interactive system that is comfortable and does not interfere with vision or hearing. In addition, they had to include a large enough battery to provide the processing power for supporting robust voice recognition. On the software side, noise-canceling microphones and a limited vocabulary for giving commands were used to overcome the high ambient noise in factories.

The development team created both an information database for each application and a prototype delivery system in the form of a wearable computer. The basic FAST hardware comprises:

- a credit card-sized computer worn on a belt that transmits data in real time to other computer systems;
- a visor that is worn like safety glasses that displays information via a miniaturized CRT;
- earphones for listening to auditory information provided by the computer;
- a microphone that enables voice-activated operation of the computer;
- flexible eight-hour battery packs worn on the belt.

The system, which is in its fourth generation, will have increased processing power and a flexible battery belt, which will let an operator work an entire shift without recharging.

SOURCE: Staff, "Wearable Computer Gives Workers Just-in-Time Help," *R&D* (August 1999), p. S-21.

Third-party logistics services involve moving and warehousing finished goods between manufacturer and merchant and sometimes, as in automobile leasing, back to the manufacturer. Outsourcing of these functions to logistics specialists can save the manufacturer time and money.[26]

third-party logistics

ACCOUNTING IMPLICATIONS OF JIT

Companies adopting a just-in-time inventory and/or flexible manufacturing system must be aware of the significant accounting implications such a system creates. A primary accounting impact occurs in variance analysis. Because a traditional standard cost accounting system is primarily historical in nature, its main goal is variance reporting. The reports allow the variances to be analyzed for cause-and-effect relationships to eliminate future similar problems.

Variances under JIT Variance reporting and analysis in JIT systems essentially disappear. Because most variances first appear in a physical (rather than financial) fashion, JIT mandates that variances be recognized on the spot so that causes can be ascertained and, if possible, promptly removed. JIT workers are trained and expected to monitor quality and efficiency continually while production occurs rather than just at the end of production. Furthermore, if the firm is using statistical process controls, workers can predict the impending occurrence of production defects and take measures to prevent them from ever actually occurring. Therefore, the number and monetary significance of end-of-period variances being reported for managerial control should be limited.

[26] Chris Isidore, "Outbound Logistic Expertise Needed," *Journal of Commerce* (October 23, 1995), p. 6A.

Under a JIT system, long-term price agreements have been made with vendors, so material price variances should be minimal. The JIT accounting system should be designed so that purchase orders cannot be cut for an amount greater than the designated price without manager approval.[27] In this way, the variance amount and its cause are known in advance, providing an opportunity to eliminate the excess expenditure before it occurs. Calls can be made to the vendor to negotiate the price, or other vendors can be contacted for quotes.

The ongoing use of specified vendors also provides the ability to control material quality. It is becoming relatively common around the world for companies to require that their vendors maintain quality standards and submit to quality assurance audits. Because better control of raw material quality is expected, little or no material quantity variances should be caused by substandard material. If usage standards are accurate based on established machine-paced efficiency, there should be virtually no favorable usage variance of material during production. Unfavorable use of material should be promptly detected because of ongoing machine and/or human observation of processing. When an unfavorable variance occurs, the manufacturing process is stopped and the error causing the unfavorable material usage is corrected to minimize material quantity variances.

One type of quantity variance is not caused by errors but by engineering changes (ENCs) made to the product specifications. A JIT system has two comparison standards: an annual standard and a current standard. Design modifications would change the current standard, but not the annual one. The annual standard is one of the bases for preparation and execution of the company's master budget and is ordinarily kept intact because all of the financial plans and arrangements for the year covered by the master budget are predicated on the standards and plans used to prepare the master budget.

Such a procedure allows comparisons to be made that indicate the cost effects of engineering changes implemented after a product has begun to be manufactured. A material quantity variance caused by an ENC is illustrated in Exhibit 16–12. In the illustration, the portion of the total quantity variance caused by the engineering change ($10,800 U) is shown separately from that caused by efficiency ($2,160 F). Labor, overhead, and/or conversion can also have ENC variances.

Labor variances in an automated just-in-time system should be minimal if standard rates and times have been set appropriately. Labor time standards should be carefully evaluated after the implementation of a JIT production system. If the plant is not entirely automated, redesigning the physical layout and minimizing any non-value-added labor activities should decrease the direct labor time component.

An accounting alternative that may occur in a JIT system is the use of a "conversion cost" category for purposes of cost control rather than use of separate labor and overhead categories. This category becomes more useful as factories reduce the direct labor cost component through continuous improvements and automation. A standard departmental or manufacturing cell conversion cost per unit of product (or per hour of production time per manufacturing cell) may be calculated rather than individual standards for labor and overhead. Denominators in each case would be practical or theoretical capacity in an appropriate activity.[28] If time were used as the base, the conversion cost for a day's production would be equal to the number of units produced multiplied by the standard number of production hours multiplied by the standard cost per hour. Variances would be determined by comparing actual cost to the designated standard. However, direct labor is a very small part of production in such an environment. Use of efficiency variances to evaluate workers can cause excess inventory because these workers are trying

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[27] This same procedure can be implemented under a traditional standard cost system as well as under a JIT system. However, it is less commonly found in a traditional system, but it is a requirement under JIT.

[28] Practical or theoretical capacity is the appropriate measure because the goal of JIT is virtually continuous processing. In a highly automated plant, these capacities more closely reflect world-class status than does expected annual capacity.

Annual standard:	8 feet of material M @ $6.10	$48.80
	5 feet of material N @ $6.70	33.50
		$82.30
Current standard:	7 feet of material M @ $6.10	$42.70
	6 feet of material N @ $6.70	40.20
		$82.90

| Production during month: | 18,000 units |

Usage during month:	129,600 feet of material M @ $6.10	$ 790,560
	104,400 feet of material N @ $6.70	699,480
	Total cost of material used	$1,490,040

Material quantity variance:

18,000 × 7 × $6.10	$ 768,600
18,000 × 6 × $6.70	723,600
Material cost at current standard	$1,492,200
Actual material cost	1,490,040
Material quantity variance	$ 2,160F

Engineering change variance for material:

18,000 × 8 × $6.10	$ 878,400
18,000 × 5 × $6.70	603,000
Material cost at annual standard	$1,481,400
Material cost at current standard	1,492,200
ENC variance	$ 10,800U

to "keep busy" to minimize this variance. Therefore, direct labor efficiency variances in this setting may be counterproductive.

In addition to minimizing and adjusting the variance calculations, a JIT system can have a major impact on inventory accounting. Companies employing JIT production processes would no longer require a separate raw material inventory classification because material would be acquired only when and as production occurs. Instead, JIT companies could use a Raw and In Process (RIP) Inventory account.

Backflush Costing The focus of accounting in a JIT system is on the plant's output to the customer.[29] Because each sequential activity in a production process is dependent on the previous activity, any problems will quickly cause the system to stop the production process. Individual daily accounting for the costs of production will no longer be necessary because all costs should be at standard, and variations will be observed and corrected almost immediately.

Additionally, fewer costs need to be allocated to products because more costs can be traced directly to their related output in a JIT system. Costs are incurred in specified cells on a per-hour or per-unit basis. Energy is a direct production cost in a comprehensive JIT system because there should be a minimum of downtime by machines or unplanned idle time for workers. Virtually the only costs still being allocated are costs associated with the structure (building depreciation, rent, taxes, and insurance) and machinery depreciation. The reduction of allocations provides more useful measures of cost control and performance evaluation than have been traditionally available.

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[29] A company may wish to measure output of each manufacturing cell or work center rather than plant output. Such measurements may indicate problems in a given area, but do not correlate with the JIT philosophy of the team approach, plantwide attitude, and total cost picture.

Robotic equipment, such as this welder, can perform tasks much more rapidly and with higher quality than humans often can. This equipment also allows for more rapid changeover time so that multiple products can be produced on the same line.

backflush costing

Backflush costing is a streamlined cost accounting method that speeds up, simplifies, and minimizes accounting effort in an environment that minimizes inventory balances, requires few allocations, uses standard costs, and has minimal variances from standard. During the period, this costing method records purchases of raw material and accumulates actual conversion costs. Then, at a predetermined trigger point such as (1) at completion of production or (2) on the sale of goods, an entry is made to allocate the total costs incurred to Cost of Goods Sold and to Finished Goods Inventory using standard production costs.

Molly Memories is a company that makes dolls and is used to illustrate just-in-time system backflush entries. The entries related to one of Molly Memories' products are presented in Exhibit 16–13 to establish a foundation set of transactions from which to illustrate subsequent alternative recordings in a backflush costing system. The product's standard production cost is $130.50. The company has a long-term contract with its direct material supplier for raw material at $38.50 per unit, so there is no material price variance on purchase. Beginning inventories for July are assumed to be zero. Standard conversion cost per unit is $92.00.

The following selected T-accounts summarize the activity presented in Exhibit 16–13.

Raw and In Process Inventory				Conversion Costs			
(1)	785,000	(4)	2,610,000	(2)	1,843,500	(3)	1,840,000
(3)	1,840,000						
Bal.	15,000						

Finished Goods Inventory				Cost of Goods Sold			
(4)	2,610,000	(5)	2,583,900	(5)	2,583,900		
Bal.	26,100						

Accounts Receivable				Sales			
(5)	4,455,000					(5)	4,455,000

Molly Memories standard production cost per unit:

Direct material	$ 38.50
Conversion	92.00
Total cost	$130.50

No beginning inventories exist.

(1) Purchased $765,000 of direct material in July:

Raw and In Process Inventory	785,000	
Accounts Payable		785,000

Purchased material at standard cost under a long-term agreement with supplier.

(2) Incurred $1,843,500 of conversion costs in July:

Conversion Costs	1,843,500	
Various accounts		1,843,500

Recorded conversion costs; various accounts include Wages Payable for direct and indirect labor, Accumulated Depreciation, Supplies, etc.

(3) Applied conversion costs to RIP for 20,000 units completed:

Raw and In Process Inventory (20,000 × $92.00)	1,840,000	
Conversion Costs		1,840,000

(4) Transferred 20,000 units of production in July:

Finished Goods Inventory (20,000 × $130.50)	2,610,000	
Raw and In Process Inventory		2,610,000

(5) Sold 19,800 units on account in July for $225 each:

Accounts Receivable (19,800 × $225)	4,455,000	
Sales		4,455,000
Cost of Goods Sold (19,800 × $130.50)	2,583,900	
Finished Goods Inventory		2,583,900

Ending Inventories:

Raw and In Process Inventory ($2,625,000 − $2,610,000)	$15,000
Finished Goods Inventory ($2,610,000 − $2,583,900)	$26,100

In addition, there are underapplied conversion costs of $3,500 ($1,843,500 − $1,840,000).

Four alternatives are given below to the entries presented in Exhibit 16–13. First, if production time were extremely short, Molly Memories might not journalize raw material purchases until completion of production. In that case, the entry [in addition to recording entries (2) and (5) in Exhibit 16–13] to replace entries (1), (3), and (4) follows. Completion of the finished goods is the trigger point for this entry.

Raw and In Process Inventory	15,000	
Finished Goods Inventory (20,000 × $130.50)	2,610,000	
Accounts Payable		785,000
Conversion Costs (20,000 × $92.00)		1,840,000

If goods were shipped immediately to customers on completion, Molly Memories could use a second alternative in which the entries to complete and sell would be combined. It would replace entries (3), (4), and the first element in (5) in Exhibit 16–13. Entries (1), (2), and the second element in (5) in Exhibit 16–13 would still be needed. Sale of the products is the trigger point for this entry.

Finished Goods Inventory (200 × $130.50)	26,100	
Cost of Goods Sold (19,800 × $130.50)	2,583,900	
Raw and In Process Inventory (20,000 × $38.50)		770,000
Conversion Costs (20,000 × $92.00)		1,840,000

The third alternative reflects the ultimate JIT system, in which only one entry [other than recording entry (2) in Exhibit 16–13] is made. Sale of the products is the trigger point for this entry. For Molly Memories, this entry would be

Raw and In Process Inventory (minimal overpurchases)	15,000	
Finished Goods Inventory (minimal overproduction)	26,100	
Cost of Goods Sold	2,583,900	
Accounts Payable		785,000
Conversion Costs		1,840,000

A fourth alternative charges all costs to the Cost of Goods Sold account, with a subsequent backflush of costs to the Raw and In Process Inventory and the Finished Goods Inventory accounts at the end of the period. The following entries replace entries (1), (3), (4), and (5) shown in Exhibit 16–13. Entry (2) in Exhibit 16–13 would still be made.

Cost of Goods Sold	2,625,000	
Accounts Payable		785,000
Conversion Costs		1,840,000

Sale of the products is the trigger point for the following entry.

Raw and In Process Inventory	15,000	
Finished Goods Inventory	26,100	
Cost of Goods Sold		41,100

Implementation of the just-in-time philosophy can cause significant cost reductions and productivity improvements. But, even within a single company, all inventory situations do not necessarily have to be on a just-in-time system. The costs and benefits of any inventory control system must be evaluated before management should consider installing the system. The use of JIT, however, does allow workers as well as managers to concentrate on providing quality service to customers.

JIT IN NONMANUFACTURING SITUATIONS

Although a JIT manufacturing system can be adopted only by a company actually producing a product, nonmanufacturers can employ other just-in-time systems. An all-encompassing view of JIT covers a variety of policies and programs that are implemented to continuously improve the use of company human and mechanical resources. Thus, just-in-time is a type of management control system having a distinct underlying philosophy of which inventory minimization is only one element. In addition to being used by manufacturers, the JIT philosophy can be adopted within the purchasing and delivery departments of any organization involved with inventory, such as retailers, wholesalers, and distributors.

Many of the just-in-time techniques do not require a significant investment in new equipment but depend, instead, on the attitude of company management and the involvement of the organization's people and their willingness to work together and trust one another. People working under a JIT system must be open to change and question established routines and procedures. The company should use all of its employees' talents by empowering its total workforce. Employee empowerment gives the employee authority, resources, support and encouragement to be proactively involved and to continuously seek improvements in the workplace. Creative abilities have sometimes been overlooked or neglected.

JIT emphasizes that there is always room for workplace improvement, whether in floor space design, training and education, equipment and technology, vendor relationships, or any one of many other items. Managers and employees should be continuously alert to the possibilities for lowering costs while increasing quality and service. But JIT is more than a cost-cutting endeavor or a matter of reducing personnel; it requires good human resources management. It involves assessing the company's products and processes not only by internal measures but also by

continuously comparing them with changing customer needs and requirements and by performance of competitors and organizations identified as "best-in-class." In many respects, JIT really requires management to act with common sense.

DESIGN FOR MANUFACTURABILITY

Design for manufacturability (DFM) is a process that is part of the project management of a new product. DFM is concerned with finding optimal solutions to minimizing product failures and other adversities in the delivery of a new product to customers. Objectives of DFM include optimizing customer satisfaction, cost to the customer of owning and using the product over its life for the customer, and cost, time, effort, and ease of producing and delivering the product to customers.

Cross-functional teams seeking advice from customers and assistance from suppliers gather and manipulate information to determine the material, methods, processes and their trade-offs that will best meet their objectives. This process involves activity analysis to minimize the presence of non-value-added activities and to streamline the performance of value-added activities.

design for
   manufacturability

Flexible Manufacturing Systems and Computer-Integrated Manufacturing

Many manufacturers have changed their basic manufacturing philosophy in the past few decades. Causes of change include: (1) automated equipment and a cellular plant layout, (2) computer hardware and software technology, and (3) new manufacturing systems and philosophies such as JIT and activity-based management.

Traditionally, most manufacturing firms employed long production runs to make thousands of identical models of the same products; this process was encouraged by the idea of economies of scale. After each run, the machines would be stopped and a slow and expensive setup would be made for the next massive production run to begin. Now, an entirely new generation of manufacturing known as **flexible manufacturing systems** (FMSs) is being developed.

An FMS involves a network of robots and material conveyance devices monitored and controlled by computers that allows for rapid production and responsiveness to changes in production needs. Two or more FMSs connected via a host computer and an information networking system are generally referred to as **computer-integrated manufacturing** (CIM). Exhibit 16–14 contrasts the dimensions of a traditional manufacturing system with an FMS. Although an FMS is typically associated with short-volume production runs, many companies (such as Werthan Packaging, Allen-Bradley, and Cummins Engine) have also begun to use CIM for high-volume lines.

7
What are flexible manufacturing systems and how do they relate to computer-integrated manufacturing?

flexible manufacturing
   system

computer-integrated
   manufacturing

http://www.werthan.com
http://www.cummins.com

Factor	Traditional Manufacturing	FMS
Product variety	Few	Extensive
Response time to market needs	Slow	Rapid
Worker tasks	Specialized	Diverse
Production runs	Long	Short
Lot sizes	Massive	Small
Performance rewards basis	Individual	Team
Setups	Slow and expensive	Fast and inexpensive
Product life-cycle expectations	Long	Short
Work area control	Centralized	Decentralized
Technology	Labor intensive	Technology intensive
Information requirements	Batch based	On line, real time
Worker knowledge of technology	Low to medium	High

EXHIBIT 16–14

Comparison of Traditional Manufacturing and FMS

FMSs are used in modular factories and are able to customize output on request for customers. Customization can be accomplished because of the ability to introduce new products quickly, produce in small lot sizes, make rapid machine and tool setups, and communicate and process large amounts of information. Information is transferred through an electronic network to the computers that control the robots performing most of the production activities. The system functions with on-line, real-time production flow control, using fiber optics and local-area networks.

Companies are able to quickly and inexpensively stop producing one item and start producing another. This ability to make quick and inexpensive production changes and to operate at great speed permits a company to build a large assortment of products and thereby offer its customers a wide variety of high-quality products while minimizing product costs. In effect, machines are able to make other machines and can do so with little human intervention. The system can operate in a "lights-out" environment and never tire.

The need for direct labor is diminished in such a technology-intensive environment. The workers in a company employing an FMS must be more highly trained than those working in traditional manufacturing environments. These workers find themselves handling a greater variety of tasks than the narrowly specialized workers of earlier manufacturing eras. Persons with greater authority and responsibility manage the manufacturing cells. This increase in control occurs because production and production scheduling changes happen so rapidly on the shop floor that an FMS relies on immediate decisions by persons who "live there" and have a grasp of the underlying facts and conditions.

http://www.nissan-usa .com/menu_nf.html

The FMS works so fast that moving products along and out of the way of other products is sometimes a problem. Japan's Nissan Motor Company's FMS facility on Kyushu Island replaced the time-honored conveyor belt with a convoy of little yellow intelligent motor-driven dollies that "tote cars at variable speeds down the assembly line sending out a stream of computer-controlled signals to coach both robots and workers along the way."[30]

THEORY OF CONSTRAINTS

8

How can the theory of constraints help in determining production flow?

theory of constraints
constraint

The **theory of constraints** (TOC) can help management reduce cycle time. The theory of constraints indicates that the flow of goods through a production process cannot be at a faster rate than the slowest bottleneck in the process.[31]

Production limitations in a manufacturing environment are caused by human, material, and machine constraints. A **constraint** is anything that confines or limits a person or machine's ability to perform a project or function. Some constraints are not related to speed—they relate to absolute production limits such as availability materials or machine hours. Other constraints are related to speed.

Human constraints can be caused by an inability to understand, react, or perform at some particular rate of speed. These constraints cannot be totally overcome (because humans will never be able to work at the speed of an automated machine), but can be reduced through proper hiring and training. Because the labor content contained in products is declining rapidly as automation increases, constraints caused by machines are often of more concern than human constraints in reducing cycle time.

bottleneck

Machine constraints, also called **bottlenecks**, are points at which the processing levels are sufficiently slow to cause the other processing mechanisms in the network to experience idle time. Bottlenecks cause the processing of an activity

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[30] Clay Chandler and Joseph B. White, "It's Hello Dollies at Nissan's New 'Dream Factory'," *The Wall Street Journal* (July 6, 1992), p. 1.
[31] The theory of constraints was introduced to business environments by Eliyahu Goldratt and Jeff Cox in the book *The Goal* (New Haven, Conn.: North River Press, Inc./Spectrum Publishing Company, Inc., 1986).

to be impeded. Even a totally automated, "lights-out" process will have some constraints, because all machines do not operate at the same speed or handle the same capacity. Therefore, the constraints must be identified and worked around.

Exhibit 16–15 provides a simplified illustration of a constraint in a production process. Although Machine 1 can process 90,000 pounds of raw material in an hour, Machine 2 can handle only 40,000 pounds. Of an input of 70,000 pounds, 30,000 pounds of processed material must wait at the constraining machine after an hour of processing. The constraint's effect on production is obvious, but the implications are not quite as clear. Managers have a tendency to want to see machines working, not sitting idle. Consider what this tendency would mean if the desired output were 450,000 pounds rather than 70,000. If Machine 1 were kept in continual use, all 450,000 pounds would be processed through Machine 1 in five hours. However, a backlog of 250,000 pounds [450,000 − 5(40,000)] of processed material would now be waiting in front of Machine 2! All of this material would require storage space and create an additional cost of a non-value-added activity.

Machine constraints also impact quality control. Managers normally choose quality control points to follow the completion of some particular process. When constraint points are known, quality control points should be placed in front of them.

> *Make sure the bottleneck works only on good parts by weeding out the ones that are defective. If you scrap a part before it reaches the bottleneck, all you have lost is a scrapped part. But if you scrap the part after it's passed through the bottleneck, you have lost time that cannot be recovered.*[32]

Once constraints are known, the best use of the time or productive capacity they provide should be made. Subsequently, "after having made the best use of the existing constraints, the next step is to reduce their limitations on the system's performance."[33] Options to reduce limitations, such as adding more machines to perform the constrained activity or processing material through other machines, should be investigated.
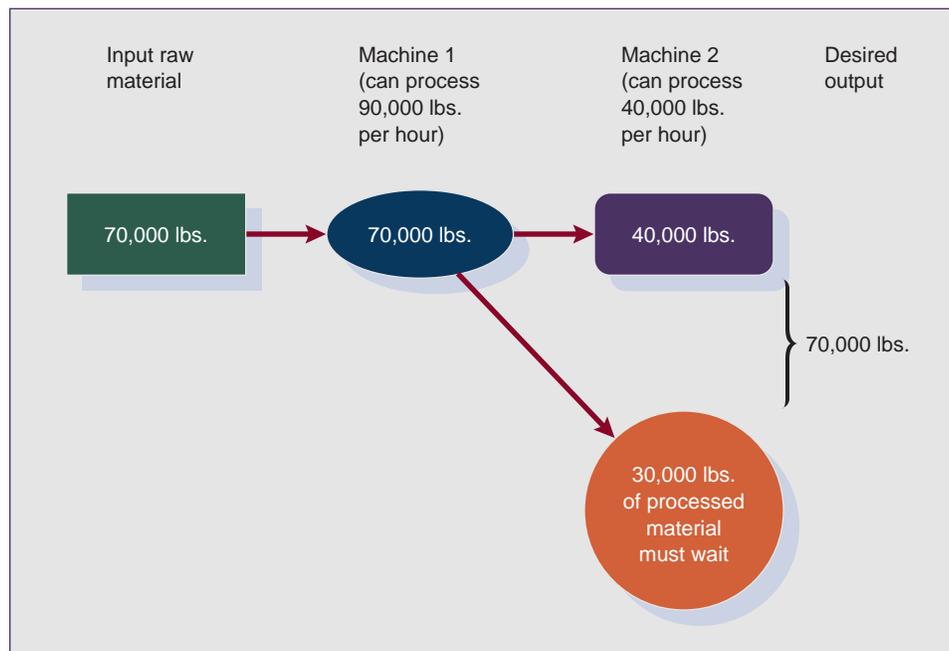

EXHIBIT 16–15

Production Constraint

[32] Ibid., p. 156.
[33] Robert E. Fox, "The Constraint Theory," in *Cost Accounting for the '90s Responding to Technological Change Proceedings* (Montvale, N.J.: National Association of Accountants, 1988), p. 51.

Managing constraints is a process of continuous improvement. After the constraint(s) in the system is (are) identified, and managers have decided how to "exploit" the constraint to avoid wasting constrained resources, better solutions are continually sought. When a constraint becomes difficult to improve, Goldratt suggests the use of what he refers to as the "evaporating clouds" method.[34] Eric Noreen *et al* describe an important step in this process, that involves identifying and challenging assumptions about a constraint, as follows:

http://www.blackand
decker.com
http://www.jj.com
http://www.bain.com

> *The key is to identify the assumptions that lead us to* believe *that a clean solution is not possible. The specific technique used to identify the assumptions underlying the apparent conflict and to break the deadlock is called an "Evaporating Cloud."*[35]

[34] Eliyahu M. Goldratt, *Theory of Constraints* (Great Barrington, Mass.: The North River Press, 1990), pp. 36–38.
[35] Eric Noreen, Debra Smith, and James T. Mackey, *The Theory of Constraints and Its Implications for Management Accounting* (Great Barrington, Mass.: The North River Press, 1995), p. 50.

REVISITING

Alexander Doll Co.

http://www.onlinedolls.com/ma/index.htm

A company that's a good candidate for *kaizen,* says William Schartz, TBM vice president, usually displays two key characteristics:

- Long lead times, usually accompanied by a lot of work-in-process inventory; and
- A dedicated and knowledgeable workforce, to participate in problem solving.

This profile reflected conditions at the Alexander Doll Co. before that unusual group of manufacturing experts translated their experience from streamlining the assemblies of fenders and crankshafts to the task of producing wigs, shoes, and all the many other small components that comprise a doll.

Although making a doll is not as difficult as making a Lexus, the endeavor is more rigorous than most might imagine. The costumes contain 20 or more separate items, which may have to go through 30 or more production steps. Because 75 percent of the styles change annually and doll fabric is bought in small quantities that cannot be reordered, accurate planning is essential.

Before TBM arrived, the doll factory used archaic methods: Because it was organized according to old-fashioned principles of batch processing, boxes of costume material and vinyl doll parts were stacked to the ceiling. Since nothing was built to order, more than 90,000 dolls were stored in partly finished condition, and customers waited up to 16 weeks for delivery.

In 1996 when the new CEO, Herbert Brown, a manufacturing expert who had previously run operations for Black & Decker and Johnson & Johnson, tried to fill a customer order for 300 dolls, only 117 could be completed because so many pieces were missing. He reorganized the factory, and in true Toyota fashion, sought the assistance of the 470 workers, mostly Dominican immigrants who spoke limited English.

Instead of having the individual workers producing batches of parts, seven- or eight-person teams were organized. Each team is responsible for completing about 300 dolls or wardrobe assemblies a day. Work in progress has been reduced by 96 percent and orders can now be filled in one or two weeks instead of two months.

Having successfully turned the operations around by 1998, the company was able to switch its focus to sales growth, and engaged Bain & Co., a top-tier consulting firm, to help devise the best growth strategies.

Sales have increased from $23.8 million in 1995 to $31.6 million for 1998, and operating profit increased by $4 million. Workers at the company have an obvious incentive to effectively apply Toyota's techniques—the building itself is a constant reminder of the consequences of failing to adapt to changing times. The first occupant of the building was Studebaker.

SOURCE: Alex Taylor III, "It Worked for Toyota. Can It Work for Toys?" *Fortune* (January 11, 1999), p. 36; and Robert Maynard, "A Company Is Turned Around Through Japanese Principles," *Nation's Business* (February 1996), p. 9.

CHAPTER SUMMARY

Costs associated with inventory can be significant for any company and sound business practices seek to limit the amount of those costs. Inventory costs include the costs of purchasing, ordering, carrying, and not carrying inventory.

A push system of production control is dictated by lead times and order-size requirements preestablished by company personnel. Work centers may buy or produce inventory not currently needed because of these requirements. This excess inventory is stored until it is needed by other work centers. In contrast, a pull system of production control (such as just-in-time manufacturing) involves the purchase and/or production of inventory only as the need arises. Storage is eliminated except for a minimal level of safety stock.

Target costing can be combined with life-cycle costing to determine an allowable product cost based on an estimated selling price and a desired profit margin. Because sales volume, costs, and profits fluctuate over a product's life cycle, these items would need to be estimated over the entire life rather than on a periodic basis to determine a target cost.

The goals of a just-in-time system are to eliminate non-value-added processes, continuously improve efficiency, and reduce costs while increasing quality. The JIT philosophy can be applied to some extent to any company having inventories. JIT requires that purchases be made in small quantities and deliveries be frequent. Production lot sizes are minimized so that many different products can be made on a daily basis. Products are designed for quality and component parts are standardized to the extent possible. Machine setup time is reduced so that production runs can be easily shifted between products. Plant layout emphasizes manufacturing cells, and the operating capabilities of all factory equipment are considered to eliminate the need for or buildup of buffer inventories between operations.

The institution of a JIT system has accounting implications. Variances should be negligible, but their occurrence should be recognized earlier in the process so that causes are found and corrective action taken quickly. Because few raw materials would be stocked (because they are only acquired as needed in production) and work in process time should be short, JIT companies may use a merged raw material and work in process inventory classification. The traditional categories of direct labor and overhead may be combined and accounted for under the single category of conversion cost, and a greater number of costs will be directly traceable to production under a JIT system. Backflush accounting techniques can be used that reduce the number of journal entries currently needed to trace production costs through the process.

Design for manufacturability is a process to help management minimize product failures and other problems in delivering a new product to customers. Information is sought from customers and suppliers to determine the methods, materials, and processes that best meet management objectives.

A special type of just-in-time company is one that engages in flexible manufacturing. Flexible manufacturing systems are so fast and versatile that products can be tailored to customer requests with only an insignificant delay in production time in most instances.

Flexible manufacturing systems involve a network of robots and material conveyance devices monitored and controlled by computers that allows for rapid production and responsiveness to changes in production needs. Two or more FMSs connected by a host computer and an information networking system are referred to as computer-integrated manufacturing.

The theory of constraints indicates that the flow of goods through a production process cannot be at a faster rate than the slowest constraint in the process. Managing constraints is a process of continuous improvement. After a constraint in the system is identified, and managers have decided how to "exploit" the constraint to avoid wasting constraint resources, better solutions are continually sought.

APPENDIX

How are economic order quantity, reorder point, and safety stock determined and used?

economic order quantity

EOQ and Related Issues

Economic Order Quantity

Companies making purchasing (rather than production) decisions often compute the **economic order quantity** (EOQ), which represents the least costly number of units to order. The EOQ indicates the optimal balance between ordering and carrying costs by mathematically equating total ordering costs to total carrying costs. The EOQ is a tool that is used in conjunction with traditional "push" production and inventory management systems. Because EOQ implies acquiring and holding inventory before it is needed, it is incompatible with "pull" systems such as JIT.

Purchasing managers should first determine which supplier could offer the appropriate quality of goods at the best price in the most reliable manner. After the supplier is selected, the most economical inventory quantity to order—at a single time—is determined. The EOQ formula is

$$EOQ = \sqrt{\frac{(2QO)}{C}}$$

where EOQ = economic order quantity in units

Q = estimated annual quantity used in units
(can be found in the annual purchases budget)

O = estimated cost of placing one order

C = estimated cost to carry one unit in stock for one year

Note that unit purchase cost is not included in the EOQ formula. Purchase cost relates to the question of from whom to buy, which is considered separately from the question of how many to buy at a single time. Inventory unit purchase cost does not affect the other EOQ formula costs except to the extent that opportunity cost is calculated on the basis of investment.

All inventory-related costs must be evaluated when purchasing or production decisions are made. The costs of ordering and carrying inventory offset each other when estimating the economic order quantity.

Molly Memories uses 80,000 pounds of a particular plastic in producing the Molly Memories' dolls. The cost associated with placing each order is $12.25. The carrying cost of 1 pound of the plastic is $1.00 per period. Therefore, Molly Memories' EOQ for this plastic is calculated as follows:

$$EOQ = \sqrt{(2 \times 80,000 \times \$12.25) \div \$1.00}$$
$$= 1,400 \text{ pounds}$$

Economic Production Run

In a manufacturing company, managers are concerned with how many units to produce in a batch in addition to how many units (of raw material) to buy. The EOQ formula can be modified to calculate the appropriate number of units to manufacture in an **economic production run** (EPR). This estimate reflects the production quantity that minimizes the total costs of setting up a production run and carrying a unit in stock for one year. The only change in the EOQ formula is that the terms of the equation are redefined as manufacturing, rather than purchasing, costs. The formula is

economic production run

$$EPR = \sqrt{\frac{(2QS)}{C}}$$

where EPR = economic production run quantity

Q = estimated annual quantity to be produced in units
(can be found in annual production budget)

S = estimated cost of setting up a production run

C = estimated cost to carry one unit in stock for one year

Another product manufactured by Molly Memories is a doll crib. A total of 162,000 units of this product are made each year. The setup cost for a doll crib production run is $40 and the annual carrying cost for each doll crib is $4. The economic production run quantity of 1,800 doll cribs is determined as

$$EPR = \sqrt{(2 \times 162,000 \times \$40) \div \$4}$$

The cost differences among various run sizes around the EPR may not be significant. If such costs were insignificant, management would have a range of acceptable, economical production run quantities.

The critical element in using either an EOQ or EPR model is to properly identify costs. Identifying all the relevant inventory costs (especially carrying costs) is very difficult, and some costs (such as those for facilities, operations, administration, and accounting) traditionally viewed as irrelevant fixed costs may, in actuality, be long-term relevant variable costs. The EOQ model also does not provide any direction for managers attempting to control all of the separate costs that collectively comprise purchasing and carrying costs. By only considering the trade-off between ordering and carrying costs, the EOQ model does not lead managers to consider inventory management alternatives that may simultaneously reduce both categories of costs.

Additionally, as companies significantly reduce the necessary setup time (and thus cost) for operations and move toward a "stockless" inventory policy, a more comprehensive cost perspective will indicate a substantially smaller cost per setup and a substantially larger annual carrying cost. If the setup and carrying cost information given for Molly Memories were reversed, the EPR would be only 180 units. Using either a new perspective of variable cost or minimizing setup cost will provide much lower economic order or production run quantities than indicated in the past.

Order Point and Safety Stock

The economic order quantity or production run model indicates how many units to order or produce. But managers are also concerned with the **order point**. This quantity reflects the level of inventory that triggers the placement of an order for additional units. Determination of the order point is based on three factors: usage, lead time, and safety stock. **Usage** refers to the quantity of inventory used or sold each day. The **lead time** for an order is the time in days it takes from the placement of an order to when the goods arrive or are produced. Many times companies can project a constant, average figure for both usage and lead time. The quantity of inventory kept on hand by a company in the event of fluctuating usage or unusual delays in lead time is called **safety stock**.

order point

usage
lead time

safety stock

If usage is entirely constant and lead time is known with certainty, the order point is equal to daily usage multiplied by lead time:

Order point = Daily usage × Lead time

As an example, assume that Molly Memories produces rhinestone tiaras for sale to chain department stores. Molly Memories uses 400 rhinestones per day, and the supplier can have the stones to Molly Memories in four days. When the stock of rhinestones reaches 1,600 units, Molly Memories should reorder.

The order point formula minimizes the dollars a company has invested in its inventory. Orders would arrive at precisely the time the inventory reached zero. This formula, however, does not take into consideration unusual events such as variations in production schedules, defective products being provided by suppliers, erratic shipping schedules of the supplier, or late arrival of units shipped. To provide for these kinds of events, managers carry a "buffer" safety stock of inventory to protect the company from stockouts. When a safety stock is maintained, the order point formula becomes:

$$\text{Order point} = (\text{Daily usage} \times \text{Lead time}) + \text{Safety stock}$$

Safety stock size should be determined based on how crucial the item is to production or to the retail business, the item's purchase cost, and the amount of uncertainty related to both usage and lead time.

One way to estimate the quantity of safety stock is to allow one factor to vary from the norm. For example, either excess usage during normal lead time or normal usage during an excess lead time can be considered in the safety stock calculation. Assume that Molly Memories never uses more than 500 rhinestones in one day. One estimate of the necessary safety stock is 400 stones, computed as follows:

Maximum daily usage	500	stones
Normal daily usage	(400)	stones
Excess usage	100	stones
Lead time	× 4	days
Safety stock	400	stones

Using this estimate of safety stock, Molly Memories would reorder rhinestones when 2,000 stones (1,600 original order point + 400 safety stock) were on hand.

Pareto Inventory Analysis

Unit cost commonly affects the degree of control that should be maintained over an inventory item. As unit cost increases, internal controls (such as inventory access) are typically tightened and a perpetual inventory system is more often used. Recognition of cost-benefit relationships may result in a **Pareto inventory analysis**, which separates inventory into three groups based on annual cost-to-volume usage.

Items having the highest value are referred to as A items; C items represent the lowest dollar volume usage. All other inventory items are designated as B items. Exhibit 16–16 provides the results of a typical Pareto inventory analysis—20 percent of the inventory items (A items) accounts for 80 percent of the cost; an additional 30 percent of the items (B items), taken together with the first 20 percent (the A items), accounts for 90 percent of the cost; and the remaining 50 percent of the items (C items) accounts for the remaining 10 percent of the cost.

Once inventory is categorized as A, B, or C, management can determine the best inventory control method for items in each category. A-type inventory should require a perpetual inventory system and would be a likely candidate for just-in-time purchasing techniques that minimize the funds tied up in inventory investment. The highest control procedures would be assigned to these items. Such a treatment reflects the financial accounting concept of materiality.

Items falling into the C category may need only periodic inventory procedures and may use a two-bin or red-line system. Under a **two-bin system**, one container (or stack) of inventory is available for production needs. When production

Pareto inventory analysis

two-bin system

begins to use materials in the second bin, a purchase order is placed to refill the first bin. In a **red-line system**, a red line is painted on the inventory container at the point at which to reorder. Both systems require that production needs and estimates of receipt time from suppliers be fairly accurate.

    Having the additional container or stack of inventory on hand is considered to be reasonable based on the insignificant dollar amount of investment involved with C category items. The degree of control placed on C items will probably be minimal because of the lack of materiality of the inventory cost. The type of inventory system (perpetual or periodic) and level of internal controls associated with items in the B category will depend on management's judgment. Such judgment will be based on significance of the item to the production process, quickness of response time of suppliers, and estimates of benefits to be gained by increased accounting or access controls. Computers and bar coding have made additional controls over inventory easier and more cost beneficial.

red-line system

KEY TERMS

autonomation (p. 730)
backflush costing (p. 736)
bar code (p. 715)
bottleneck (p. 740)
carrying cost (p. 717)
computer-integrated manufacturing
    (p. 739)
constraint (p. 740)
cost table (p. 719)
design for manufacturability (p. 739)
economic order quantity (p. 744)
economic production run (p. 744)

electronic data interchange (p. 715)
flexible manufacturing system (p. 739)
focused factory arrangement (p. 732)
Internet business model (p. 731)
just-in-time (p. 723)
just-in-time manufacturing system
    (p. 723)
just-in-time training (p. 732)
kaizen costing (p. 721)
kanban (p. 723)
lead time (p. 745)
life-cycle costing (p. 723)

SOLUTION STRATEGIES

Target Costing

$$\text{Target cost} = \text{Expected long-range selling price} - \text{Desired profit}$$

Compare predicted total life-cycle cost to target cost; if life-cycle cost is higher, determine ways to reduce life-cycle cost.

Material and Labor Variances under JIT
Two standards may exist:

1. an annual standard (set and held constant for the year) or
2. a current standard (based on design modifications or engineering changes).

Generally firms will have minimal, if any, material price variances because prices are set by long-term contracts. A labor rate variance may exist and would be calculated in the traditional manner.

Material Quantity Variance
    Actual material cost
− Material cost at current standard
    Material quantity variance

Engineering Change Variance for Material
    Material cost at annual standard
− Material cost at current standard
    ENC variance

Labor Efficiency Variance
    (Actual labor hours × current standard rate)
− (Standard labor hours × current standard rate)
    Labor efficiency variance

Engineering Change Variance for Labor
(Would exist only if a change occurred in the mix of labor used to manufacture the product or through the automation of processes.)

    (Standard labor hours × annual standard rate)
− (Standard labor hours × current standard rate)
    ENC variance

Economic Order Quantity

$$EOQ = \sqrt{(2QO) \div C}$$

where EOQ = economic order quantity in units

Q = estimated annual quantity to be used in units

O = estimated cost of placing one order

C = estimated cost to carry one unit in stock for one year

Economic Production Run

$$EPR = \sqrt{(2QS) \div C}$$

where EPR = economic production run quantity

Q = estimated annual quantity to be produced in units

S = estimated cost of setting up a production run

C = estimated cost to carry one unit in stock for one year

Order Point

Order point = (Daily usage × Lead time) + Safety stock

DEMONSTRATION PROBLEM

Free Enterprise Manufacturing Company (FEM) has designed a new doll that is expected to have a five-year life cycle. Based on its market research, management at FEM has determined that the new doll could sell for $175 in the first three years and $100 during the last two years. Unit sales are expected as follows:

Year 1	3,000 units
Year 2	4,500 units
Year 3	4,800 units
Year 4	5,000 units
Year 5	1,500 units

Variable selling costs are expected to be $15 per doll throughout the product's life. Annual fixed selling and administrative costs of $200,000 are expected. FEM desires a 25 percent profit margin on selling price.

Required:
a. Compute the life-cycle target cost to manufacture the product. (Round to the nearest penny.)
b. If FEM anticipates the doll to cost $52 to manufacture in the first year, what is the maximum that manufacturing cost can be in the following four years? (Round to the nearest penny.)
c. Suppose that engineers at FEM determine that expected manufacturing cost per doll is $50. What actions might the company take to reduce this cost?

Solution to the Demonstration Problem
a. Step 1—Determine total product life revenue:

Year 1	3,000 × $175 =	$ 525,000
Year 2	4,500 × $175 =	787,500
Year 3	4,800 × $175 =	840,000
Year 4	5,000 × $100 =	500,000
Year 5	1,500 × $100 =	150,000
Total Revenue		$2,802,500

Step 2—Determine average product life revenue (AR):

$$AR = \text{Total revenue} \div \text{Total product life units}$$
$$= \$2{,}802{,}500 \div 18{,}800 \text{ units}$$
$$= \underline{\$149.07}$$

Step 3—Determine average total fixed selling and administrative cost (ATFS&A):

$$ATFS\&A = (5 \text{ years} \times \$200{,}000) \div 18{,}800 \text{ units}$$
$$= \underline{\$53.19}$$

Step 4—Determine unit selling and administrative cost (US&AC):

$$US\&AC = ATFS\&A + \text{Variable selling cost}$$
$$= \$53.19 + \$15$$
$$= \underline{\$68.19}$$

Step 5—Calculate target cost (TC):

$$TC = AR - 0.25(AR) - US\&AC$$
$$= \$149.07 - \$37.27 - \$68.19$$
$$= \underline{\$43.61}$$

b. Step 1—Determine total allowable cost over product life:

$$18{,}800 \text{ units} \times \$43.61 = \$819{,}868$$

Step 2—Determine expected cost in first year equals unit cost × unit sales:

$$= \$52 \times 3{,}000 \text{ units}$$
$$= \underline{\$156{,}000}$$

Step 3—Determine allowable unit cost in last 4 years:

$$(\$819{,}868 - \$156{,}000) \div 15{,}800 \text{ units} = \underline{\$42.02}$$

c. The following actions are potential options for the company:
- Product design and/or production processes can be changed to reduce costs. Cost tables may be used that provide information on the impact of using different input resources, processes, or design specifications.
- The 25 percent acceptable profit margin can be reduced.
- FEM can suspend consideration of the project at the present time.

QUESTIONS

1. What are the important relationships in a value chain and how can they be beneficially exploited?

2. What are the three basic costs associated with inventory? Explain each and give examples.

3. What are the differences between push and pull systems of production?

4. What is the relationship between ordering costs and setup costs?

5. How have advances in information technology affected the purchasing function? Give four examples and briefly describe each.

6. What is a stockout? What costs are associated with a stockout?

7. Does the product life-cycle stage have a bearing on production cost management? Explain.

8. What are the five stages in the product life cycle and why is each important?

9. Why do costs, sales, and profits change over the product life cycle?

10. What is target costing and how is it useful in assessing a product's total life-cycle costs?

11. Does target costing require that profitability be viewed on a period-by-period basis or on a long-term basis? Explain.

12. From a marketing standpoint, why can some companies (such as Seiko) introduce products with little or no product research while other companies cannot?

13. Why would a cost table be a valuable tool in designing a new product or service?

14. What is kaizen costing and how does it differ from target costing?

15. Discuss the concept of substitute goods and why these would affect pricing.

16. How would focusing on total life-cycle costs call for a different treatment of research and development costs than is made for financial accounting?

17. What are the primary goals of a JIT philosophy and how does JIT attempt to achieve these goals?

18. What kinds of changes need to occur in a production environment to effectively implement JIT? Why are these changes necessary? Is JIT a push or a pull system?

19. "JIT cannot be implemented as effectively in the United States as it can be in Japan." Discuss the rationale behind this statement.

20. How can the JIT philosophy be used by nonmanufacturers?

21. Describe the production system found in a "lights-out" environment.

22. How would switching from a traditional manufacturing system to a flexible manufacturing system affect a firm's inventory and production control systems?

23. In what areas of accounting can a company implementing a JIT manufacturing system expect changes? Why will such changes arise? Why is backflush costing used in JIT environments?

24. What is meant by the theory of constraints? How is this concept appropriate for manufacturing and service companies?

25. Why should quality control inspection points be placed in front of bottleneck operations?

26. *(Appendix)* How do ordering costs and carrying costs relate to one another?

27. *(Appendix)* How are economic order quantity and order point related?

28. *(Appendix)* What is safety stock and why is it necessary?

29. *(Appendix)* What is Pareto inventory analysis? Why do A items and C items warrant different inventory control methods? What are some methods that can be employed to control C items?

30. *(Appendix)* How and why is the cost of capital used in economic order quantity computations?

31. *(Appendix)* You own a manufacturing company and your friend Joe owns a retail appliance store. Joe is concerned about how many VCRs to order at a time. You proceed to tell him about using economic production runs at your company. How do EPRs relate to Joe's concerns? What adjustments must he make to the formula you use?

EXERCISES

32. *(Terminology)* Match the lettered terms on the left with the numbered descriptions on the right. A letter may be used more than once.

a.	Autonomation	**1.**	Expected selling price less desired profit
b.	Electronic data interchange		
c.	Flexible manufacturing system	**2.**	A system in which inventory is produced before it is needed and placed in storage until needed
d.	Just-in-time		
e.	Multiprocess handling		
f.	Order point	**3.**	Streamlined accounting system
g.	Pull system	**4.**	The situation of not having a product or component available when it is needed
h.	Push system		
i.	Safety stock		
j.	Stockout	**5.**	A manufacturing environment in which machinery is programmed to stop work when specified situations arise
k.	Target cost		
l.	Backflush		

6. The use of machines and robots to perform the production process

7. The broadening of worker involvement to include monitoring all machines in a manufacturing cell

8. Computer-to-computer transfer of information in virtual real time using standardized formats developed by the American National Standards Institute.

9. A buffer supply of inventory that minimizes the possibility of running out of a product or component

10. A system in which purchases and production are made only on an as-needed basis

11. A philosophy that focuses on value-added activities

12. The inventory level at which a purchase order is to be issued

33. *(Cost classification)* For each of the following costs, indicate whether it would be considered an ordering cost (O), a carrying cost (C), or a cost of not carrying (N) inventory. For any costs that do not fit these categories, indicate N/A for "not applicable."

1. Telephone call to supplier

2. Stationery and purchase order forms

3. Purchasing agent's salary

4. Purchase price of product

5. Goodwill of customer lost due to unavailability of product

6. Postage on purchase order

7. Freight-in cost on product

8. Insurance for products on hand

9. Wages of receiving clerks

10. Preparing and issuing checks to suppliers

11. Contribution margin lost due to unavailability of product

12. Storage costs for products on hand

13. Quantity discounts on products ordered

14. Opportunity cost of funds invested in inventory

15. Property taxes on warehouses

16. Handling costs for products on hand

17. Excess ordering and shipping charges for rush orders of standard product lines

18. Spoilage of products awaiting use

34. *(Carrying costs)* Determine the carrying costs for an item costing $4.30, given the following per-unit cost information:

Storage cost	$0.04
Handling cost	0.03
Production labor cost	0.80
Insurance cost	0.02
Opportunity cost	10% of investment

35. *(Target costing)* Millennium Attire has developed a new material that has significant potential in the manufacture of sports caps. The firm has conducted significant market research and estimated the following pattern for sales of the new caps:

Year	Expected Volume	Expected Price per Unit
1	16,000 units	$7
2	40,000 units	8
3	70,000 units	6
4	30,000 units	5

If the firm desires to net $1.50 per unit in profit, what is the target cost to produce the new caps?

36. *(Target costing)* The marketing department at Walters Production Company has an idea for a new product that is expected to have a life cycle of five years. After conducting market research, the company has determined that the product could sell for $250 per unit in the first three years of life and $175 per unit for the last two years. Unit sales are expected as follows:

Year 1	3,000 units
Year 2	4,600 units
Year 3	4,700 units
Year 4	5,000 units
Year 5	1,500 units

Per-unit variable selling costs are estimated at $30 throughout the product's life; annual fixed selling and administrative costs are expected to be $1,750,000. Walters Production Company desires a profit margin of 20 percent of selling price per unit.

a. Compute the life-cycle target cost to manufacture the product. (Round to the nearest penny.)

b. If the company expects the product to cost $65 to manufacture in the first year, what is the maximum that manufacturing cost can be in the following four years? (Round to the nearest penny.)

c. Assume Walters Production Company engineers indicate that the expected manufacturing cost per unit is $70. What actions might the company take to reduce this cost?

37. *(Target costing)* Pickles Corporation is in the process of developing an outdoor power source for various electronic devices used by campers. Market research has indicated that potential purchasers would be willing to pay $175 per unit for this product. Company engineers have estimated first-year production costs would amount to $180 per unit. On this type of product, Pickles would

normally expect to earn $10 per unit in profits. Using the concept of target costing, write a memo that (1) analyzes the prospects for this product and (2) discusses possible organizational strategies.

38. *(JIT variances)* James Company uses a JIT system. The following standards are related to Materials A and B, which are used to make one unit of the company's final product:

Annual Material Standards

6 pounds of material A @ $2.25	$13.50
8 pounds of material B @ $3.40	27.20
	$40.70

Current Material Standards

7 pounds of material A @ $2.25	$15.75
7 pounds of material B @ $3.40	23.80
	$39.55

The current material standards differ from the original because of an engineering change made near the end of June. During July, the company produced 3,000 units of its final product and used 22,000 pounds of Material A and 20,500 pounds of Material B. All material is acquired at the standard cost per pound.
  a. Calculate the material variance and the ENC material variance.
  b. Explain the effect of the engineering change on product cost.

39. *(JIT variances)* Erica Tommasen uses a JIT system in her manufacturing firm, which makes "Mew" for cats. Erica provides you with the following standards for a can of Mew:

Annual Material Standards

5 ounces of component X @ $0.10	$0.50
1 ounce of component Y @ $0.25	0.25
	$0.75

Current Material Standards

4 ounces of component X @ $0.10	$0.40
2 ounces of component Y @ $0.25	0.50
	$0.90

The standards were changed because of a nutritional (engineering) adjustment. Production during March was 60,000 cans of Mew. Usage of raw material (all purchased at standard costs) was 250,000 ounces of Component X and 108,000 ounces of Component Y.
  a. Calculate the material quantity variance for each component.
  b. Calculate the engineering change variance for each component.
  c. Why would a company implement an engineering change that increases the standard production cost by 20 percent?

40. *(Backflush costing)* Kuchen Manufacturing uses backflush costing to account for an electronic meter it makes. During August 2001, the firm produced 16,000 meters, of which it sold 15,800. The standard cost for each meter is

Direct material	$20
Conversion costs	44
Total cost	$64

Assume that the firm had no inventory on August 1. The following events took place in August:

1. Purchased $320,000 of direct material.
2. Incurred $708,000 of conversion costs.
3. Applied $704,000 of conversion costs to Raw and In Process Inventory.
4. Finished 16,000 meters.
5. Sold 15,800 meters for $100 each.

a. Prepare journal entries using backflush costing with a minimum number of entries.
b. Post the amounts in part (a) to T-accounts.
c. Explain any inventory account balances.

41. *(Production constraints)* Office Superstore produces commercial calendars in a two-department operation: Department 1 is labor intensive and Department 2 is automated. The average output of Department 1 is 45 units per hour. The units are then transferred to Department 2 where they are finished by a robot. The robot can finish a maximum of 45 units per hour. Office Superstore needs to complete 180 units this afternoon for an order that has been backlogged for four months. The production manager has informed the people in Department 1 that they are to work on nothing else except this order from 1 p.m. until 5 p.m. The supervisor in Department 2 has scheduled the same times for the robot to work on the order. Department 1's activity for each hour of the afternoon follows:

Time	1:00–2:00	2:00–3:00	3:00–4:00	4:00–4:58
Production	44 units	40 units	49 units	47 units

Assume that each unit moves directly from Department 1 to Department 2 with no lag time. Did Office Superstore complete the 180 units by 5:00 p.m.? If not, explain and provide detailed computations.

42. *(Carrying cost)* Feline Delights manufactures a variety of pet food products from dried seafood "pellets." The firm has determined that its EOQ is 20,000 pounds of pellets. Based on the EOQ, the firm's annual ordering costs for pellets is $12,700. Given this information, what is the firm's annual carrying cost of pellets? Explain.

43. *(Appendix: Multiproduct EOQs)* A drugstore carries three types of face cream: Wonder Cream, Skin-so-Bright, and Fresh & Sweet. Determine the economic order quantity for each, given the following information:

Product	Order Cost	Carrying Cost	Demand
Wonder Cream	$4.30	$1.90	1,200 units
Skin-so-Bright	6.25	1.45	1,000 units
Fresh & Sweet	3.70	1.25	900 units

44. *(Appendix: Product demand)* Compute the annual estimated demand if the economic order quantity for a product is 78 units; carrying cost is $0.65 per unit; and ordering cost is $3.04 per order.

45. *(Appendix: EPR)* Lars Gonzalez has taken a new job as production superintendent in a plant that makes briefcases. He is trying to determine how many cases to produce on each production run. Discussions reveal that last year the plant made 2,500 such cases, and this level of demand is expected for the coming year. The setup cost of each run is $200, and the cost of carrying a case in inventory for a year is estimated at $5.
a. Calculate the economic production run (EPR) and the total cost associated with it.
b. Recalculate the EPR and total cost if the annual cost of carrying a case in inventory is $10 and the setup cost is $20.

46. *(Appendix: EPR)* Johns Company manufactures parts to be sold to other companies. Part No. 48 has the following data related to its production:

Annual quantity produced in units	3,200
Cost of setting up a production run	$200
Cost of carrying one unit in stock for a year	$2

Calculate the economic production run for Part No. 48.

47. *(Appendix: EPR)* Mohawk Manufacturing requires 10,000 castings a year for use in assembling lawn and garden tractors. The foundry can produce 30,000 castings a year. The cost associated with setting up the production line is $25, and the carrying cost per unit is $2 annually. Lead time is 60 days.
   a. Find the production quantity that minimizes cost.
   b. Calculate the total annual cost of setting up for and carrying inventory, based on the answer to part (a) for a year.

48. *(Appendix: EOQ, number of orders)* Jonathan Jingles is a wholesale distributor of videotapes. He sells approximately 9,000 tapes every year. He estimates that it costs $0.25 per tape to carry inventory for 12 months and it costs $15 each time he orders tapes from the factory.
   a. How many tapes should he order to minimize costs?
   b. Based on the order size computed in part (a), how many orders will he need to place each year?
   c. Based on your answer to part (b), at what time interval will Jonathan be placing orders for videotapes?

PROBLEMS

49. *(Identification of carrying, ordering costs)* Catalina Metal Works has been evaluating its policies with respect to control of costs of metal tubing, one of the firm's major component materials. The firm's controller has gathered the following financial data, which may be pertinent to controlling costs associated with the metal tubing:

Ordering Costs

Annual salary of purchasing department manager	$41,500
Depreciation of equipment in purchasing department	$22,300
Cost per order for purchasing department supplies	$0.30
Typical phone expense per order placed	$30.20
Monthly expense for heat and light in purchasing department	$400

Carrying Costs

Annual depreciation on materials storage building	$15,000
Annual inventory insurance premium (per dollar of inventory value)	$0.05
Annual property tax on materials storage building	$2,500
Obsolescence cost per dollar of average annual inventory	$0.07
Annual salary of security officer assigned to the materials storage building	$18,000

   a. Which of the ordering costs would Catalina's controller take into account in performing short-run decision analysis? Explain.
   b. Which of the carrying costs would Catalina's controller take into account in performing short-run decision analysis? Explain.

50. *(Life-cycle costing)* The Products Development Division of Lite & Fine Cuisine has just completed its work on a new microwave entrée. The marketing group has decided on an original price for the entrée, but the selling price will be reduced as competitors appear. Market studies indicate that the following quantities of the product can be sold at the following prices over its life cycle:

Year	Quantity	Selling Price	Year	Quantity	Selling Price
1	100,000	$2.50	5	600,000	$2.00
2	250,000	2.40	6	450,000	2.00
3	350,000	2.30	7	200,000	1.90
4	500,000	2.10	8	130,000	1.90

Development costs plus other startup costs for this product will total $600,000. Engineering estimates of direct material and direct labor costs are $0.85 and $0.20, respectively, per unit. These costs can be held constant for approximately four years and in year 5 will each increase by 10 percent. Variable overhead per unit is expected to be $0.25, and fixed overhead is expected to be $100,000 per year. Lite & Fine Cuisine management likes to earn a 20 percent gross margin on products of this type.

a. Prepare an income statement for each year of the product's life, assuming all product costs are inventoried and using eight-year amortization of the development and startup costs. What is the cost per unit each year? What rate of gross margin will the product generate each year?

b. Determine the total gross margin to be generated by this product over its life. What rate of gross margin is this?

c. Discuss the differences in the information provided by the analyses in parts (a) and (b).

51. *(Just-in-time features)* Given the features below concerning just-in-time systems, indicate by letter which of the three categories apply to the following items. If more than one category applies, indicate with an additional letter.

D = desired intermediate result of using JIT
U = ultimate goal of JIT
T = technique associated with JIT

a. Reducing setup time
b. Reducing total cost of producing and carrying inventory
c. Using focused factory arrangements
d. Designing products to minimize design changes after production starts
e. Monitoring quality on a continuous basis
f. Using manufacturing cells
g. Minimizing inventory stored
h. Measuring variances caused by engineering changes
i. Using autonomation processes
j. Pulling purchases and production through the system based on sales demand

52. *(JIT journal entries)* Brandt Production Company has implemented a just-in-time inventory system for the production of its insulated wire. Inventories of raw material and work in process are so small that Brandt uses a Raw and In Process account. In addition, almost all labor operations are automated and Brandt has chosen to cost products using standards for direct material and conversion. The following production standards are applicable at the beginning of 2000 for one roll of insulated wire:

Direct material (100 yards @ $2.00)	$200
Conversion (4 machine hours @ $35)	140
Total cost	$340

The conversion cost of $35 per machine hour was estimated on the basis of 500,000 machine hours for the year and $17,500,000 of conversion costs. The following activities took place during 2000:

1. Raw material purchased and placed into production totaled 12,452,000 yards. All except 8,000 yards were purchased at the standard price of $2 per yard. The other 8,000 yards were purchased at a cost of $2.06 per yard

due to the placement of a rush order. The order was approved in advance by management. All purchases are on account.

2. From January 1 to February 28, Brandt manufactured 20,800 rolls of insulated wire. Conversion costs incurred to date totaled $3,000,000. Of this amount, $600,000 was for depreciation, $2,200,000 was paid in cash, and $200,000 was on account.

3. Conversion costs are applied to the Raw and In Process account from January 1 to February 28 on the basis of the annual standard.

4. The Engineering Department issued a change in the operations flow document effective March 1, 2000. The change decreased the machine time to manufacture one roll of wire by 5 minutes per roll. However, the standard raises the quantity of direct material to 100.4 yards per roll. The Accounting Department requires that the annual standard be continued for costing the Raw and In Process Inventory for the remainder of 2000. The effects of the engineering changes should be shown in two accounts: Material Quantity Engineering Change Variance and Machine Hours Engineering Change Variance.

5. Total production for the remainder of 2000 was 103,200 rolls of wire. Total conversion costs for the remaining 10 months of 2000 were $14,442,000. Of this amount, $4,000,000 was depreciation, $9,325,000 was paid in cash, and $1,117,000 was on account.

6. The standard amount of conversion cost is applied to the Raw and In Process Inventory for the remainder of the year.

Note: Some of the journal entries for the following items are not explicitly covered in the chapter. This problem challenges students regarding the accounting effects of the implementation of a JIT system.

a. Prepare entries for items 1, 2, 3, 5, and 6 above.

b. Determine the increase in material cost due to the engineering change related to direct material.

c. Prepare a journal entry to adjust the Raw and In Process Inventory account for the engineering change cost found in part (b).

d. Determine the reduction in conversion cost due to the engineering change related to machine time.

e. Prepare a journal entry to reclassify the actual conversion costs by the savings found in part (d).

f. Making the entry in part (e) raises conversion costs to what they would have been if the engineering change related to machine time had not been made. Are conversion costs under- or overapplied and by what amount?

g. Assume the reduction in machine time could not have been made without the corresponding increase in material usage. Is the net effect of these engineering changes cost beneficial? Why?

53. *(Appendix: EOQ)* Andrew Jackson operates a health food bakery that uses a special type of ground flour in its products. The bakery operates 365 days a year. Andrew finds that he seems to order either too much or too little flour and asks for your help. After some discussion, you find he does not have any idea of when or how much to order. An examination of his records and Andrew's answers to further questions reveal the following information:

Annual usage of flour	14,000 pounds
Average number of days delay between initiating and receiving an order	12
Estimated cost per order	$8.00
Estimated annual cost of carrying a pound of flour in inventory	$0.25

a. Calculate the economic order quantity for flour.

b. Assume that Andrew desires a safety stock cushion of seven days' usage. Calculate the appropriate order point.

54. *(Appendix: EPR)* The Town and Country Nursery grows and sells a variety of household and outdoor plants. The firm also grows and sells garden vegetables. One of the more popular vegetables grown by the firm is a red onion. The company sells approximately 30,000 pounds of red onions per year. Two of the major inputs in the growing of onions are seeds and fertilizer. Due to the poor germination rate, two seeds must be purchased for each onion plant grown (a mature onion plant provides 0.5 pound of onion). Also, 0.25 pound of fertilizer is required for each pound of onion produced. The following information summarizes costs pertaining to onions, seeds, and fertilizer. Carrying costs for onions are expressed per pound of onion; carrying costs for seeds are expressed per seed; and for fertilizer, carrying costs are expressed per pound of fertilizer. To plant onions, the company incurs a cost of $50 to set up the planter and the fertilizing equipment.

	Onions	Seeds	Fertilizer
Carrying cost	$0.25	$0.01	$0.05
Ordering cost	—	$4.25	$8.80
Setup cost	$50.00	—	—

a. What is the economic production run for onions?
b. How many production runs will Town and Country make for onions annually?
c. What are the economic order quantities for seeds and fertilizer?
d. How many orders will be placed for seeds? For fertilizer?
e. What is the total annual cost of ordering, carrying, and setting up for onion production?
f. How is the planting of onions similar to and different from a typical factory production run?
g. Are there any inconsistencies in your answers to parts (a) through (c) that need to be addressed? Explain.

CASE

55. *(Using EOQ for cash/securities management)* Chemcon Corporation sells various industrial supplies used for general-purpose cleaning. Approximately 85 percent of its sales are to not-for-profit and governmental institutions. These sales are on a contract basis with an average contract length of two years. Al Stanly, Chemcon's treasurer, wants to initiate a system that will maximize the amount of time Chemcon holds its cash in the form of marketable securities. Chemcon currently has $9 million of securities that have an expected annual earnings rate of 8 percent. Chemcon is expecting a cash drain over the next 12-month period. Monthly cash outflows are expected to be $2,650,000, but inflows are only expected to be $2,500,000. The cost of either buying or selling securities is $125 per transaction. Stanly has heard that the EOQ inventory model can be applied to cash management. Therefore, he has decided to employ this model to determine the optimal value of marketable securities to be sold to replenish Chemcon's cash balance.

a. Use the EOQ model in the chapter to
  (1) explain the costs Al Stanly is attempting to balance in this situation, and
  (2) calculate the optimal dollar amount of marketable securities Stanly should sell when Chemcon needs to replenish its cash balance.

(continued)
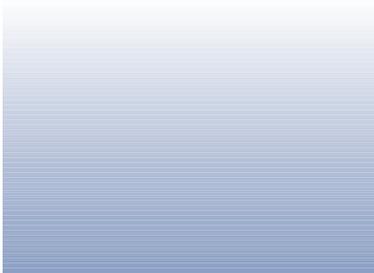
b. Without prejudice to your solution in part a(2), assume that the optimal dollar amount of marketable securities to be sold is $60,000.

    (1) Calculate the average cash balance in Chemcon's checking account that will be on hand during the course of the year.

    (2) Determine the number of times during the year that Stanly will have to sell securities.

c. Describe two different economic circumstances applicable to Chemcon that would render its use of the EOQ inventory model inappropriate as a cash management model.   *(CMA adapted)*

REALITY CHECK

56. The Smith Company manufactures various electronic assemblies that it sells primarily to computer manufacturers. Smith's reputation has been built on quality, timely delivery, and products that are consistently on the cutting edge of technology. Smith's business is fast paced. The typical product has a short life; the product is in development for about a year and in the growth stage, with sometimes spectacular growth, for about a year. Each product then experiences a rapid decline in sales as new products become available.

Smith's competitive strategy requires a reliable stream of new products to be developed each year. This is the only way that the company can overcome the threat of product obsolescence. Although the products go through the first half of the product life cycle like products in other industries, they do not go through the second half of the product life cycle in a similar manner. Smith's products never reach the mature product or declining product stage. Toward the end of the growth stage, products just die as new ones are introduced.

a. In the competitive market facing Smith Company, what would be key considerations in production and inventory control?

b. How would the threat of immediate product obsolescence affect Smith's practices in purchasing product components and materials?

c. How would the threat of product obsolescence affect the EPR for a typical product produced by Smith Company?   *(CMA adapted)*

57. The director of supply management at Benson Tool & Die has contracted for $1 million of spare parts that are currently unneeded. His rationale for the contract was that the parts were available for purchase at a significantly reduced price. The company just hired a new president who, on learning about the contracts, stated that the parts contracts should be canceled because the parts would not be needed for at least a year. The supply director informed the president that the penalties for canceling the contracts would cost more than letting the orders go through. How would you respond to this situation from the standpoint of the president? From the standpoint of the supply director?

58. A plant manager and her controller were discussing the plant's inventory control policies one day. The controller suggested to the plant manager that the ordering policies needed to be reviewed because of new technology that had been put in place in the plant's purchasing department. Among the changes that had been implemented in the plant were installation of (1) computerized inventory tracking, (2) electronic data interchange capabilities with the plant's major suppliers, and (3) in-house facilities for electronic fund transfers.

a. As technology changes, why should managers update ordering policies for inventory?

b. Write a memo to the plant manager describing the likely impact of the changes made in this plant on the EOQ of material input.

59. Johnson Manufacturing Company began implementing a just-in-time inventory system several months ago. The production and purchasing managers, however, have not seen any dramatic improvements in throughput. They have decided that the problems are related to their suppliers. The suppliers (there are three) seem to send the wrong materials at the wrong times. Prepare a discussion of the problems that might exist in this situation. Be certain to address the following items: internal and external communications; possible engineering changes and their impacts; number, quality, and location of suppliers; and length of system implementation.

60. According to Barry Bayus, a marketing professor, the perception that product life cycles are getting shorter is a mistaken one. Bayus identified three reasons for the appearance of shortened product life cycles:

  1. New knowledge is being applied faster. The time between an invention and its first application is decreasing, from 90 years during the 1700s to 20 years from 1901 to 1950.
  2. More new products are being introduced. In 1986, for example, the number of new-product introductions was just under 13,000. By 1991, the number had increased to more than 15,000.
  3. The time between innovations is decreasing.

  SOURCE: Glenn Rifkin, "The Myth of Short Life Cycles," *Harvard Business Review* (July–August 1994), p. 11.

  a. As a team, investigate the reality or myth of shortened product life cycles. Use all resources (library, Internet, personal) at your disposal.
  b. Prepare a report on your findings.

61. Choose a fast-food restaurant and prepare a report showing how JIT can be used to improve operations.

62. Everyone in your company seems excited about the suggestion that the firm implement a JIT system. Being a cautious person, your company president has asked you to write a report describing situations in which JIT will not work. Prepare such a report.

63. General Motors Corp. is now spending about $1 billion a year to implement "an integrated portfolio of computer math-based tools" to streamline its product design and development processes by eliminating the need for physical models "making it possible to solve manufacturing problems in 'virtual' factories rather than real ones."

  http://www.gm.com

  SOURCE: Adapted from Robert L. Simison, "GM Turns to Computers to Cut Development Costs," *The Wall Street Journal* (October 12, 1998), p. B4.

  Discuss the advantages of spending so much money on this sort of technology.

64. Research the topic of manufacturing cells on the Internet and write a brief report on company experiences using them.

65. Research the topic of value engineering on the Internet and write a brief report on a company or an organization's experiences using this technique.