

Chapter

7

Measuring and Managing Process Performance

After completing this chapter, you will be able to:

1. Explain the theory of constraints.
2. Compare the different types of facilities layouts: process, product, and group technology.
3. Explain lean manufacturing.
4. Describe the concept of the cost of quality.
5. Demonstrate the value of just-in-time manufacturing systems.
6. Explain kaizen costing.
7. Discuss the various kinds of benchmarking approaches.
8. Calculate the cost savings resulting from reductions in inventories, reductions in production cycle time, improvements in production yields, and reductions in rework and defect rates.

Blast from the Past Robot Company

For the past 10 years, the Blast from the Past Robot (BFTPR) Company of Worthington, Ohio, has been producing high-quality reproduction tin toy robots that had originally been produced in Japan during the 1950s and 1960s. Many of these toys such as Robby the Robot and Gort were tied into famous science fiction films such as *Forbidden Planet* and *The Day the Earth Stood Still*.

In today's market, original toy robots cost thousands of dollars and only the most rabid collectors are willing to pay such prices. BFTPR was able to produce reproduction robots that could be purchased often for a fraction of the price of the originals to satisfy those seeking nostalgia on a limited budget.

The company prided itself on faithfully reproducing robots. Using parts from the original robots, the company cast individual pieces and then assembled them. Their best-selling toy was a mechanical toy robot called Mr. Mechanical that performed several functions such as lighting up, moving forward and backward with its arms moving up and down.



Blast from the Past Robot Company's Mr. Mechanical
Photo courtesy of S. Mark Young

The robot, which was also "aged" to look more vintage, was fashioned after the original Robby the Robot from *Forbidden Planet*. It commanded a 40% market share. In early 2011, however, Mr. Mechanical experienced a large drop in sales and market share. After some investigation, this loss was attributed to a significant decrease in the quality of the product and to general delays in getting it to customers. Customers complained that the toy robots failed to perform many of their functions and simply stopped working after several days. The number of returns was astronomical.

Top management decided that the quality of the toy robot needed to be improved dramatically so that the company could regain its reputation and market share. Apparently, the quality problem was due to deterioration of equipment and an out-of-date production process. Morale among the workers was also poor. Neva Dominguez, senior manager of manufacturing, was asked to conduct a thorough investigation and arrive at recommendations for change and improvement.

After several weeks of study, Neva and a cross-functional team of management and shop floor personnel documented numerous shop floor problems:

1. A disorganized, sloppy production system in which piles of both work-in-process and raw materials inventories were scattered over the shop floor
2. A lengthy and complex flow of production
3. The use of outdated machinery.

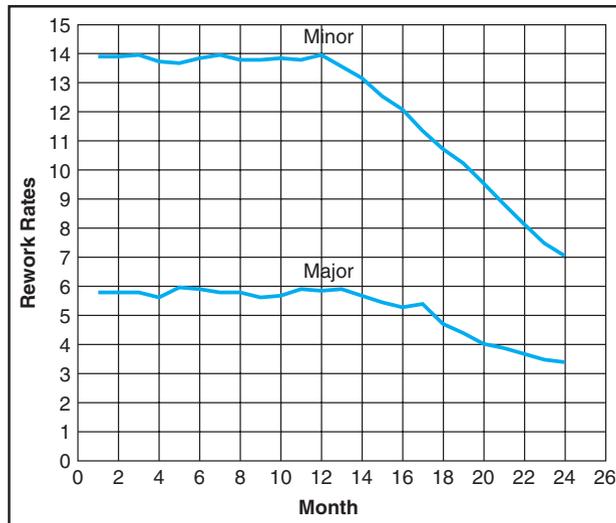
In addition, the quality of the computer chip that allowed the robot to perform its functions was found to be highly variable, and thus there were as many defective robots sent back for rework as acceptable ones. Neva, a proponent of lean manufacturing, a philosophy centered on producing the highest quality product with the lowest level of waste and inefficiency, had just completed a benchmarking study of another company that had implemented the just-in-time (JIT) manufacturing philosophy. She believed that the BFTPR Company could benefit greatly from implementing JIT. The JIT system seemed to have many advantages, such as streamlining the production process and improving facilities layout, eliminating waste, reducing raw and work-in-process inventories, and generally creating an environment in which producing quality products was rewarded. Further, costs would be easier to control if the company had a well-designed and well-understood production process. Neva's report to top management raised several questions:

1. Should many of the existing machines, including the major injection-molding machine, be replaced?
2. What should the company do about the local vendor who produced the faulty computer chips?
3. Would it make sense to implement an entirely new production process such as JIT?

After a month of study, top management decided to implement the JIT approach. The cost of implementation and worker training amounted to \$300,000. Management personnel wanted to be able to assess the return (benefits) from their investment in JIT. They were adamant that Neva and her team carefully monitor the quality of products and the changes in the amount of rework. The cost of rework was part of a calculation the company made to determine what it called the *cost of quality*.

After the first year, Neva plotted a graph of the rates of major rework, which required scrapping the robot, and minor rework, which included repairs such as realignment of parts and gears. The graph is shown in Exhibit 7-1. Major rework had declined by about 2.5%, whereas the minor rework rate showed a larger decrease of 6.6%.

Exhibit 7-1
BFTPR: Major
and Minor
Rework Rates



Neva believed that improvement in yield rates should improve **cycle time**—the time it took to produce the robot from start to finish. On average, she found that cycle time had indeed decreased from 16.4 days to 7.2 days and that the work-in-process inventory had decreased from \$1,774,000 to \$818,000, for a savings of \$956,000.

Neva knew that the transition to a full JIT system would take some time, but she also wondered what the bottom-line effect on company profits would be for the year. Would the benefits of less rework, yield increases, and cycle time and inventory reductions be sufficient to offset the \$300,000 implementation costs?

In this chapter, we will discuss many issues related to how management accounting information is used to measure and manage process decisions. This chapter presents three types of facility designs—(1) process layouts, (2) product layouts, and (3) group technology—all of which can be used to help organizations reduce costs. We follow this with a discussion of how organizations can reduce costs by using a lean manufacturing approach aimed at improving the quality of their processes and reducing cycle time. The JIT manufacturing system, originally developed by Toyota, is presented as a system that integrates many of the ideas we discuss in the chapter. Benchmarking will also be introduced as a way in which organizations can find out what their competition is doing and to take the best methods from what they observe.

PROCESS PERSPECTIVE AND THE BALANCED SCORECARD

As we noted in Chapter 2, the process perspective of the Balanced Scorecard identifies the key operations management, customer management, innovation, and regulatory and social processes in which the organization must excel to achieve its customer, revenue growth, and profitability objectives. In this chapter we discuss the operations management processes that allow organizations to produce products and services and deliver them to customers. Objectives for these processes include streamlining operations through lean manufacturing; improving the cost, quality, and cycle times of processes; and using benchmarking as a way to obtain information for competitive purposes. These tools form the basis of decisions about the organization's activities and processes, as we saw in the case of the BFTPR Company.

FACILITY LAYOUT SYSTEMS

Determining the right kind of facility layout for an operation is a critical part of managing operations. Managers must consider the entire operations process within a facility and consider the amount of space required, the demand for the product or service produced, and the number of operations that are needed. In this section we discuss the three general types of facility designs: (1) process layouts, (2) product layouts, and (3) group technology.

Regardless of the type of facility design, a central goal of the design process is to streamline operations and thus increase the operating income of the system. One method that can guide this process for all three designs is the **theory of constraints (TOC)**.

This theory maintains that operating income can be increased by carefully managing the bottlenecks in a process. A bottleneck is any condition that impedes or constrains the efficient flow of a process; it can be identified by determining points at which excessive amounts of work-in-process inventories are accumulating. The buildup of inventories also slows the cycle time of production.

The TOC relies on the use of three measures: (1) the throughput contribution; (2) investments, and (3) operating costs. The **throughput contribution** is the difference between revenues and direct materials for the quantity of product sold; **investments** equal the materials costs contained in raw materials, work-in-process, and finished goods inventories; and **operating costs** are all other costs, except for direct materials costs, that are needed to obtain throughput contribution. Examples of operating costs are depreciation, salaries, and utility costs.

The TOC emphasizes the short-run optimization of throughput contribution. Its planning horizon is typically one month. For this short time period, almost all of an organization's costs will be fixed and unavoidable, which explains why TOC concentrates on maximizing short-run contribution margin. At first, this seems contrary to the view of activity-based costing (ABC), presented in Chapters 5 and 6, but ABC's planning horizon is quarterly, annually, and longer. For these horizons, managers have the ability to decrease resources that are in excess supply and not needed for current or future production, and also add to the supply of resources that would otherwise create bottlenecks. The ability of managers to adjust resource capacity to meet current and future demands is why ABC treats the resource capacity costs as relevant for decisions about products and customers. In fact, therefore, TOC and ABC are entirely compatible with TOC providing insights for short-run profit optimization and ABC providing managers with signals about how to optimize performance over longer periods of time. In this way, TOC and ABC can be used simultaneously and productively by organizations.

Process Layouts

To understand why inventories stockpile in conventional processing systems and thus increase cycle time, we must understand the conventional way in which factory or office facilities are organized. In a **process layout** (sometimes called a job shop or functional layout), all similar equipment or functions are grouped together. Process layouts exist in organizations in which production is done in small batches of unique products. The product follows a serpentine path, usually in batches, through the factories and offices that create it. In addition to these long production paths, process layouts are also characterized by high inventory levels because it is necessary to store work in process in each area while it awaits the next operation. Often a product can travel for several miles within a factory as it is transformed from raw materials to finished goods.

For example, the process associated with a loan application at a bank may occur as follows: The customer goes to the bank (a moving activity). The bank takes the loan application from the customer (a processing activity). Loan applications are accumulated (a storage activity) and passed to a loan officer (a moving activity) for approval (both a processing and an inspection activity). Loans that violate standard loan guidelines are accumulated (a storage activity) and then passed (a moving activity) to a regional supervisor for approval (a processing activity). The customer is contacted when a decision has been made (a processing activity), and if the loan is approved, then the loan proceeds are deposited in the customer's account (a processing activity).

In most banks, work in process is stockpiled at each of the processing points or stations. Loan applications may be piled on the bank teller's desk, the loan officer's

desk, and the regional supervisor's desk. Work-in-process inventory, such as bank loan applications, accumulates at processing stations in a conventional organization for three reasons:

1. Handling work in batches is the most obvious cause of work-in-process inventory in a process layout system. Organizations use batches to reduce setting up, moving, and handling costs; however, batch processing increases the inventory levels in the system because at each processing station all items in the batch must wait while the designated employees process the entire batch before moving all parts in the batch to the next station.
2. If the rate at which each processing area handles work is unbalanced—because one area is slower or has stopped working because of problems with equipment, materials, or people—work piles up at the slowest processing station. Such scheduling delays create another reason why inventory levels increase in a process layout system.
3. Since supervisors evaluate many processing area managers on their ability to meet production quotas, processing station managers try to avoid the risk of having their facility idle. Many managers deliberately maintain large stocks of incoming work in process so that they can continue to work even if the processing area that feeds them is shut down. Similarly, to avoid idling the next processing station and suffering the resulting recriminations, managers may store finished work that they can forward to supply stations further down the line when their stations are shut down because of problems.

Some organizations have developed innovative approaches to eliminating many of the costs related to moving and storing, which are significant non-value-added costs associated with process layout systems.

Product Layouts

In a **product layout** (sometimes called a flow-shop layout), equipment is organized to accommodate the production of a specific product; an automobile assembly line or a packaging line for cereal or milk, for example, is a product layout. Product layouts exist primarily in companies with high-volume production. The product moves along an assembly line beside which the parts to be added to it have been stored. Placement of equipment or processing units is made to reduce the distance that products must travel.

Product layout systems planners often can arrange for raw materials and purchased parts to be delivered directly to the production line where and when they are needed. Suppose that an assembly line is scheduled to handle 600 cars on a given day. The purchasing group knows that these 600 automobiles require 2,400 regular tires and 600 spare tires. Under ideal conditions, the purchasing group will arrange delivery of small batches of these tires to the assembly line as frequently as they are needed. However, because each batch of tires from the supplier incurs some related ordering, transportation, and delivery costs, planners may arrange for a few days' worth of tires to be delivered at a time.

Consider the work in process in a cafeteria setting. People pass by containers of food and take what they want. Employees organize the food preparation activities so that the containers are refilled just as they are being emptied—not one unit at a time. For example, the cook does not make and replace one bowl of soup at a time because the setup costs of making soup in this fashion will be prohibitively expensive. Reducing setup costs, however, allows for the reduction of batch sizes (the size of the containers) along the line. This reduces the level of inventory in the system and, therefore, costs. It also improves quality while increasing customer satisfaction. The ultimate goal is to



Peugeot assembly line. In this assembly line, each workstation is designed to perform a specific process. Thus, the car is constructed as it moves down the line and ultimately emerges as a finished product.

Alamy Images

IN PRACTICE

Manufacturing a CD

A CD or compact disc is an optical digital audio disc that contains up to 74 minutes of hi-fi stereo sound. CDs were first introduced into the U.S. market in 1983. CDs are plastic platters that are recorded on one side and can store between 650 and 700 MB of information. Audio tracks are recorded as microscopic pits in a groove that starts at the center of the disc and spirals outward to the edge.

Manufacturing a CD typically usually requires a process layout involving six major steps. The first step is to make a glass master, which is an exact copy of the source material, such as a song. The master is made by taking a glass disc that is coated with a very thin layer

of light-reactive material. Digital data 1's and 0's are carved by a laser into the CD as pits (low spots) and lands (high spots).

In the second step a mold is made on metal stampers of the contents of the disc. The disc itself is too fragile to be used in the replication process. The metal stampers are then attached to injection molding machines. In the third step, the metal stamper is put into a mold and polycarbonate plastic is injected into it. The stamper imprints data pits into the plastic. The fourth step involves placing a layer of reflective material directly onto the polycarbonate plastic so that the laser can then read what is on the disc. Aluminum is next applied to the back of the disc



Shutterstock

to create the reflective surface. In the fifth step, this layer is then coated with an acrylic lacquer for protection and is cured under UV light.

The final step involves silk-screening a face label onto the cured lacquer in inks cured with a UV light. This creates the finished product as shown below.



A boxed set of Beatles CDs.
Getty Images Editorial

reduce setup costs to zero and to reduce processing time to as close to zero as possible so that the system can produce and deliver individual products just as they are needed.

Group Technology

The third approach to facilities layout, **group technology** (sometimes called cellular manufacturing), refers to the organization of a plant into a number of cells so that within each cell all machines required to manufacture a group of similar products are arranged in proximity to each other. As Exhibit 7-2 illustrates, the shape of a cell is often U shaped, which allows workers convenient access to required parts. The machines in a group technology layout are usually flexible and can be adjusted easily or even automatically to make different products. Often when group technology is introduced, the number of employees needed to produce a product can be reduced because of the new work design. The U shape also provides better visual control of the workflow because employees can observe more directly what their coworkers are doing.

INVENTORY COSTS AND PROCESSING TIME

Inventory and Processing Time

Not only does batch production create inventory costs, but it also creates the delays associated with storing and moving inventory. These delays increase cycle times, thereby reducing service to customers. Delays can happen at any stage of the production cycle, even before manufacturing begins. For example, because of high setup

Exhibit 7-2 Group Technology Layout

<http://ti2.com.au/web/ti2images/LineLayout.jpg>
Group technology or cellular manufacturing is built on the principle of grouping machines together in one place to reduce waiting time and increase visual control.



costs, a manufacturer may require that a product be manufactured in some minimum batch size. If a customer order is less than the minimum batch size and if the order cannot be filled from existing finished goods inventory, then the customer must wait until enough orders have accumulated to meet the minimum batch size requirement. It may take a loan officer only 5 minutes to read and approve a loan application at the bank; however, the application may have to wait for several hours or even days before it reaches the loan officer because having a clerk run back and forth with each new loan application when it arrives is too expensive.

Inventory-Related Costs

Demands for inventory lead to huge costs in organizations, including the cost of moving, handling, and storing the work in process, in addition to costs due to obsolescence or damage. Many organizations have found that factory layouts and inefficiencies that create the need to hold work-in-process inventory also hide other problems, leading to excessive costs of rework.

For example, in batch operations, workers near the end of a process—downstream—often find batch-size problems resulting from the way workers earlier in the process—upstream—have done their jobs. When work is performed continuously on one component at a time, however, workers downstream can identify an upstream problem in that component almost immediately and correct it before it leads to production of more defective components.

Costs and Benefits of Changing to a New Layout: An Example Using Group Technology

Pinsky Electric Corporation is a leader in the manufacturing of small electrical appliances for household and industrial use. It produces a variety of electrical valve controls at its plant in Pasadena, California. Until recently, the plant was organized into five production departments: casting, machining, assembly, inspection, and packing.

Now the plant layout has been reorganized to streamline production flows and introduce group technology. In the following sections we will take an extended look at both the old and the new work flows, identify the benefits of the new system, and compare the costs and benefits of the two.

The plant manufactures 128 different products that have been grouped into eight product lines for accounting purposes, based on common product features and production processes. Under the old plant layout, the 128 products followed a similar sequence of steps in the manufacturing process (see Exhibit 7-3). Manufacturing of panels for valve controls occurred in large batches in the casting department. Then the manufactured panels were stored in a large work-in-process storage area located near the machining department, where they remained until the lathes and drilling machines were free.

After machining, the panels were stored until they were requisitioned for assembly, during which switches and other components received from outside suppliers were placed onto each panel. Another storage area located near the assembly department was used for work in process awaiting inspection or packing, which occurred before the panels were packed for shipping. Finally, the packed valve control panels were stored in the finished goods warehouse until they were shipped to distributors and other customers.

This production flow required storage of work-in-process inventory for a long time and at several times before the beginning of the next production stage. As mentioned, manufacturing cycle time is measured as the time from the receipt of the raw materials from the supplier to the delivery of the finished goods to the distributors and customers. At Pinsky, cycle time was 28 days (5 + 1 + 9 + 1 + 1 + 4 + 1 + 2 + 1 + 3) under the old plant layout. The 4 days during which switches and other components were kept as inventory were not added to the **processing time**, the time expended for the product to be made, because the time spent in inventory represented parallel time with other production activities, such as work-in-process storage and machining. Therefore, the storage requirements for switches and other components did not prolong the time for the total production activity in the plant.

To evaluate how much of the old cycle time was spent in inventory, we need to know how organizations assess the efficiency of their manufacturing processes. One widely used measure, which would be a key operating metric in a company's Balanced Scorecard process perspective, is **processing cycle efficiency (PCE)**. PCE is calculated as follows:

$$\text{PCE} = \text{Processing time} / (\text{Processing time} + \text{Moving time} + \text{Storage time} + \text{Inspection time})$$

Of the 28 days required for the manufacturing cycle under Pinsky's old system, only 4 days were spent on actual processing [(1 casting) + (1 machining) + (1 assembly) + (1 packing)]. The other 24 days were spent in non-value-added activities, such as moving, storage, and inspection. The amount of time that materials spent in inventory could be as long as 24 days. The PCE formula reveals that processing time equaled 14.3% (4 ÷ 28) of total cycle time. These results are representative of many other plants that manufacture products from mechanical or electronic components. We will see shortly how the PCE changes for Pinsky after its reorganization.

Reorganization

A primary objective of the reorganization of the Pinsky plant layout was to reduce the production cycle time (another key BSC process metric). The plant was reorganized into eight manufacturing cells (corresponding to the eight product lines) in addition to the casting department. Each cell focused on the manufacturing of similar products belonging to the same product line.

Exhibit 7-3
Pinsky Electric
Corporation:
Production Flows
and Average Time
under Old Plant
Layout

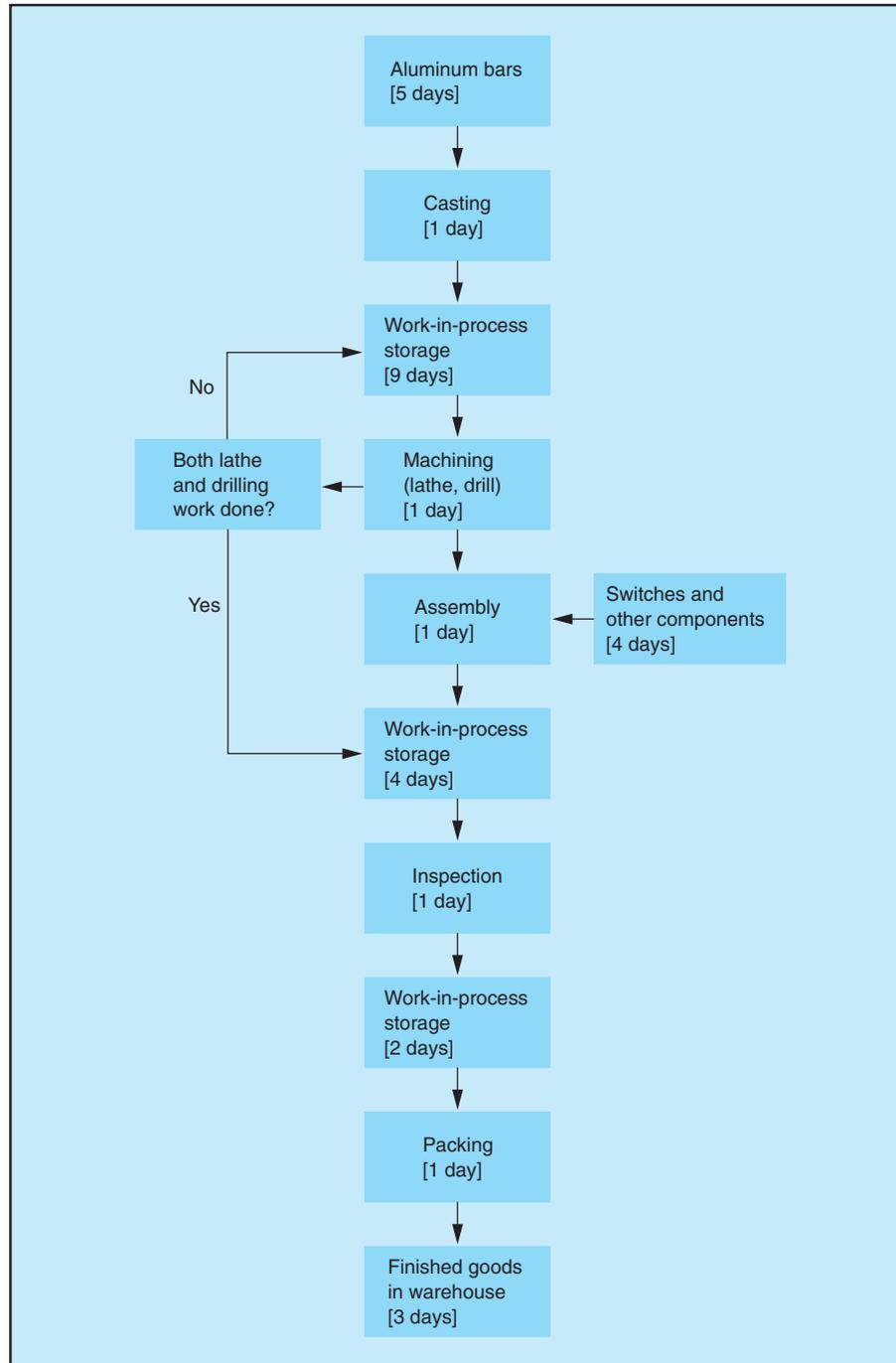
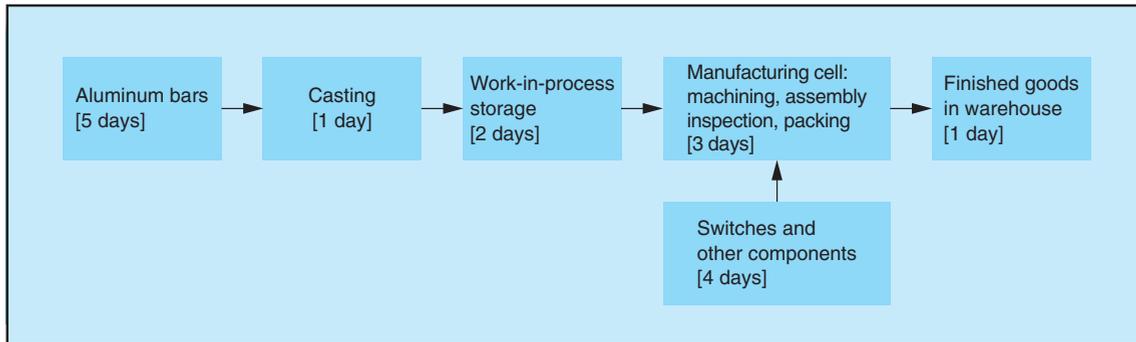


Exhibit 7-4 depicts the production flows under the new plant layout. While the casting department remains a separate department, the other four operations—machining, assembly, inspection, and packing—are now located in proximity to each other within each manufacturing cell. Aluminum panels received from the casting

Exhibit 7-4

Pinsky Electric Corporation: Production Flows and Average Time under New Plant Layout



department are lathe machined, drilled, and assembled in the manufacturing cells. Workers in the cells also are responsible for inspection and packing operations. Thus, material handling distances and the time required to move a panel from one process to the next are greatly reduced.

Pinsky Electric also made a transition toward JIT production. The change required that there be no work-in-process inventories among the various stages of operations in the manufacturing cells because panel production flowed immediately from lathe to drilling to assembly to inspection to packing operations. As a result of these steps, the time between operations has been greatly reduced as production is pulled from one stage to the next on the basis of orders for the finished product.

When comparing Exhibits 7-3 and 7-4, notice that Pinsky Electric Corporation did not reduce the amount of time spent on actual manufacturing when it changed the plant layout. The time spent on manufacturing operations after the change (see Exhibit 7-4) is the same as the time spent before the change (see Exhibit 7-3). However, the cycle time is reduced substantially in the new plant layout from 28 to only 12 days. Thus, PCE changes from 14.3% to 33.3% ($4 \div 12$). This significant improvement in efficiency over the previous layout comes from eliminating the need for work-in-process inventory between many of the manufacturing operations.

Analysis of Costs and Benefits

Has this change helped improve the profitability of the Pasadena plant? Kaylee Young, the Pasadena plant controller, identified the following costs associated with the implementation of the changes in the plant layout:

Moving machines and reinstallation	\$600,000
Training workers for group technology	+ \$400,000
Total costs	<u>\$1,000,000</u>

Kaylee also identified three types of benefits resulting from the plant reorganization: (1) an increase in sales because of the decrease in production cycle time, (2) a reduction in inventory-related costs because of the decrease in the amount and handling of work-in-process inventory, and (3) an improvement in quality since defective processes are detected much faster (at the next processing stage), before many defective items have been produced.

Kaylee interviewed several production and sales managers to assess the extent of these benefits. She began with Vicki Mulligan, a senior sales manager with 17 years of experience at Pinsky:

KAYLEE YOUNG: Has the reduction in production cycle time increased sales?

VICKI MULLIGAN: Yes, we have been able to win over many customers from our competitors because we can now quote a much shorter delivery lead time to them. Also, we have been able to retain some of our own customers because we have cut our delivery lead time. We commissioned a market research study to ascertain the impact that reduction in delivery lead time has had on our sales. On the basis of this study, our best estimate is that an increase of \$880,000 in sales this year can be attributed to the change in our production cycle time. Details of estimated sales increases for individual products are also provided in this study. I think you'll find it interesting.

Kaylee next turned to her analyst, Bob Phillips, to collect the information necessary to assess the profitability of the sales increase. He returned the next day with several detailed cost accounting reports.

BOB PHILLIPS: I've prepared a detailed analysis of the costs for all our products. Here is a summary that gives the totals for all 128 products (see Exhibit 7-5). I began with the estimate of the increase in sales for each of the 128 products. Here is an example for product TL32 (see Exhibit 7-6). I multiplied the 800-unit sales increase by the direct materials cost of \$7.00 per unit and direct labor cost of \$4.00 per unit. Using our time-driven ABC system, I also included support costs of \$5.50 per unit. The \$10,000 profit is obtained by calculating the difference between the \$23,200 increase in sales revenue and the \$13,200 in costs. The summary in Exhibit 7-5 displays the totals of similar revenue and cost numbers across all of our 128 products.

Exhibit 7-5
Pinsky Electric Corporation:
Impact of Increase in Sales on Profit

Increase in sales revenue		\$880,000
Increase in costs:		
Direct materials	\$245,000	
Direct labor	140,000	
Support resources	<u>194,000</u>	<u>579,000</u>
Net increase in profit		\$301,000

Exhibit 7-6
Pinsky Electric Corporation:
Impact of Increase in Sales of Product TL32

Increase in sales	(800 units × \$29 price per unit)		\$23,200
Increase in costs:			
Direct materials	(800 units × \$7 cost per unit)	\$5,600	
Direct labor	(800 units × \$4 cost per unit)	3,200	
Support resources	(800 units × \$5.50 cost per unit)	<u>4,400</u>	<u>\$13,200</u>
Net increase in profit			\$10,000

KAYLEE YOUNG: Thanks, Bob, for all your efforts. I see that our best estimate is that the increase in sales resulting from the lower production cycle time has generated a profit of \$301,000 this year.

Kaylee next met with Megan McDermott, production and inventory manager at the Pasadena plant, to find out how the reduction in the level of work-in-process inventory affected the consumption of support resources:

KAYLEE YOUNG: Has the change in the plant layout led to changes in the handling and storage of work-in-process inventory?

MEGAN MCDERMOTT: Yes, we have been able to make many changes. We don't need a materials-handling crew to move work-in-process inventory from lathes to drilling machines to storage areas on the shop floor. Nor do we need to move and store work-in-process inventory between the assembly, inspection, and packing stages. We did not reduce the number of materials handling workers immediately, but as work patterns stabilized a few weeks after the change in the plant layout, we reduced our materials handling crew from 14 to only 8 workers.

KAYLEE YOUNG: Were there any other changes in the workload of people performing these support activities?

MEGAN MCDERMOTT: With an almost 70% reduction in work-in-process inventory, down from \$2,270,000 to \$690,000, we had a corresponding decrease in inventory-related transactions. We did not require as much record keeping for the movement of materials into and out of storage. We expect to be able to reduce our shop-floor-stores staff by 75%, from four workers to only one. So far we have reassigned only one worker, but two more will be reassigned to other production-related tasks next week.

KAYLEE YOUNG: So far we have talked about personnel. Were any other resources freed up as a result of the reduction in work-in-process inventory?

MEGAN MCDERMOTT: Yes, we need only one-third of the storage space we used earlier for work-in-process inventory. The extra space is idle at present, however, because we haven't yet found an alternative use for it. I don't believe there was any proposal to use that extra space in the three-year facilities plan prepared last month, but eventually as production activity expands, we should be able to place new manufacturing cells in the space formerly used to store work-in-process inventory.

KAYLEE YOUNG: But you don't expect any immediate benefit to arise from the availability of the extra storage space?

MEGAN MCDERMOTT: Yes, that's correct. But there is one more benefit that you shouldn't forget. When some panels are produced in large batches and stored awaiting the next stage of processing, we always find that some of them get damaged in handling, and at times some of them become obsolete because the customer no longer requires them. The change to JIT production in the manufacturing cells and the elimination of much of our work-in-process inventory have resulted in a reduction in materials scrap and obsolescence cost from 0.32% of materials cost to only 0.12%.

KAYLEE YOUNG: Thank you, Megan. The information you've provided will be very useful in evaluating the impact of the change in the plant layout.

Kaylee and Vicki sat in Kaylee's office to analyze the information they had collected so far. Support costs pertaining to plant space included building depreciation, insurance, heating, lighting, janitorial services, building upkeep, and maintenance. Kaylee and Vicki decided that the costs associated with the extra storage space were at present a sunk cost with no cost savings yet realized from freeing up this space.

A check of the materials handling activity costs indicated that the annual wages of workers in this grade averaged \$21,000, with 35% more, or \$7,350 ($\$21,000 \times 0.35$), added for fringe benefits. The total materials handling cost savings, therefore, was \$170,100 ($\$28,350 \times 6$) because the crew size was reduced by six workers.

In a similar fashion, Megan determined that the annual wages of stores personnel averaged \$26,400. With a 35% fringe benefit rate and an expected reduction of three workers, the total annual cost savings was \$106,920 ($\$26,400 \times 1.35 \times 3$).

The financing of inventories can involve significant costs. Kaylee estimated the interest rate on bank loans to finance the investment in inventories to be 12% per year. The work-in-process inventory was reduced by \$1,580,000 ($\$2,270,000 - \$690,000$). This reduced the cost of inventory financing correspondingly by \$189,600 ($\$1,580,000 \times 0.12$).

Finally, Kaylee determined that the total annual materials cost was \$31,000,000. If the rate of materials, scrap, and obsolescence had remained at the previous 0.32% of materials cost, this loss would have been \$99,200 ($\$31,000,000 \times 0.0032$). But because of the reduction in the rate to 0.12%, the cost of materials scrap and obsolescence was reduced to only \$37,200 ($\$31,000,000 \times 0.0012$). This represents a cost savings of \$62,000 ($\$99,200 - \$37,200$).

Summary of Costs and Benefits

Kaylee then summarized the information on cost savings resulting from the change in the plant layout (see Exhibit 7-7). she estimated that annual benefits were \$829,620. In comparison, the one-time costs of implementing the change were only \$1,000,000. If benefits from the changed layout continue to accrue at the same rate for at least three more months, the total benefits will exceed the amount that Pinsky invested in the project:

$$\$829,620 \times 15/12 = \$1,037,025$$

More specifically, the process improvements from the investment would repay the front-end cost in $\$1,000,000 / \$829,620 = 1.205$ years.

Exhibit 7-7

Pinsky Electric Corporation: Annual Benefits Resulting from the Change in Plant Layout



Contribution from increased sales:			
Sales increase	(Exhibit 7-5)	\$880,000	
Incremental manufacturing costs	(Exhibit 7-5)	<u>579,000</u>	\$301,000
Cost savings from work-in-process inventory reduction:			
Cost of financing investment in work-in-process inventory		\$189,600	
Cost of materials handling labor		170,100	
Cost of stores labor		106,920	
Cost of materials scrap and obsolescence		<u>62,000</u>	<u>528,620</u>
Total benefits			\$829,620

The Pinsky case study introduces several important concepts. We have identified several different ways in which new manufacturing practices can improve a plant's profitability. In particular, we have seen that financing is a principal inventory-related cost. It is important to consider this cost, although financing costs are often not emphasized in many traditional cost accounting systems. Streamlining manufacturing processes also reduces the demand placed on many support-activity resources. Analyzing the use of support resources in production helps to identify the total potential cost savings that can be realized from more efficient product flows.

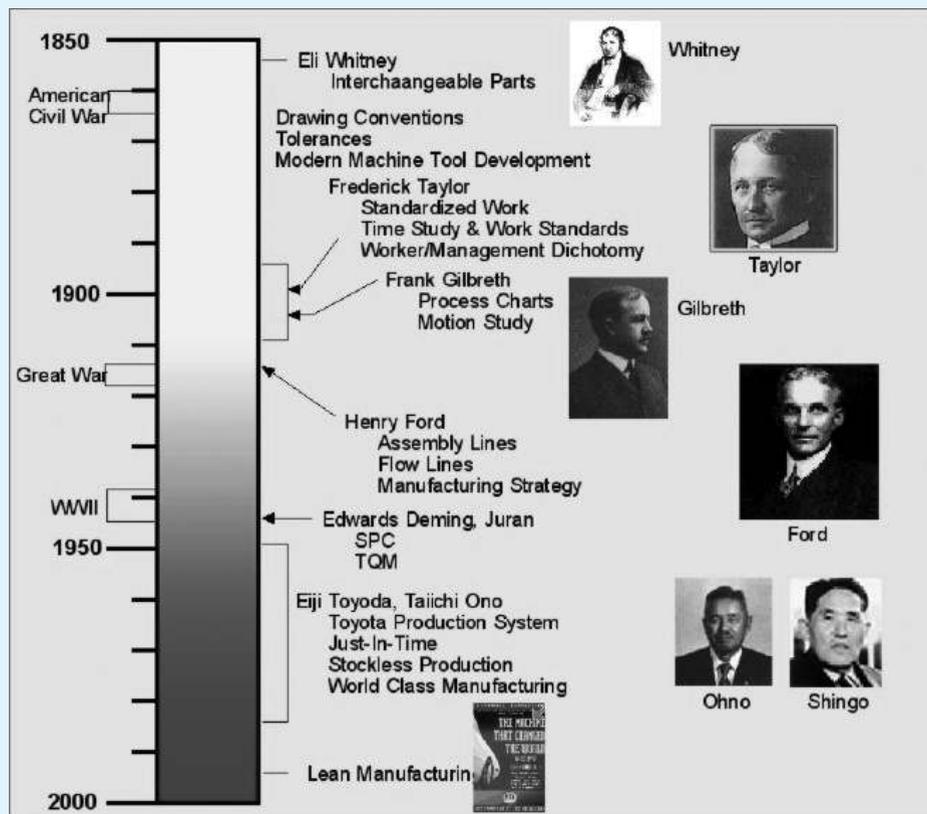
Many new manufacturing practices are designed to promote continuous improvement in manufacturing performance by enabling workers to learn and innovate. In this example, changing to a manufacturing cell layout led to improvements in production

IN PRACTICE

History of Lean Manufacturing

The history of lean manufacturing is summarized well in the chart below. Lean manufacturing can trace its roots back as far as Eli Whitney, who invented the cotton gin and the concept of interchangeable parts. Early pioneers' work, such as Frederick Taylor and Frank Gilbreth's time

and motion studies, Henry Ford's assembly line, Taiichi Ohno and Shigeo Shingo's just-in-time system based on stockless production, and the quality movement pioneered by Edwards Deming and Joseph Juran, were all critical to the development of lean manufacturing.



Source: http://www.strategosinc.com/lean_manufacturing_history.htm

yield rates and quality and, consequently, improvements in overall plant productivity. In addition, revenues also can increase from shorter lead times to customers.

Lean manufacturing or lean production, often just called “lean,” is another new manufacturing approach. Lean’s central philosophy is that any resource spending that does not create value for the end customer is wasteful and must be eliminated. Value is defined as any action or process for which a customer would be willing to pay. Lean manufacturing is a generic process management philosophy derived from the legendary Toyota Production System that is associated with just-in-time manufacturing. We will discuss this topic in depth later in the chapter.

COST OF NONCONFORMANCE AND QUALITY ISSUES

The preceding example shows that cost reduction has become a significant factor in the management of most organizations. Reducing costs, however, involves much more than simply finding ways to cut product design costs by, for example, using less expensive materials. The premise underlying cost reduction efforts today is to decrease costs while maintaining or improving product quality in order to be competitive.

An emphasis on quality has been a focal point for business worldwide since the 1980s when quality circles (typically unpaid groups of workers who voluntarily tried to solve quality issues) and total quality management (TQM), now known as continuous quality improvement (CQI), were developed. CQI takes a systems view of quality and focuses on how to improve both internal and external processes related to customers using objective data.

Quality Standards

Global competition led to the development of the ISO 9000 series of standards beginning in 1987 by the International Organization for Standardization (ISO), headquartered in Geneva. These international quality standards have been updated several times and the new standard is called ISO 9001–2008. Company certification under these standards indicates to customers that management has committed their company to follow procedures and processes that will ensure the production of the highest quality goods and services. These standards are comprehensive and companies interested in becoming ISO 9000 registered must comply with regulatory agencies, meet or exceed customer requirements or implement a quality improvement program.

In the 1990s Motorola introduced Six Sigma, which moved the quality criterion of three standard deviations (1 defect in 100) that was developed by the father of statistical quality control, Walter Shewhart, to six standard deviations, or 3.4 defects per million items produced. Trainers in the Six Sigma system, known as Black Belts, and new computing technology made this system possible.

If the quality of products and services does not conform to quality standards, then the organization incurs a cost known as the **cost of nonconformance (CONC) to quality standards**.

Quality may mean different things to different people. It usually can be viewed as hinging on two major factors:

1. Satisfying customer expectations regarding the attributes and performance of the product, such as in functionality and features.
2. Ensuring that the technical aspects of the product’s design and performance, such as whether it performs to the standard expected, conform to the manufacturer’s standards.

Costs of Quality Control

This section focuses on how to interpret **quality costs** from a management accounting point of view. Companies have discovered that they can spend as much as 20% to 30% of total manufacturing costs on quality-related processes such as detection and correction of internal and external failure. The best known framework for understanding quality costs classifies them into four categories:

1. Prevention costs.
2. Appraisal costs.
3. Internal failure costs.
4. External failure costs.

Experience shows that it is much less expensive to prevent defects than to detect and repair them after they have occurred.

Prevention Costs

Prevention costs are incurred to ensure that companies produce products according to quality standards. Quality engineering, training employees in methods designed to maintain quality, and statistical process control are examples of prevention costs. Prevention costs also include evaluating and training suppliers to ensure that they can deliver defect-free parts and materials and better, more robust product designs. Such suppliers earn a **certified supplier** designation.

Appraisal Costs

Appraisal costs relate to inspecting products to make sure they meet both internal and external customers' requirements. Inspection costs of purchased parts and materials and costs of quality inspection on an assembly line are considered to be appraisal costs. Examples include inspection of incoming materials, maintenance of test equipment, and process control monitoring.

Internal Failure Costs

Internal failure costs result when the manufacturing process detects a defective component or product before it is shipped to an external customer. Reworking defective components or products is a significant cost of internal failures. The cost of downtime in production is another example of internal failure. Engineers have estimated that the cost of defects rises by an order of magnitude for each stage of the manufacturing process during which the defect goes undetected. For example, inserting a defective \$1 electronic component into a subassembly leads to \$10 of scrap if detected at the first stage, \$100 at the next stage, and perhaps \$10,000 if not detected for two more stages of assembly.

External Failure Costs

External failure costs occur when customers discover a defect. All costs associated with correcting the problem—repair of the product, warranty costs, service calls, and product liability recalls—are examples of external failure costs. For many companies, this is the most critical quality cost to avoid. Not only are costs required to fix the problem in the short run, but customer satisfaction, future sales, and the reputation of the manufacturing organization also may be in jeopardy over the long run. Exhibit 7-8 provides examples of the quality costs in each category.

This information is compiled in a **cost-of-quality (COQ) report**, developed for several reasons. First, it illustrates the financial magnitude of quality factors. Often managers are unaware of the enormous impact that rework has on their costs.

Exhibit 7-8
Examples of
Quality-Related
Costs

PREVENTION COSTS	APPRAISAL COSTS
Quality engineering	Inspection/testing of incoming materials
Quality training	Maintenance of test equipment
Statistical Process control	Process control monitoring
Supplier certification	Product quality audits
Research of customer needs	
INTERNAL FAILURE COSTS	EXTERNAL FAILURE COSTS
Downtime due to defects	Product liability lawsuits
Waste	Repair costs in the field
Net cost of scrap	Returned products
Rework costs	Product liability recalls
	Service calls
	Warranty claims

Second, COQ information helps managers set priorities for the quality issues and problems they should address. For example, one trend that managers do not want to see is a very high percentage of quality costs coming from external failure of a product. External quality problems are expensive to fix and can greatly harm the reputation of the product or organization producing the product. Third, the COQ report allows managers to see the big picture of quality issues and allows them to try to find the root causes of their quality problems. Fixing the problem at its root will have positive ripple effects throughout the organization, as so many quality issues are interrelated.

JUST-IN-TIME MANUFACTURING

A comprehensive and effective manufacturing system that integrates many of the ideas discussed in this chapter is **just-in-time (JIT) manufacturing**. Recall that the Blast from the Past Robot Company implemented this system in the opening vignette to this chapter.

JIT manufacturing requires making a product or service only when the customer, internal or external, requires it. It uses a product layout with a continuous flow—one with no delays once production starts. This means there must be a substantial reduction in setup costs in order to eliminate the need to produce in batches; therefore, processing systems must be reliable.

Implications of JIT Manufacturing

JIT manufacturing is simple in theory but hard to achieve in practice. Some organizations hesitate to implement JIT because with no work-in-process inventory, a problem anywhere in the system can stop all production. For this reason, organizations that use JIT manufacturing must eliminate all sources of failure in the system. The production process must be redesigned so that it is not prohibitively expensive to process one or a small number of items at a time. This usually means reducing the distance over which work-in-process has to travel and using very adaptable people and equipment that can handle all types of jobs.

At the core of the JIT process is a highly trained workforce whose task is to carry out activities using the highest standards of quality. When an employee discovers a problem with a component he or she has received, it is the responsibility of that employee to call immediate attention to the problem so that it can be corrected. Suppliers must be able to produce and deliver defect-free materials or components just when they are required. In many instances, companies compete with suppliers of the same components to see who can deliver the best quality. At the end of a performance period, the supplier who performs the best will obtain a long-term contract. Preventive maintenance is also employed so that equipment failure is a rare event.

Consider how JIT manufacturing can be used at a fast-food restaurant. Some use a JIT, continuous-flow product layout, while others use batch production in a process layout. In fact, some fast-food restaurants combine both approaches into hybrid systems that use a batch approach to production and keep inventories at predefined levels. For example, the restaurant may use racks or bins to hold food ready to be sold to the customer and have employees start another batch of production when the existing inventory falls below a line drawn on the bin or rack. At off-peak times, the restaurant may produce to order.

The motivation to use the JIT approach is to improve the quality of the food and to reduce waste by eliminating the need to discard food that has been held in the bin too long. The motivation to use batch production is to sustain a certain level of inventory to reduce the time the customer has to wait for an order. As processing time and setup costs drop, the organization can move closer to JIT manufacturing and reduce the waste and quality problems that arise with batch production.

JIT Manufacturing and Management Accounting

JIT manufacturing has two major implications for management accounting. First, management accounting must support the move to JIT manufacturing by monitoring, identifying, and communicating to decision makers the sources of delay, error, and waste in the system. Balanced Scorecard process metrics related to a company's ability to implement a JIT production system include:

1. Defect rates.
2. Cycle times.
3. Percent of time that deliveries are on time.
4. Order accuracy.
5. Actual production as a percent of planned production.
6. Actual machine time available compared with planned machine time available.

Conventional production systems use performance metrics based on labor and machine utilization ratios. These metrics encourage large batch sizes and high levels of production. The result is large inventory quantities that lead to long manufacturing cycle times. Therefore, the use of conventional labor and machine productivity ratios is inconsistent with the JIT production philosophy, in which operators are expected to produce only what is requested, when it is requested, and on time. The second implication is that the clerical process of management accounting is simplified by JIT manufacturing because there are fewer inventories to monitor and report.

JIT manufacturing has been a benefit to many organizations. Those interested in implementing this system need to remember several things. First, any significant management innovation, such as ABC or JIT, requires a major cultural change for an organization. Because the central ideas behind JIT are the streamlining of operations and the reduction of waste, many people inside companies are ill prepared

for the change. JIT also can alter the pace of work and the overall work discipline of the organization. It can cause structural changes in such areas as the arrangement of shop floors. Finally, because JIT relies on teamwork, often individuals have to subordinate their own interests to those of the team. Some employees find this difficult, especially if they have come from a work environment where they worked on a single component in relative isolation or if their personalities are not team oriented.

IN PRACTICE

Using Lean Manufacturing in a Hospital Setting

According to Dr. Gary Kaplan, CEO of Virginia Mason Hospital, after studying their hospital's infrastructure, senior management at Virginia Mason hospital determined it was designed for them and not their patients. Patients complained that they had to hurry to be on time for scheduling but once they were there they had long waits to see a doctor.

Management decided to look for better ways to improve quality, safety, and patient satisfaction. Using the lean manufacturing approach originally developed at Toyota, Virginia Mason tailored the Japanese model to fit the health care environment.

Over the years Kaplan and 200 company employees visited manufacturing plants at Toyota and Yamaha. Much of their time was spent learning how to cut out waste. According to the production system

there are seven wastes. Three of the most critical wastes are wasting time, such as patients waiting for a doctor or for test results to come back; inventory waste, having more materials and information than is necessary; and overproduction waste, producing more than is necessary.

One example of reducing waste relates to the number of pamphlets and brochures that the hospital has on hand. Historically, the hospital over-ordered these brochures and filled closets with them. After installing a Kanban system, which signals the need to restock the brochures, thousands of dollars were saved and the clutter was reduced.

The hospital also developed standardized instrument trays for surgeries and procedures. This saved hundreds of dollars because instruments that were not



Paul Joseph Brown Photography

needed were not used. In the past, unused but opened instruments had to be thrown away.

Another innovation was a flip chart showing the level of mobility in physical therapy patients. The chart shows the level of what the patient can and cannot do, and each nurse or physician who comes in the room doesn't have to waste time searching charts or asking questions.

Further, instead of waiting until the end of the day to go through a stack of patient records, doctors now

write comments and recommendations immediately after seeing the patient before going to see the next one. The time saved increases the time a physician can spend with a patient.

Virginia Mason has also redesigned their facilities to make patient and staff work flow more productive. Overtime and labor expenses were reduced by \$500,000 in one year and productivity was increased by 93%. Overall hospital efficiency has been greatly improved.

Source: Cherie Black, "To Build a Better Hospital, Virginia Mason Takes Lessons from Toyota Plants," *Seattle Post-Intelligencer* (March 15, 2008), retrieved November 30, 2010, from http://www.seattlepi.com/local/355128_lean15.html

KAIZEN COSTING

The lean manufacturing approach has been successfully implemented in many companies. What has not kept pace with these operational changes are the finance and cost management systems. **Kaizen costing** is a system that provides relevant data to support lean production systems. Kaizen costing focuses on reducing costs during the manufacturing stage of a product. *Kaizen* is the Japanese term for making improvements to a process in small, incremental amounts rather than through large innovations. Kaizen's incremental approach is appropriate since products are already in the manufacturing process, making it difficult to make large changes to reduce costs.

Kaizen costing is tied into the profit-planning system. In the Japanese automobile industry, for example, an annual budgeted profit target is allocated to each plant. Each automobile has a predetermined cost base that is equal to the actual cost of that automobile in the previous year. All cost reductions use this cost base as their starting point. Kaizen costing's goal is to ensure that a product meets or exceeds customer requirements for quality, functionality, and prices in order to effectively compete.

The *target reduction rate* is the ratio of the target reduction amount to the cost base. This rate is applied over time to all variable costs and results in specific target reduction amounts for materials, parts, direct and indirect labor, and other variable costs. Then management makes comparisons of actual reduction amounts across all variable costs to the preestablished targeted reduction amounts. If differences exist, variances for the plant are determined. Kaizen costing's goal is to ensure that actual production costs are less than the cost base. However, if the cost of disruptions to production is greater than the savings due to kaizen costing, then it will not be applied. Exhibit 7-9 illustrates one example of determining the total amount of kaizen costs across multiple plants in a Japanese automobile plant.

Comparing Traditional Cost Reduction to Kaizen Costing

The kaizen costing system is quite distinct from a traditional standard costing system in which the typical goal is to meet the cost standard while avoiding unfavorable variances. Under kaizen costing, the goal is to achieve cost reduction targets that are continually adjusted downward. Variance analysis under a standard cost system compares actual to standard costs. Under the kaizen costing system,

Exhibit 7-9 Computing Kaizen Costs for Plants

Cost savings in Japanese automobile plants involve reducing both committed (fixed) and flexible (variable) costs. Since fixed costs are believed necessary for growth, the main emphasis is on reducing variable costs.

In this example, the total amount of kaizen costs in all plants determined in a kaizen planning meeting is designated as C in the formulas that follow:

Amount of actual cost per car in the last period (A)	=	Amount of actual cost in the last period	÷	Actual production in the last period
Estimated amount of actual cost for all plants in this period (B)	=	Amount of actual cost per car in the last period (A)	×	Estimated production in this period
Kaizen cost target in this period for all plants (C)	=	Estimated amount of actual cost for all plants in this period (B)	×	Target ratio of cost decrease to the estimated cost

The target ratio of cost decrease to the estimated cost is based on attaining the target profit for the year.

The kaizen cost target for each plant is determined in the following manner:

Assignment ratio (D)	=	Costs controlled directly by each plant	÷	Total amount of costs controlled directly by plants
Total kaizen cost for each plant	=	Kaizen cost target in this period for all plants (C)	×	Assignment ratio (D)

The amount of kaizen cost for each plant is subdivided to each division and subdivisions as cost reduction goals.

variance analysis compares the target costs with actual cost reduction amounts. Kaizen costing operates outside the standard costing system, in part because standard costing systems in Japan are used only for financial accounting reports.

Another key difference between standard and kaizen costing has to do with the assumptions about who has the best knowledge to improve processes and reduce costs. Traditional standard costing assumes that engineers and managers know best because they have the technical expertise and can determine procedures that workers are required to perform according to preset standards and procedures. Under kaizen costing, workers are assumed to have superior knowledge about how to improve processes because they actually work with the manufacturing processes used to produce products. To facilitate the process, information on actual costs must be shared with front-line employees, which is a significant change for many companies. Thus, another central goal of kaizen costing is to give workers the responsibility and control to improve processes and reduce costs. Exhibit 7-10 summarizes the differences in philosophy between standard costing and kaizen costing methods.

Concerns about Kaizen Costing

Kaizen costing also has been criticized for the same reasons as target costing in the research, development, and engineering stage (discussed in Chapter 8): The system places enormous pressure on employees to reduce every conceivable cost. To address the problem, some Japanese automobile companies use a grace period in manufacturing just before a new model is introduced. This period, called a *cost-sustainment period*, provides employees with the opportunity to learn any new procedures before the company imposes kaizen and target costing goals on them.

Another concern has been that kaizen costing leads to incremental rather than radical process improvements. This can cause myopia as management tends to focus on the details rather than the overall system.

Exhibit 7-10

Comparison of Standard Costing to Kaizen Costing

STANDARD COSTING CONCEPTS	KAIZEN COSTING CONCEPTS
Cost control system concept	Cost reduction system concept
Assumes stability in current manufacturing processes	Assumes continuous improvement in manufacturing
Goal is to meet cost performance standards	Goal is to achieve cost reduction standards
STANDARD COSTING TECHNIQUES	KAIZEN COSTING TECHNIQUES
Standards are set annually or semiannually	Cost reduction targets are set and applied monthly, and continuous improvement (Kaizen) methods are applied all year long to meet targets
Cost variance analysis involves comparing actual to standard costs	Cost variance analysis involves target Kaizen costs versus actual cost reduction amounts
Cost variance investigation occurs when standards are not met	Investigation occurs when target cost reduction (Kaizen) amounts are not attained
WHO HAS THE BEST KNOWLEDGE TO REDUCE COSTS?	WHO HAS THE BEST KNOWLEDGE TO REDUCE COSTS?
Managers and engineers develop standards as they have the technical expertise	Workers are closest to the process and thus know best

BENCHMARKING

In the opening vignette, Neva Dominguez used benchmarking to find out that her competition was using the JIT manufacturing system to produce its products. Her research and discussions with another local firm provided her with much information, as discussed next.

Organizations interested in new ways to improve their operations usually choose one of three ways to learn about and adopt a method:

1. The first is to bring in outside consultants to implement a particular method. Outside consultants can be effective but costly.
2. A second approach is for organizational members to develop their own systems internally with little or no assistance from outside consultants. Although this approach can be satisfying, it can be highly costly and time consuming, especially if the organization fails in its first few attempts at change.
3. The third approach, known as **benchmarking**, requires that organizational members first understand their current operations and approaches to conducting business and then look to the best practices of other organizations for guidance on improving.

Benchmarking is a way for organizations to gather information regarding the best practices of others. It is often highly cost effective, because organizations can save time and money by avoiding the mistakes that other companies have made or by not reinventing a process or method that other companies have already developed and tested. Since its inception benchmarking has undergone many changes. Most notably, the once cumbersome process that took six to nine months has now been streamlined and has become a fast and flexible tool. Thus, selecting appropriate benchmarking partners (discussed later in this chapter) is a critical aspect of the process. The benchmarking process typically consists of five stages that include several organizational/ diagnostic, operational, and informational factors. We present each stage here by listing its key factors. Exhibit 7-11 depicts the benchmarking process.

Exhibit 7-11

Stages of the Benchmarking Process

STAGES OF THE BENCHMARKING PROCESS	FACTORS TO CONSIDER
<p><i>Stage 1:</i> Internal study and preliminary competitive analyses</p>	<p>Preliminary internal and external competitive analyses Determine key areas for study Determine scope and significance of the study</p>
<p><i>Stage 2:</i> Developing long-term commitment to the benchmarking project and coalescing the benchmarking team</p>	<p><i>Developing long-term commitment to the benchmarking project:</i> Gain senior management support Develop a clear set of objectives Empower employees to make change</p> <p><i>Coalescing the benchmarking team:</i> Use an experienced coordinator Train employees</p>
<p><i>Stage 3:</i> Identifying benchmarking partners</p>	<p>Size of partners Number of partners Relative position within and across industries Degree of trust among partners</p>
<p><i>Stage 4:</i> Information-gathering and-sharing methods</p>	<p><i>Type of benchmarking information:</i> Product Functional (process) Strategic (includes management accounting methods)</p> <p><i>Method of information collection:</i> Unilateral Cooperative Database Indirect/third party Group</p> <p>Determine performance measures Determine the benchmarking performance gap in relation to performance measures</p>
<p><i>Stage 5:</i> Taking action to meet or exceed the benchmark</p>	<p>Comparisons of performance measures are made</p>

Stage 1: Internal Study and Preliminary Competitive Analyses

In this stage, the organization decides which key areas to benchmark for study, such as the company's activities, products, or management accounting methods. Then the company determines how it currently performs on these dimensions by initiating both preliminary internal competitive analyses using internal company data and preliminary external competitive analyses using, for example, industry comparisons of quality from publications such as *Consumer Reports* or reports from J. D. Power and Associates. Both types of analyses will determine the scope and significance of the study for each area. Another key factor to remember is that these analyses are not limited only to companies in a single industry. Thus, for example, although Kaylee Young works in the toy industry, she could do competitive analyses in any type of organization.

Stage 2: Developing Long-Term Commitment to the Benchmarking Project and Coalescing the Benchmarking Team

In this stage, the organization must develop its commitment to the benchmarking project and coalesce a benchmarking team. Because significant organizational change can take several years, the level of commitment to benchmarking has to be long term rather than short term. Long-term commitment requires (1) obtaining the support of senior management to give the benchmarking team the authority to spearhead the changes, (2) developing a clear set of objectives to guide the benchmarking effort, and (3) empowering employees to make change.

The benchmarking team should include individuals from all functional areas in the organization. An experienced coordinator is usually necessary to organize the members' team and develop training in benchmarking methods. Lack of training often leads to failure of the implementation.

Stage 3: Identifying Benchmarking Partners

The third stage of benchmarking includes identification of partners—willing participants who know the process. Some critical factors are as follows:

1. Size of the partners
2. Number of partners
3. Relative position of the partners within and across industries
4. Degree of trust among partners.

Size

The size of the benchmarking partner will depend on the specific activity or method being benchmarked. For example, if an organization wants to understand how a huge organization with several divisions coordinates its suppliers, then the organization would probably seek another organization of similar size for benchmarking. However, size is not always an important factor. For example, DaimlerChrysler Corporation, a huge corporation, studied L.L. Bean's warehousing method of flowcharting wasted motion. As a result, Chrysler implemented a method that led to significant changes in the ways that its workers were involved in organizational problem solving.

Number

Initially, it is useful for an organization to consider a wide array of benchmarking partners. However, organizations must be aware that as the number of partners increases, so do issues of coordination, timeliness, and concern over proprietary information disclosure. Researchers argue that today's changing business environment is likely to encourage firms to have a larger number of participants because increased competition and technological progress in information processing increases benchmarking benefits relative to costs.

Relative Position within and across Industries

Another factor is the relative position of the organization within an industry. In many cases, industry newcomers and those whose performance on leading indicators has declined are more likely to seek a wider variety of benchmarking partners than those who are established industry leaders. Those who are industry leaders may benchmark because of their commitment to continuous improvement.

Degree of Trust

From the benchmarking organization's point of view, developing trust among partners is critical to obtaining truthful and timely information. Most organizations, including industry leaders, operate on a quid pro quo basis, with the understanding that both organizations will obtain information they can use.

Stage 4: Information Gathering and Sharing Methods

Two dimensions relating to information gathering and sharing emerge from the literature: (1) the type of information that benchmarking organizations collect and (2) methods of information collection.

Type of Information

Firms interested in benchmarking can focus on three broad classes of information: *Product benchmarking* is the long-standing practice of carefully examining other organizations' products. *Functional (process) benchmarking* is the study of other organizations' practices and costs with respect to functions or processes, such as assembly or distribution. *Strategic benchmarking* is the study of other organizations' strategies and strategic decisions, such as why organizations choose one particular strategy over another. Since management accounting methods have become an integral part of many organizations' strategies, benchmarking of these methods would occur as part of the management accounting function.

Methods of Gathering Information

Management accountants play a key role in gathering and summarizing information used for benchmarking. Two major methods are used to collect information for benchmarking. The most common can be described as **unilateral (covert) benchmarking**, in which companies independently gather information about one or several other companies that excel in the area of interest. Unilateral benchmarking relies on data that companies can obtain from industry trade associations or clearinghouses of information.

A second method is **cooperative benchmarking**, which is the voluntary sharing of information through mutual agreements. The major advantage of cooperative benchmarking is that information sharing occurs both within and across industries. Cooperative benchmarking has three subcategories: database, indirect/third-party, and group benchmarking.

Companies that use **database benchmarking** typically pay a fee and in return gain access to information from a database operator. The database operator collects and edits the information prior to making it available to users. In most cases, there is no direct contact with other firms, and the identity of the source of the data often is not revealed. The database method has the advantage of including a large amount of information in one place; however, insights regarding what the data mean for the firm and how to use the information often are not available.

Indirect/third-party benchmarking uses an outside consultant to act as a liaison among firms engaged in benchmarking. The consultant supplies information from one party to the others and handles all communications. Often the consultant participates in the selection of partners. Because the members may be competitors, they pass information through a consultant so that members remain anonymous. This approach requires that the sources of the information remain confidential.

Participants using **group benchmarking** meet openly to discuss their methods. They coordinate their efforts, define common terminology, visit each other's sites, and generally have a long-run association. Typically, firms that engage in cooperative

benchmarking abide by a code of conduct that they agree on prior to the study. As in most interactions, direct contact offers the opportunity for better understanding of the other parties involved and usually is the most effective benchmarking method. This method also is the most costly to implement; therefore, firms must evaluate the cost–benefit trade-offs.

After the information gathering process is complete, the participants conducting the benchmarking study determine a **benchmarking (performance) gap** by comparing their organization’s own performance with the best performance that emerges from the data. The performance gap is defined by specific performance measures on which the firm would like to improve. Performance measures may include reduced defectives, faster on-time delivery, increased functionality, or reduced life-cycle product costs. Other, more qualitative measures may include better employee decisions concerning ways to work or solve problems, increased motivation and satisfaction, and improved cooperation and coordination among work groups and employees.

Financial gains such as reduced product costs usually occur as a result of addressing the relevant nonfinancial measures involved. Since most financial gains may take a significant amount of time to be felt, organizations should monitor the nonfinancial variables in the short term. Simply judging the effects of a benchmarking effort in the short term on the basis of financial indicators may lead to premature abandonment of what has been learned during the benchmarking project.

Stage 5: Taking Action to Meet or Exceed the Benchmark

In the final stage, the organization takes action and begins to change as a result of the benchmarking initiative. After implementing the change, the organization makes comparisons to the specific performance measures selected. In many cases,

IN PRACTICE

Benchmarking Mobile Web Experiences

Benchmarking can be used in many different contexts. Trey Harvin, CEO of dotMobi, stated in a recent article, “Benchmarking allows businesses to see their sites in relation to the sites of their industry peers, which will also help drive the creation of more good sites for consumers to use.”

As an example dotMobi has come up with a five-dimensional approach that benchmarks the mobile web experience of users when accessing websites using mobile technology. The five key metrics that they have derived are:

- Discoverability: how readily a consumer can find the mobile website using different URLs
- Readiness: how well the mobile website renders on popular mobile devices
- Availability: the percentage of successful transactions or the availability of a Web page

- Response time: how long each page takes to download and the duration of an entire transaction
- Consistency: how well the mobile website performs on different mobile carriers, in different geographies and time frames.

“As dotMobi announced in a recent study, there are now more than 1.1 million Web sites designed for mobile users, and that number is continuing to grow at an incredibly fast pace. Helping consumers better understand which of those sites will offer them a good experience—no matter what handset or operator they’re using—will help increase the use of the mobile Web,” said Harvin. “Benchmarking allows businesses to see their sites in relation to the sites of their industry peers, which will also help drive the creation of more good sites for consumers to use.”

Source: dotMobi, “Benchmarks that Measure Five Critical Dimensions of Success for Mobile Websites,” *CircleID* (April 21, 2009), retrieved November 30, 2010, from http://www.circleid.com/posts/20090421_gomez_dotmobi_benchmarks_measure_mobile_websites

the decision may be to perform better than the benchmark to be more competitive. The implementation stage, especially the change process, is perhaps the most difficult stage of the benchmarking process, as the buy-in of organizational members is critical for success.

EPILOGUE TO BLAST FROM THE PAST ROBOT COMPANY

We return now to see how the Blast from the Past Robot Company fared after its adoption of the JIT manufacturing system. BFTPR succeeded in decreasing its major rework rate from 5.8% to 3.3% and its minor rework rate from 13.6% to 7.0%. Major rework required scrapping the robot. Minor rework required correcting the alignment of robot body parts or fixing the ways the gears were functioning, and it had to be done in a specially designated rework area. Minor rework did not cycle back to the beginning of the process but instead went to a different processing area where direct labor and indirect labor costs were incurred.

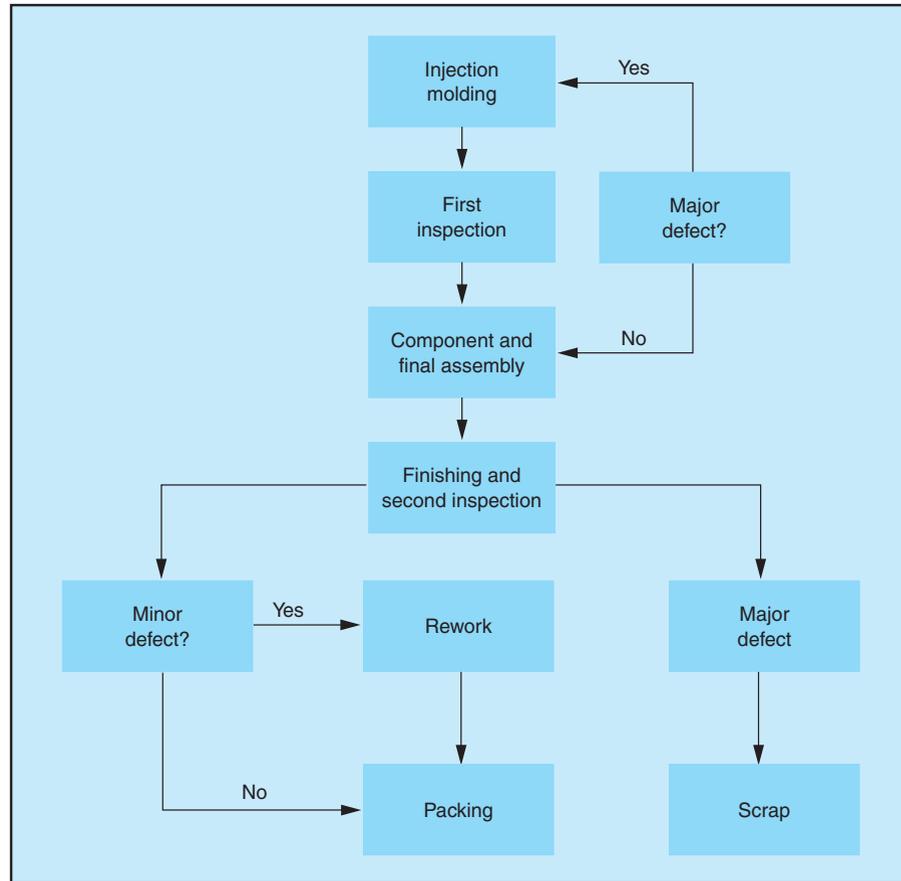
As a result of the improvements in rework rates, average production cycle time was reduced by 9.2 days, from 16.4 days to 7.2 days. Average work-in-process inventory was reduced from \$1,774,000 to \$818,000. Neva Dominguez, BFTPR Company's senior manufacturing manager, now had to prepare a report for her chief executive officer detailing how these improvements had affected the company's profits.

Production Flows

Neva began by obtaining the new production flowchart shown in Exhibit 7-12. She wanted to assess how the change to the JIT system was progressing. In the first step, the arms and legs of the robot were produced via an injection-molding process in plastic. To accomplish this, metal molds were designed for each component. A measured amount of polypropylene in the form of granules was fed into a horizontal heated cylinder where it was forced into a closed cold mold by a plunger. The liquid plastic entered the mold by means of a channel that led directly into the mold. Runners fed off the channel and moved the liquid plastic to each individual cavity. On cooling, the plastic took the shape of the mold. The process was designed so that each channel produced enough components for 60 robots.

Workers now assembled the various components using the JIT manufacturing system. Other components, such as the computer chip, nylon gears, wheels, and various parts, were added as the production process continued. Although BFTPR was striving to eliminate defective robots through the JIT process, achieving this goal was going to take some time. Thus, at the end of the process, any defective robots were rejected and returned for rework or scrapping, depending on the defect. Several finishing operations and inspections were performed next. Any excess plastic, or flashing, from the molding process was eliminated. The toy robot was then polished to a high gloss. During this process, each robot was inspected. A separate rework area was set aside for correcting the defects and reinserting the robots to ensure that no defects remained. Robots that passed inspection, either before or after rework, were packed and made available for shipment to customers. Neva concluded that the integration of the JIT system into the overall production flow was relatively successful.

Exhibit 7-12
BFTPR Company:
Production
Flowchart



Effects on Work-in-Process Inventory

Neva next turned her attention to records for work-in-process inventory. She had already found that the average work-in-process inventory decreased by \$956,000 after the implementation of the JIT system. She determined from meetings with production personnel that some work-in-process inventory was still maintained between each pair of successive process stages because each batch of robots had to await the completion of work on the preceding batch. Neva could find no detailed records to identify the change in work-in-process inventory. The number of major and minor defects, however, directly influenced it. When defect rates were high, inventory of rejected robots would build up, awaiting rework or scrap. More important, production supervisors sought to accumulate a large inventory of work in process in stages occurring after the two inspection points to enable them to keep busy when many robots were rejected. Therefore, production managers attributed the reduction in work-in-process inventory entirely to reductions in defect rates.

Effect on Production Costs

An important part of Neva's analysis was an assessment of the impact that the improvement in defect rates had on production costs. Direct materials costs included

the cost of the plastic content and the cost of the gears and the computer chip in the robot. The average cost of this type of chip in a robot was \$58.

Neva also collected information about direct labor and time-driven ABC support costs for each stage of the production process. Exhibit 7-13 includes these costs presented on a unit (robot) basis. The support costs include material handling, indirect labor and machine time for setup of molds for each batch, and power.

Cost of Rework

Remembering that rework costs are considered internal failure costs, what is the cost of a major defect detected during the first inspection following the injection-molding stage? Because a robot with a major defect cannot be processed further, all operations must be repeated, incurring the conversion costs again. Neva summarized the costs associated with the correction of a major defect and found that they were \$42 per robot (see Exhibit 7-14).

This estimation includes additional support costs because they represent the cost of the entire mold-making, casting, and first-inspection operations that were repeated to rectify the major defect. Neva found it somewhat easier to assess the costs of correcting minor defects, which are detected at the second inspection and do not require the rejection of the entire robot. Instead, such minor defects require additional rework operations. Therefore, the additional costs of correcting minor defects are only the rework costs. Neva did some new analyses and determined that the cost of rework per robot equaled the following:

Direct rework labor	\$24
Support	<u>12</u>
Total cost	\$36

Exhibit 7-13
BFTPR Company:
Conversion Costs
per Robot by
Production Stages

	INJECTION MODELING	FIRST INSPECTION	COMPONENT AND FINAL ASSEMBLY	FINISHING AND SECOND INSPECTION	PACKING
Direct labor (including fringe benefits)	\$14	\$10	\$20	\$8	\$6
Support	<u>14</u>	<u>4</u>	<u>14</u>	<u>3</u>	<u>10</u>
Total costs	\$28	\$14	\$34	\$11	\$16

Exhibit 7-14
BFTPR Company:
Cost per Unit
(Robot) for the
Correction of a
Major Defect

TYPE OF COST	AMOUNT
Conversion costs for injection molding:	
Direct labor	\$14
Support	14
Costs of first inspection:	
Direct labor	10
Support	<u>4</u>
Total costs	\$42

BFTPR manufactures and sells 180,000 robots each year. Before implementation of the JIT system, on average, 10,440 ($180,000 \times 0.058$) major defects and 24,480 ($180,000 \times 0.136$) minor defects occurred each year. Now, only 5,940 ($180,000 \times 0.033$) major defects and 12,600 ($180,000 \times 0.070$) minor defects occur, representing a reduction of 4,500 and 11,880 defects, respectively. Therefore, the cost savings of correcting fewer defects because of the JIT system are \$189,000 ($\$42 \times 4,500$) for major rework and \$427,680 ($\$36 \times 11,880$) for minor rework:

	MAJOR DEFECTS	MINOR DEFECTS
Before JIT	10,440	24,480
After JIT	5,940	12,600
Reduction	4,500	11,880
Cost per correction	$\times \$42$	$\times \$36$
JIT cost reduction	\$189,000	\$427,680

Cost of Carrying Work-in-Process Inventory

Neva turned next to the problem of evaluating the cost savings resulting from the reduction in the amount of work-in-process inventory. Interest rates on bank loans to finance the investment in inventories averaged 12.5% per year. With a reduction of \$956,000 in work-in-process inventory ($\$1,774,000 - \$818,000$), the cost of financing also decreased by \$119,500 ($\$956,000 \times 0.125$).

In addition, Neva estimated that support costs for various production stages included a total cost of \$30 per batch (of 60 robots) that pertained to activities such as work-in-process, inventory handling, and storage. With the 53.89% reduction in work-in-process inventory [$100 \times (\$956,000 \div \$1,774,000)$], Neva estimated these related costs would also decrease by about 30% or, equivalently, by about \$9 per batch ($\30×0.30). With an annual production of 180,000 robots in 3000 batches ($180,000 \div 60$), Neva expected a decrease of \$27,000 in the costs of work-in-process inventory handling and storage costs ($\$9 \times 3,000$). As in the case of Pinsky Electric Corporation, however, Neva's estimate of \$27,000 represented the reduction in the demand for these activities because of the reduction in work-in-process inventory. Over time, these costs should decrease by this amount, but for the reduction to actually occur, the plant management must identify the personnel and other resources committed to this activity and eliminate the resources not required because of the reduction in the demand for them.

Benefits from Increased Sales

Neva finally decided to evaluate whether the reduction in the production cycle time had resulted in any gains in sales. For this purpose, she met with the marketing manager, Emma Rothschild. Emma pointed out that annual sales had remained stable at around 180,000 robots for the past three years; however, she did believe that the improvement in the production cycle time had had an impact on sales. Because of increased competition in the robot market, Emma had expected to lose sales of about 2,000 robots. But the reduction of 6.5 days in the production cycle time had permitted her to respond more aggressively to market demand by offering the robots to customers with a much shorter lead time. Emma believed that the shorter production cycle time led to maintaining sales of about 2,000 robots that otherwise would have been lost. As a result, BFTPR had not lost any market share in this market segment.

Neva determined that the average net selling price (the net of sales commission and shipping costs) for these 2,000 robots was \$250. Exhibit 7-15 presents her list of the

Exhibit 7-15
BFTPR Company:
Additional Costs
of Production per
Robot

TYPE OF COST	COST PER ROBOT	
Direct materials:		
Chip	\$58.00	
All others	32.00	
Incremental conversion costs:		
Injection molding	28.00	
First inspection	14.00	
Component and final assembly	34.00	
Second inspection	11.00	
Packing	16.00	
Prorated rework costs:		
Major defects ^a	1.43	
Minor defects ^b	2.71	
Total incremental costs	\$197.14	
Average net sales price	\$250.00	
Contribution margin per robot	\$52.86	
$^a \frac{33}{1,000 - 33} \times \$42 = \$1.43$		
$^b \frac{70}{1,000 - 70} \times \$36 = \$2.71$		

additional costs for the production of these robots. Notice in Exhibit 7-15 that rework costs are prorated over the good units of production. For example, additional costs for major rework are \$42 for each robot that requires rework. For every 1,000 robots produced, an average of 33 robots ($1,000 \times 3.3\%$) now require major rework. Therefore, the company obtains 967 good robots ($1,000 - 33$). The total additional major rework cost for 33 robots is \$1,386 ($\42×33), which is borne by the 967 good robots at the rate of \$1.43 ($\$1,386 \div 967$) per good robot.

The profit is estimated to be \$52.86 per robot, or \$105,720 in total for the 2,000 robots ($\$52.86 \times 2,000$). Without the JIT system and the consequent reduction in cycle time, this contribution from sales would have been lost.

Summary of Costs and Benefits

Exhibit 7-16 displays Neva's summary of the benefits from the quality improvement program. Total estimated annual benefits of \$868,900 are much greater than the one-time costs of \$300,000 spent on the JIT system and worker training discussed in this chapter's opening vignette.

Exhibit 7-16
BFTPR Company:
Summary of
Annual Benefits
Resulting from
the JIT System

Reduction in network costs:		
Major rework	\$189,000	
Minor rework	427,680	\$616,680
Reduction in work-in-process inventory-related costs:		
Financing costs	119,500	
Inventory handling and storage-activity costs	27,000	146,500
Contribution from sales increases resulting from improved production cycle time		105,720
Total annual benefits		\$868,900

SUMMARY

Managers need various types of costs and other functional information to assess the impact of process decisions, such as improved plant layouts that streamline production operations. A detailed evaluation of implemented actions may shed light on ways to increase the benefits derived from them. Managers can choose from three general types of facility designs: (1) process layout, in which all similar equipment or functions are grouped together, (2) product layouts, in which equipment is organized to accommodate the production of a specific product, and (3) cellular manufacturing, in which a plant is divided into a number of cells so that within each cell all machines required to manufacture a group of

similar products are arranged in close proximity. Managers can also apply the tools of JIT or lean manufacturing, kaizen, and benchmarking to improve their operations.

Finally, the implementation of a JIT or lean manufacturing system has many positive effects on the levels of work-in-process inventory, the cost of support activities of handling and storing work-in-process inventory, and the amounts of major and minor rework. Further, it reduces cycle times so that there are shorter lead times to fulfilling customer orders. All these changes have a very tangible and quantifiable bottom-line effect.

KEY TERMS

appraisal costs, 269	external failure costs, 269	prevention costs, 269
benchmarking, 275	group benchmarking, 278	process layout, 256
benchmarking (performance) gap, 279	group technology, 259	processing cycle efficiency (PCE), 261
certified supplier, 269	indirect/third-party benchmarking, 278	processing time, 261
cooperative benchmarking, 278	internal failure costs, 269	product layout, 257
cost of nonconformance (CONC) to quality standards, 268	investments, 256	quality costs, 269
cost-of-quality (COQ) report, 269	just-in-time (JIT) manufacturing, 270	theory of constraints (TOC), 255
cycle time, 255	kaizen costing, 273	throughput contribution, 256
database benchmarking, 278	lean manufacturing, 268	unilateral (covert) benchmarking, 278
	operating costs, 256	

ASSIGNMENT MATERIALS

Questions

- 7-1 The theory of constraints relies on three measures: throughput contribution, investments, and operating costs. Define these three measures in the context of the theory of constraints. **(LO 1)**
- 7-2 What is the difference between process and product layout systems? **(LO 2)**
- 7-3 What is group technology? **(LO 2)**
- 7-4 Describe the lean manufacturing approach. **(LO 3)**
- 7-5 What is meant by the phrase *cost of nonconformance* in relation to quality? **(LO 4)**
- 7-6 Waste, rework, and net cost of scrap are examples of what kinds of quality costs? **(LO 4)**
- 7-7 Quality engineering, quality training, statistical process control, and supplier certification are what kinds of quality costs? **(LO 4)**
- 7-8 List three examples for each of the following quality costing categories:
a. Prevention costs
b. Appraisal costs
c. Internal failure costs
d. External failure costs. **(LO 4)**
- 7-9 How is a just-in-time manufacturing system different from a conventional manufacturing system? **(LO 5)**
- 7-10 What creates the need to maintain work-in-process inventory? Why is work-in-process inventory likely to decrease on the implementation of group technology, just-in-time production, and quality improvement programs? **(LO 2, 5)**
- 7-11 Why are production cycle time and the level of work-in-process inventory positively related? **(LO 2, 5)**

- 7-12 List two types of costs incurred when implementing a group technology layout. (LO 2)
- 7-13 What are two types of financial benefits resulting from a shift to group technology, just-in-time production, or continuous quality improvements? (LO 2, 5)
- 7-14 What is kaizen costing? (LO 6)
- 7-15 When is a cost variance investigation undertaken under kaizen costing? (LO 6)
- 7-16 Why is it said that a kaizen costing system operates “outside the standard costing system”? (LO 6)
- 7-17 What is benchmarking, and why is it used? (LO 7)
- 7-18 What are the five stages of the benchmarking process? (LO 7)
- 7-19 What are the three broad classes of information on which firms interested in benchmarking can focus? Describe each. (LO 7)
- 7-20 What stage of the benchmarking process is the most important for benchmarking management accounting methods? Why? (LO 7)
- 7-21 What are the two general methods of information gathering and sharing when undertaking a benchmarking exercise? (LO 7)
- 7-22 What are the three types of information gathering and sharing used under the cooperative form of benchmarking? (LO 7)
- 7-23 What is a benchmarking (performance) gap? (LO 7)
- 7-24 What is the additional cost of replacing one unit of a product rejected at inspection and scrapped? (LO 4, 8)
- 7-25 What is the additional cost if a unit rejected at inspection can be reworked to meet quality standards by performing some additional operations? (LO 4, 8)
- 7-26 What costs and revenues are relevant in evaluating the profit impact of an increase in sales? (LO 8)

Exercises

- LO 2, 5 7-27 *Facilities layout* How would you classify the layout of a large grocery store? Why do you think it is laid out this way? Can you think of any way to improve the layout of a conventional grocery store? Explain your reasoning. (*Hint*: Think about JIT, cycle time, and so on.)
- LO 4 7-28 *Quality cost categories* Regarding the quality costing categories, how do prevention costs differ from appraisal costs? How do internal failure costs differ from external failure costs?
- LO 4 7-29 *Quality cost categories* Of the four quality costing categories, which quality cost is the most damaging to the organization? Explain.
- LO 5, 8 7-30 *JIT manufacturing and cost savings* Boris Company introduced JIT manufacturing last year and has prepared the following data to assess the benefits from the change:

CATEGORY	BEFORE THE CHANGE	AFTER THE CHANGE
Production cycle time	50 days	25 days
Inventories	\$220,000	\$40,000
Total sales	\$1,000,000	\$1,500,000
Costs as percent of sales:		
Direct materials	25%	20%
Direct labor	20%	15%
Support	27%	17%

Inventory financing costs are 12% per year. Support costs are based on a time-driven activity-based costing analysis. Estimate the total financial benefits that resulted from the switch to JIT manufacturing operations.

- LO 8 7-31 *Inventory carrying costs* SMY Corporation produces 60,000 videophones per year. The company estimates its direct material costs for the videophone to be \$300 per unit and its conversion (direct labor plus support) costs to be

\$400 per unit. Annual inventory carrying costs, not included in these costs, are estimated to be 10%.

SMY's average inventory levels are estimated as follows:

Direct material	2 months of production
Work in process (100% complete for materials and 50% for conversion)	2 months of production
Finished goods	1 month of production

Compute the annual inventory carrying costs for SMY Corporation.

Problems

LO 1 7-32 *ABC and TOC* Discuss the similarities and differences between activity-based costing and the theory of constraints, as well as situations in which one approach might be preferable to the other.

LO 2, 5, 8 7-33 *Relevant cost and revenues: changes in facilities layout* To facilitate a move toward JIT production, AB Company is considering a change in its plant layout. The plant controller, Anita Bentley, has been asked to evaluate the costs and benefits of the change in plant layout. After meeting with production and marketing managers, Anita has compiled the following estimates:

- Machine moving and reinstallation will cost \$100,000.
- Total sales will increase by 20% to \$1,200,000 because of a decrease in production cycle time required under the new plant layout. Average contribution margin is 31% of sales.
- Inventory-related costs will decrease by 25%. Currently, the annual average carrying value of inventory is \$200,000. The annual inventory financing cost is 15%.

Should AB implement the proposed change in plant layout? Support your answer.

LO 2, 5 7-34 *Cycle time efficiency and JIT* Walker Brothers Company is considering the installation of a JIT manufacturing system in the hope that it will improve the company's overall processing cycle efficiency. Data from the traditional system and estimates for the JIT system are presented here for their Nosun product:

TIME CATEGORY	TRADITIONAL SYSTEM	JIT SYSTEM
Storage	4 hours	1 hour
Inspection	40 minutes	5 minutes
Moving	80 minutes	20 minutes
Processing	2 hours	75 minutes

Required

- (a) Calculate processing cycle efficiency (PCE) under the traditional and JIT systems for the Nosun product.
- (b) Based strictly on your PCE calculations above, should Walker Brothers implement the JIT system? Explain.

LO 2, 5, 8 7-35 *JIT and group technology* You are a manufacturing manager faced with the decision about how to improve manufacturing operations and efficiency. You have been studying both group technology and JIT manufacturing systems. Your boss expects you to prepare a report covering the costs and benefits of each approach.

Required

Write a detailed memorandum discussing the costs and benefits of group technology versus JIT.

- LO 8** 7-36 *Quality improvement programs and cost savings* Gurland Valves Company manufactures brass valves that meet precise specification standards. All finished valves are inspected before being packaged and shipped to customers. Rejected valves are returned to the initial production stage to be melted and recast. Such rework requires no new materials in casting but requires new materials in finishing. The following unit cost data for direct materials, direct labor, and time-driven activity-based costing (ABC) support are available:

COSTS	CASTING	FINISHING	INSPECTION	PACKING	TOTAL
Direct materials	\$225	\$12	\$0	\$8	\$245
Direct labor	84	121	24	16	245
Support	122	164	30	20	336

As a result of a quality improvement program, the reject rate has decreased from 6.4% to 5.1%, and the number of rejects has decreased by $(6.4\% - 5.1\%) \times (10,000)$ units. Improvements in reject rates have also led to a decrease in work-in-process inventory from \$386,000 to \$270,000. Inventory carrying costs are estimated to be 15% per year. Estimate the annual cost savings as a result of the quality improvement, assuming that capacity costs as indicated by the time-driven ABC support costs can be reduced if not needed.

- LO 2, 4** 7-37 *Group technology and processing cycle efficiency* Ray Brown's company, Whisper Voice Systems, is trying to increase its processing cycle efficiency (PCE). Because Ray has a very limited budget, he has been searching for a way to increase his PCE by using group technology. One of Ray's manufacturing managers, Maria Lopez, has been studying group technology and claims that with minimal cost that includes downtime in the operation, she can rearrange existing machinery and workers and improve PCE. Ray is quite skeptical about this and decides to allow Maria to rearrange a small part of his operation. For Ray to be satisfied, he has stated that PCE must increase by 12%. PCE data before and after the rearrangement are as follows:

TIME CATEGORY	BEFORE REARRANGEMENT	AFTER REARRANGEMENT
Inspection	30 minutes	15 minutes
Moving	45 minutes	10 minutes
Processing	70 minutes	30 minutes
Storage	55 minutes	20 minutes

Does the change in PCE meet Ray's requirement? Why or why not?

- LO 2** 7-38 *Facilities layout* One aspect of facilities layout for McDonald's is that when customers come into the building, they can line up in one of several lines and wait to be served. In contrast, customers at Wendy's are asked to stand in one line that snakes around the front of the counter and to wait for a server to become available.

Required

- (a) What is the rationale for each approach?
(b) Which approach do you favor from (1) a customer's perspective and (2) management's perspective? Explain.

- LO 4** 7-39 *Quality of customer service* Read “Everyone Likes to Laud Serving the Customer; Doing It Is the Problem,” by Carol Hymowitz (*Wall Street Journal*, February 27, 2006, p. B1).

Required

- (a) According to the article, what measures are commonly used to evaluate customer service representatives, and what measure(s) should be used?
- (b) Explain how the prevention, appraisal, and external failure aspects of the cost-of-quality framework might be applied to customer service processes. In your response, include a discussion of which of the three aspects companies should focus on and illustrate how evaluation measures may affect performance in customer service processes.

- LO** 7-40 *Quality costing: balancing category costs* Managers concerned with improving quality sometimes have a difficult balancing act, given the four types of quality costs they have to manage. As a new manager, you are trying to figure out a strategy for managing \$2 million of quality costs; your total quality costs cannot exceed 4% of sales.

Required

You need to decide how much should go into each of the four quality-cost categories. How would you go about allocating these costs? What trade-offs would you have to make as you allocate the costs?

- LO 4** 7-41 *Preparing a cost-of-quality report* The following information shows last year’s quality-related costs for the Madrigal Company:

ITEM	AMOUNT
Quality engineering	\$600,000
Warranty claims	2,814,000
Product liability lawsuits	5,400,000
Research of customer needs	90,000
Maintenance of test equipment	420,000
Returned products	1,440,000
Rework costs	1,440,000
Quality training	150,000
Process control monitoring	1,200,000
Inspection of and testing of incoming materials	480,000
Repair costs in the field	1,020,000
Statistical process control	300,000
Product recalls	2,400,000
Waste	840,000
Net cost of scrap	762,000
Product quality audits	570,000
Downtime due to defects	150,000
Supplier certification	108,000

Total sales for the year were \$120,000,000.

Required

- (a) Prepare a cost-of-quality report grouping costs into prevention, appraisal, internal failure, and external failure. Also show costs as a percent of sales.
- (b) Interpret the data and make recommendations to Madrigal’s management.

- LO 4** 7-42 *Preparing a cost-of-quality report* The following data have just been gathered on last year's quality-related costs at the Ideal Company:

COST CATEGORY	AMOUNT
Product recalls	\$325,000
Downtime due to defects	600,000
Warranty claims	420,000
Inspection of and testing of incoming materials	300,000
Product liability lawsuits	500,000
Process quality audits	350,000
Rework costs	2,000,000
Quality training	150,000
Process control monitoring	350,000
Repair costs in the field	375,000
Statistical process control	300,000
Waste	900,000
Net cost of scrap	1,500,000
Supplier certification	350,000
Quality engineering	200,000
Returned products	380,000

Total sales last year were \$75,000,000.

Required

- (a) Prepare a cost-of-quality report grouping costs into prevention, appraisal, internal failure, and external failure. Also show costs as a percentage of sales.
 (b) Interpret the data and make recommendations to Ideal's management.

- LO 6** 7-43 *Kaizen versus standard costing* What factors differentiate kaizen costing from standard costing?
LO 6 7-44 *Kaizen costing: knowledge* According to the kaizen costing approach, who has the best knowledge to reduce costs? Why is this so?
LO 6 7-45 *Kaizen meaning* What do the terms *kaizen* and *kaizen costing* mean?
LO 6 7-46 *Kaizen costing* Under what condition will the cost savings due to kaizen costing not be applied to production?
LO 6 7-47 *Kaizen costing: managerial issues* Kaizen costing is a method that many Japanese companies have found effective in reducing costs.

Required

- (a) What are the biggest problems in using kaizen costing?
 (b) How can managers overcome these problems?
- LO 7** 7-48 *Benchmarking partners* What are the key factors in identifying benchmarking partners? Explain why these factors are important.
LO 7 7-49 *Benchmarking mobile web experiences* As a manager asked to benchmark another organization's mobile web experience provided to users, on what factors would you gather information? Why?
LO 6 7-50 *Standard costing versus kaizen costing* Many companies are interested in adopting a kaizen costing approach to reducing costs. However, they are not sure how their current standard costing system will fit with the kaizen costing approach.

Required

How do the standard costing system and the kaizen costing system differ? Can the two systems coexist? Explain.

- LO 6** 7-51 *Kaizen costing versus standard costing* Your organization, located in Worthington, Ohio, is contemplating introducing kaizen costing to help with cost reduction. As someone who has an understanding of management accounting, you have been asked for your opinion. Specifically, some of your colleagues are wondering about the differences between standard costing and kaizen costing.

Required

Write a report discussing the following:

- (a) The similarities and differences between standard costing and kaizen costing
- (b) Under what conditions kaizen costing can be adapted to U.S. organizations.

- LO 7** 7-52 *Benchmarking: field exercise with other students* Assume that you are an average student who has a desire to be one of the best students in class. Your professor suggests that you benchmark the working habits of the best student in the class. You are somewhat skeptical but decide to take on the challenge.

Required

How would you go about this benchmarking exercise? In answering this question, describe the process that you would undertake in benchmarking the best student, the factors that you would try to study, and how you would implement changes to your working habits.

- LO 7** 7-53 *Benchmarking: field exercise in a company* Benchmarking a product, process, or management accounting method takes a great deal of time and effort. Companies have many choices when it comes to conducting a benchmarking study. For example, in following the five stages of the benchmarking process, companies have to decide how to proceed, who to select as benchmarking partners, and what information they are willing to share and to gather.

Required

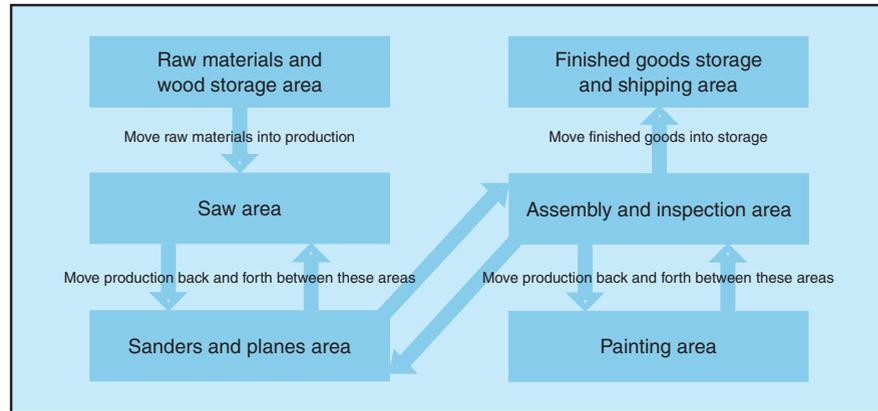
Locate a company in your local community that has engaged in a benchmarking study. Try to arrange a visit to the company (perhaps through your professor, relative, or friend) in order to talk to employees who have been involved in the benchmarking effort. Using the five-stage process, critique the approach that this company followed. What are the similarities and differences between what this company did and the process described in this chapter? Be specific about the procedures that were used and the variables that were assessed. Finally, what were the results of the benchmarking exercise at this company? Was it a success or a failure? Why?

Cases

LO 2 7-54 *Facilities layout, value-added activities* Woodpoint Furniture Manufacturing produces various lines of pine furniture. The plant is organized so that all similar functions are performed in one area, as shown in Exhibit 7-17. Most pieces of furniture are made in batches of 10 units.

Raw materials are ordered and stored in the raw materials storage area. When an order is issued for a batch of production, the wood needed to complete that batch is withdrawn from the raw materials storage area and taken to the saw area. There the wood is sawed into the pieces that are required for the production lot.

Exhibit 7-17
Woodpoint
Furniture
Manufacturing



The pieces are then transferred to the sanding and planing area, where they are stored awaiting processing in that area. When the machines are free, any sanding or planing is done on all the pieces in the batch. Any pieces that are damaged by the planing or sanding are reordered from the saw area. The other pieces in the lot are set aside in a storage area when pieces have to be reordered from the saw area.

When all of the pieces have been sanded or planed, the pieces are then transferred to the assembly area, where they are placed in a large bin to await assembly. Pieces are withdrawn from the bin as assembly proceeds. Defective pieces are returned to the saw or sand and plane area, where they are remanufactured.

As assembly proceeds or when assembly is completed, depending on the product, any required painting or staining is done in the painting area. Pieces to be stained or painted are transferred back and forth on a trolley between the assembly and paint areas. The paint department has a storage area for pieces awaiting painting. Whenever assembly is halted to await pieces that have been sent for painting and staining, the rest of the pieces in that batch are put into the storage bin to await the return of the stained or painted pieces.

When assembly is completed, the quality inspector checks the product. Any defective products are returned to the appropriate department for rework. When the product is approved, it is packaged and put into final storage to await an order by the customer.

Required

- Chart the process (that is, specify, from start to finish, the activities used) for making furniture at Woodpoint Furniture Manufacturing. Which activities do you think add value from the customer's perspective?
- What performance indicators do you think are critical in evaluating the performance of this manufacturing operation from the standpoint of customers and the company?

LO 2, 3, 5 7-55 *Facilities layout, lean manufacturing, brand management, value-added activities*
Some firms in the fashion industry have adopted lean or just-in-time approaches to maintain or increase their competitive advantage. Read the following articles or other resources to address the questions below: "Brand-New Bag: Louis Vuitton Tries Modern Methods On Factory Lines" (C. Passariello, *The Wall Street Journal*, October 9, 2006, p. A1) and "Zara Thrives By Breaking All Rules" (K. Capell, *BusinessWeek*, October 20, 2008, p. 66).

Required

- (a) Compare Louis Vuitton's previous and current processes for making a bag. For example, how many people and days are required, what are the workers' degrees of specialization, and what improvements have resulted?
- (b) How did Louis Vuitton's previous process for making bags support the company's value proposition?
- (c) How have practices from competitors such as Zara changed Louis Vuitton's view of what its target customers want? Has Louis Vuitton's value proposition changed? If so, how well will the new process support the company's value proposition?
- (d) What performance indicators do you think are critical in evaluating the performance of this manufacturing operation from the standpoint of customers and the company?

LO 4 7-56 *Cost-of-quality framework, health care* Johnson & Johnson (www.jnj.com), a major health care and pharmaceutical firm, voluntarily recalled a number of its products in 2010 because of quality problems. These products included hip-repair implants, contact lenses, and over-the-counter medications.

Required

Using information from the company's website, the business press, or other sources, develop responses to the following:

- (a) What specific quality problems were reported?
- (b) What are some examples of external failure costs related to the recalls? What financial estimates are available?
- (c) What new prevention or appraisal costs will the company incur in response to the quality problems?

LO 4 7-57 *Relevant costs, qualitative factors, cost-of-quality framework, environmental issues* Kwik Clean handles both commercial laundry and individual customer dry cleaning. Kwik Clean's current dry cleaning process involves emitting a pollutant into the air. In addition, the commercial laundry and dry cleaning processes produce sediments and other elements that must receive special treatment before disposal. Pat Polley, Kwik Clean's owner, is concerned about the cost of dealing with increasingly stringent laws and environmental regulations. Recent legislation requires Kwik Clean to reduce its amount of air pollution emissions.

To reduce pollution emissions, Polley is considering the following two options:

- **Option 1:** Invest in equipment that would reduce emissions through filtration. The equipment would involve a large capital expenditure but would bring Kwik Clean into compliance with current regulations for emissions.
- **Option 2:** Invest in a new dry cleaning process that would eliminate current air pollution emissions, partly by using a different solvent than the one currently used. This option would require an even larger capital expenditure than option 1, but the new equipment would reduce some operating costs. Moreover, Kwik Clean might be able to market its environmentally safer process to increase business.

In evaluating the two options and current operations, Polley has enumerated the following items:

1. The price and quantity of solvent used in current operations (and option 1).
2. The price and quantity of the new solvent that would be used in option 2.
3. The purchase price of new equipment for option 1 and for option 2.
4. The cost of removing old equipment and installing new equipment under option 2.
5. The purchase price of the filtration equipment in option 1 as well as the useful life of the equipment.

6. The purchase price of the current equipment and its remaining useful life.
7. The salvage value of the current equipment, which would be sold under option 2.
8. Polley's salary and fringe benefits.
9. Labor costs for current operations (and option 1) and option 2; labor costs would be lower under option 2 than under option 1.
10. Training costs associated with the new equipment in option 2.
11. Legal fees paid to handle paperwork associated with hazardous waste liabilities connected with the sediments produced when cleaning commercial laundry by the current operations (the same sediments would be produced with the equipment in option 2).
12. Storage and disposal costs associated with the sediments produced when cleaning commercial laundry.
13. Insurance for the equipment and workers; under option 2, insurance fees would be reduced from the current level.

Polley was concerned about recent events that were publicized locally. A newspaper article reported that the Occupational Safety and Health Administration fined one of Polley's competitors several thousand dollars for unsafe employee working conditions related to handling solvents. Another business incurred a very expensive cleanup for accidental hazardous waste leakage that contaminated the soil. The leakage received major attention in the local television and radio news broadcasts and was headlined in the local newspapers.

Required

- (a) Which costs are relevant to Polley's decision to choose either option 1 or option 2?
- (b) What qualitative factors is Polley likely to consider in choosing either option 1 or option 2?
- (c) Explain how the cost-of-quality framework of prevention, appraisal, internal failure, and external failure might be applied to operations with environmental pollution, where *failures* are defined as accidental spillage or leakage of hazardous wastes or as illegal levels of pollutants. On which of the four cost-of-quality categories would you advise Polley to focus her attention?

LO 2, 4 7-58 *Customer service processes, non-value-added activities* Daniel Morris purchased a 42-inch plasma television, manufactured by TVCO, from a local electronics store that permits customers to return defective products within 30 days of purchase. Approximately 45 days after Daniel's purchase, the TV began to malfunction periodically. Because Daniel could not return the TV to the local store, he turned to the warranty information and found that the warranty included picking up the approximately 100-pound TV from the owner's home, repairing the TV, and delivering the repaired TV to the owner's home. TVCO's customer service process for handling warranty repairs is as follows:

1. The customer calls Customer Service (CS) to request authorization of the TV repair.
2. CS requests the customer to mail or fax the receipt, TV model number, and serial number.
3. On receipt of the information, CS locates a nearby repair shop to perform the repair.
4. CS forwards the repair request to the Warranty Department (WD) for approval.
5. On approval, WD informs CS so that CS can inform the customer and fax authorization for the repair to the approved repair shop.
6. The customer contacts the designated repair shop to arrange for the TV pickup. The repair shop picks up the TV.
7. The repair shop diagnoses the problem and orders parts.
8. On receipt of the parts, the shop repairs the TV and delivers it to the customer.
9. If the TV cannot be repaired, TVCO replaces the defective TV with a new one.

Accordingly, Daniel called CS to request authorization to repair the TV and faxed the receipt, TV model number, and serial number to CS. CS located a repair shop (RS1) 30 miles from Daniel's city of Anytown. On obtaining WD's approval, CS faxed authorization for the repair to the approved

repair shop. Daniel contacted RS1 to arrange for the TV pickup, but RS1 refused to pick up the TV, stating that Daniel's location is too far away. After several more phone calls to CS, with wait times before talking to a CS representative ranging from 25 to 45 minutes, CS authorized another repair shop, RS2. RS2 picked up the TV, and Daniel informed RS2 that he planned to move to Othertown in two weeks and therefore hoped the TV could be repaired by then. RS2 did not look at the TV until Daniel called eight days later to check on progress. RS2 then diagnosed the problem and contacted TVCO for parts for the repair and was told that parts would not be available for several weeks. Because of his impending move to another city, Daniel requested RS2 to return the TV to him, thinking that he would get the TV repaired in Othertown.

After moving to Othertown, Daniel again called CS to request authorization for the TV repair. After several phone calls with sizable wait times before talking to CS, and several miscommunications between CS and WD that led Daniel to talk to a supervisor, CS located RS3 in Othertown. However, RS3 was backlogged and would not pick up the TV for at least a week. RS3 picks up only on weekdays during regular working hours. Moreover, the technician would not look at the TV for at least 10 days after the TV arrived in the shop. Given the length of time that had now passed since Daniel's first contact with CS, Daniel found this situation unacceptable, so he called CS and asked to talk to a supervisor. The supervisor suggested other approved stores for the repair.

Daniel found RS4, which was willing to pick up the TV at a day's notice and diagnose problems as soon as possible so that parts could be ordered. Daniel called CS to arrange for authorization, and CS promised to call back soon. After a week with no response, Daniel called CS and was told that WD refused to authorize RS4 to perform the repair because WD thought Daniel still lived in Anytown and RS4 was too far from Anytown. Daniel called the supervisor again, and after a week the supervisor arranged for authorization for RS4 to do the repair. RS4 picked up the TV; by now, more than two months had passed since Daniel first contacted CS, and RS4 could not provide a definite date for completion of the repair. However, as promised, RS4 diagnosed the problem shortly after the TV arrived in the shop and ordered the apparently appropriate part. Disappointingly, changing the part did not correct the problem. TVCO suggested that RS4 try changing another part but could not provide an estimated date of arrival for the part. After Daniel's further phone calls, TVCO agreed to exchange the defective TV for a new one. By this time, more than three months had passed since Daniel first contacted CS.

Required

- (a) Assuming that TVCO has a performance measurement system for CS, what measures do you think the company is using to evaluate CS performance?
- (b) What measures reflect what the customer is concerned about?
- (c) What changes in the warranty service approval process might improve the process from the customer's perspective?
- (d) Compare how RS3 and RS4 have designed their repair process and explain to RS3 how it can reduce the time spent on non-value-added activities.

LO 8 7-59 Cost savings: replacement decision Rossman Instruments, Inc., is considering leasing new state-of-the-art machinery at an annual cost of \$900,000. The new machinery has a four-year expected life. It will replace existing machinery leased one year earlier at an annual lease cost of \$490,000 committed for five years. Early termination of this lease contract will incur a \$280,000 penalty. There are no other fixed costs.

The new machinery is expected to decrease variable costs from \$42 to \$32 per unit sold because of improved materials yield, faster machine speed, and lower direct labor, supervision, materials handling, and quality inspection requirements. The sales price will remain at \$56. Improvements in quality, production cycle time, and customer responsiveness are expected to increase annual sales from 36,000 units to 48,000 units.

The variable costs stated earlier exclude the inventory carrying costs. Because the new machinery is expected to affect inventory levels, the following estimates are also provided. The enhanced

speed and accuracy of the new machinery are expected to decrease production cycle time by half and, consequently, lead to a decrease in work-in-process inventory level from 3 months to just 1.5 months of production. Increased flexibility with these new machines is expected to allow a reduction in finished goods inventory from 2 months of production to just 1 month. Improved yield rates and greater machine reliability will enable a reduction in raw materials inventory from 4 months of production to just 1.5 months. Annual inventory carrying cost is 20% of inventory value.

CATEGORY	OLD MACHINE	NEW MACHINE
Average per unit cost of raw materials inventory	\$12	\$11
Average per unit cost of work-in-process inventory	25	20
Average per unit cost of finished goods inventory	46	36
Variable cost per unit sold	42	32

Required

- Determine the total value of annual benefits from the new machinery. Include changes in inventory carrying costs.
- Should Rossman replace its existing machinery with the new machinery? Present your reasoning with detailed steps identifying relevant costs and revenues.
- Discuss whether a manager evaluated on the basis of Rossman's net income will have the incentive to make the right decision as evaluated in part b.

LO 2,4 7-60 Customer service processes, non-value-added activities Precision Systems, Inc. (PSI).¹ Precision Systems, Inc. (PSI) has been in business for more than 40 years and has generally reported a positive net income. The company manufactures and sells high-technology instruments (systems). Each product line at PSI has only a handful of standard products, but configuration changes and add-ons can be accommodated as long as they are not radically different from the standard systems.

Faced with rising competition and increasing customer demands for quality, PSI adopted a total quality improvement program in 1989. Many employees received training and several quality initiatives were launched. Like most businesses, PSI concentrated on improvements in the manufacturing function and achieved significant improvements. However, little was done in other departments.

In early 1992, PSI decided to extend its total quality improvement program to its order entry department, which handles the critical functions of preparing quotes for potential customers and processing orders. Order processing is the first process in the chain of operations after the order is received from a customer. High-quality output from the order entry department improves quality later in the process, and allows PSI to deliver higher quality systems both faster and cheaper, thus meeting the goals of timely delivery and lower cost.

As a first step, PSI commissioned a cost of quality (COQ) study in its order entry department. The study had two objectives:

- To develop a system for identifying order entry errors
- To determine how much an order entry error costs.

PSI's Order Entry Department

PSI's domestic order entry department is responsible for preparing quotations for potential customers and taking actual sales orders. PSI's sales representatives forward requests for quotations to the order entry department, though actual orders for systems are received directly from customers. Orders for parts are also received directly from customers. Service-related orders (for parts or repairs), however, are generally placed by service representatives. When PSI undertook the COQ

¹ Source: Institute of Management Accountants, *Cases from Management Accounting Practice, Volume 12*. Adapted with permission.

study, the order entry department consisted of nine employees and two supervisors who reported to the order entry manager. Three of the nine employees dealt exclusively with taking parts orders, while the other six were responsible for system orders. Before August 1992, the other six were split equally into two groups: One was responsible for preparing quotations, and the other was responsible for taking orders.

The final outputs of the order entry department are the quote and the order acknowledgment or “green sheet.” The manufacturing department and the stockroom use the green sheet for further processing of the order.

The order entry department’s major suppliers are (1) sales or service representatives; (2) the final customers who provide them with the basic information to process further; and (3) technical information and marketing departments, which provide configuration guides, price masters, and similar documents (some in printed form and others online) as supplementary information. Sometimes the printed configuration guides contain information in the format the order entry requires, but other times it does not.

At times there are discrepancies in the information available to order entry staff and sales representatives with respect to price, part number, or configuration. These discrepancies often cause communication gaps between the order entry staff, sales representatives, and manufacturing.

An order entry staff provided the following example of lack of communication between a sales representative and manufacturing with respect to one order.

If the sales reps. have spoken to the customer and determined that our standard configuration is not what they require, they may leave a part off the order. [In one such instance] I got a call from manufacturing saying when this system is configured like this, it must have this part added. . . . It is basically a no charge part and so I added it (change order #1) and called the sales rep. and said to him, “Manufacturing told me to add it.” The sales rep. called back and said, “No [the customer] doesn’t need that part, they are going to be using another option . . . so they don’t need this.” Then I did another change order (#2) to take it off because the sales rep. said they don’t need it. Then manufacturing called me back and said, “We really need [to add that part] (change order #3). If the sales rep. does not want it then we will have to do an engineering special and it is going to be another 45 days lead time. . . .” So, the sales rep. and manufacturing not having direct communication required me to do three change orders on that order; two of them were probably unnecessary.

A typical sequence of events might begin with a sales representative meeting with a customer to discuss the type of system desired. PSI’s sales representatives have scientific knowledge that enables them to configure a specific system to meet a customer’s needs. After deciding on a configuration, the sales representative then fills out a paper form and faxes it or phones it in to an order entry employee, who might make several subsequent phone calls to the sales representative, the potential customer, or the manufacturing department to prepare the quote properly. These phone calls deal with such questions as exchangeability of parts, part numbers, current prices for parts, or allowable sales discounts. Order entry staff then keys in the configuration of the desired system, including part numbers, and informs the sales representative of the quoted price. Each quote is assigned a quotation number. To smooth production, manufacturing often produces systems with standard configurations in anticipation of obtaining orders from recent quotes for systems. The systems usually involve adding on special features to the standard configuration. Production in advance of orders sometimes results in duplication in manufacturing, however, because customers often fail to put their quotation numbers on their orders. When order entry receives an order, the information on the order is reentered into the computer to produce an order acknowledgment. When the order acknowledgment is sent to the invoicing department, the information is reviewed again to generate an invoice to send to the customer.

Many departments in PSI use information directly from the order entry department (these are the internal customers of order entry). The users include manufacturing, service (repair), stockroom, invoicing, and sales administration. The sales administration department prepares commission payments for each system sold and tracks sales performance. The shipping, customer support (technical support), and collections departments (also internal customers) indirectly use order

entry information. After a system is shipped, related paperwork is sent to customer support to maintain a service-installed database in anticipation of technical support questions that may arise. Customer support is also responsible for installations of systems. A good order acknowledgment (i.e., one with no errors of any kind) can greatly reduce errors downstream within the process and prevent later non-value-added costs.

Cost of Quality

Quality costs arise because poor quality may—or does—exist. For PSI’s order entry department, poor quality or nonconforming “products” refer to poor information for further processing of an order or quotation (see Exhibit 7-18 for examples). Costs of poor quality here pertain to the time spent by the order entry staff and concerned employees in other departments (providers of information, such as sales or technical information) to rectify the errors.

Class I Failures

Class I failure costs are incurred when nonconforming products (incorrect quotes or orders) are identified as nonconforming before they leave the order entry department. The incorrect quotes or orders may be identified by order entry staff or supervisors during inspection of the document. An important cause of Class I failures is lack of communication. Sample data collected from the order entry staff show that they encountered more than 10 different types of problems during order processing (see Exhibit 7-18 for examples). Analysis of the sample data suggests that, on average, it takes 2.3 hours (including waiting time) to rectify errors on quotes and 2.7 working days for corrections on orders. In determining costs, the COQ study accounted only for the time it actually takes to solve the problem (i.e., excluding waiting time). Waiting time was excluded because employees use this time to perform other activities or work on other orders. The total Class I failure costs, which include only salary and fringe benefits for the time it takes to correct errors, amount to more than 4% of order entry’s annual budget for salaries and fringe benefits (see Exhibit 7-19).

Class II Failures

Class II failure costs are incurred when nonconforming materials are transferred out of the order entry department. For PSI’s order entry department, “nonconforming” refers to an incorrect order acknowledgment as specified by its users within PSI. The impact of order entry errors on final (external) customers is low because order acknowledgments are inspected in several departments, so most errors are corrected before the invoice (which contains some information available on the

Exhibit 7-18 Examples of Failures

1. Incomplete information on purchase order
2. Transposition of prices on purchase order
3. More than one part number on order acknowledgment when only one is required
4. Incorrect business unit code (used for tracking product line profitability) on the order acknowledgment
5. Freight terms missing on the purchase order
6. Incorrect part number on order acknowledgment
7. Incorrect shipping or billing address on the order acknowledgment
8. Credit approval missing (all new customers have a credit approval before an order is processed)
9. Missing part number on order acknowledgment
10. Customer number terminated on the computer’s database (an order cannot be processed if customer number is missing)
11. Incorrect sales tax calculation on the order acknowledgment
12. Part number mismatch on purchase order

Exhibit 7-19
Estimated Annual Failure Costs (as a Percentage of Order Entry's Annual Salary and Fringe Benefits Budget)

	ORDER ENTRY	OTHER DEPARTMENTS	TOTAL COSTS
Class I failure costs			
Quotations	1.1%	0.4%	1.5%
Orders	0.9%	1.7%	2.6%
Total Class I failure costs	2.0%	2.1%	4.1%
Class II failure costs			
Order acknowledgments	2.6%	4.4%	7.0%
Change orders	2.6%	—	2.6%
Final customers	0.02%	0.1%	0.12%
Return authorizations	1.9%	—	1.9%
Total Class II failure costs	7.12%	4.5%	11.62%
Total failure costs	9.12%	6.6%	15.72%

order acknowledgment) is sent to the final customer. Corrections of the order entry errors do not guarantee that the customer receives a good quality system, but order entry's initial errors do not then affect the final customer. Mistakes that affect the final customer can be made by individuals in other departments (e.g., manufacturing or shipping).

Sample data collected from PSI's users of order entry department information show that more than 20 types of errors can be found on the order acknowledgment (see Exhibit 7-18 for examples). The cost of correcting these errors (salary and fringe benefits of order entry person and a concerned person from another PSI department) accounts for approximately 7% of order entry's annual budget for salaries and fringe benefits (see Exhibit 7-19).

In addition to the time spent on correcting the errors, the order entry staff must prepare a change order for several of the Class II errors. A change order may be required for several other reasons that cannot necessarily be controlled by order entry. Examples include (1) changes in ship-to or bill-to address by customers or sales representatives, (2) canceled orders, and (3) changes in invoicing instructions. Regardless of the reason for a change order, the order entry department incurs some cost. The sample data suggest that for every 100 new orders, order entry prepares 71 change orders; this activity accounts for 2.6% of order entry's annual budget for salaries and fringe benefits (see Exhibit 7-19).

Although order entry's errors do not significantly affect final customers, customers who find errors on their invoices often use the errors as an excuse to delay payments. Correcting these errors involves the joint efforts of the order entry, collections, and invoicing departments; these costs account for about 0.12% of order entry's annual budget (see Exhibit 7-19).

The order entry staff also spends considerable time handling return authorizations when final customers send their shipments back to PSI. Interestingly, more than 17% of the goods returned are because of defective shipments, and more than 49% fall into the following two categories: (1) ordered in error and (2) 30-day return rights. An in-depth analysis of the latter categories suggests that a majority of these returns can be traced to sales or service errors. The order entry department incurs costs to process these return authorizations, which account for more than 1.9% of the annual budget (see Exhibit 7-19). The total Class I and Class II failure costs account for 15.72% of the order entry department's annual budget for salaries and fringe benefits. Although PSI users of order entry information were aware that problems in their departments were sometimes caused by errors in order entry, they provided little feedback to order entry about the existence or impact of the errors.

Changes in PSI's Order Entry Department

In October 1992, preliminary results of the study were presented to three key persons who had initiated the study: the order entry manager, the vice president of manufacturing, and the vice president of service and quality. In March 1993, the final results were presented to PSI's executive council, the top decision-making body. During this presentation, the CEO expressed alarm not only at the variety

of quality problems reported, but also at the cost of correcting them. As a consequence, between October 1992 and March 1993, PSI began working toward obtaining the International Organization for Standardization's ISO 9002 registration for order entry and manufacturing practices, which it received in June 1993.

The effort to obtain the ISO 9002 registration suggests that PSI gave considerable importance to order entry and invested significant effort toward improving the order entry process. Nevertheless, as stated by the order entry manager, the changes would not have been so vigorously pursued if cost information had not been presented. COQ information functioned as a catalyst to accelerate the improvement effort. In actually making changes to the process, however, information pertaining to the different types of errors was more useful than the cost information.

Required

- (a) Describe the role that assigning costs to order entry errors played in quality improvement efforts at Precision Systems, Inc.
- (b) Prepare a diagram illustrating the flow of activities between the order entry department and its suppliers, internal customers (those within PSI), and external customers (those external to PSI).
- (c) Classify the failure items in Exhibit 7-18 as internal failures (identified as defective before delivery to internal or external customers, that is, Class I failures) or external failures (nonconforming "products" delivered to internal or external customers, that is, Class II failures) with respect to the order entry department. For each external failure item, identify which of order entry's internal customers (that is, other departments within PSI who use information from the order acknowledgment) will be affected.
- (d) For the order entry process, how would you identify internal failures and external failures, as defined in question (c)? Who would be involved in documenting these failures and their associated costs? Which individuals or departments should be involved in making improvements to the order entry process?
- (e) What costs, in addition to salary and fringe benefits, would you include in computing the cost of correcting errors?
- (f) Provide examples of incremental (fairly low-cost and easy to implement) and breakthrough (high-cost and relatively difficult or time consuming to implement) improvements that could be made in the order entry process. In particular, identify prevention activities that can be undertaken to reduce the number of errors. Describe how you would prioritize your suggestions for improvement.
- (g) Discuss the issues that PSI should consider if it wishes to implement a web-based ordering system that permits customers to select configurations for systems.
- (h) What nonfinancial quality indicators might be useful for the order entry department? How frequently should data be collected or information be reported? Can you make statements about the usefulness of cost-of-quality information in comparison to nonfinancial indicators of quality?