Chapter 14

The Production Cycle

Learning Objectives

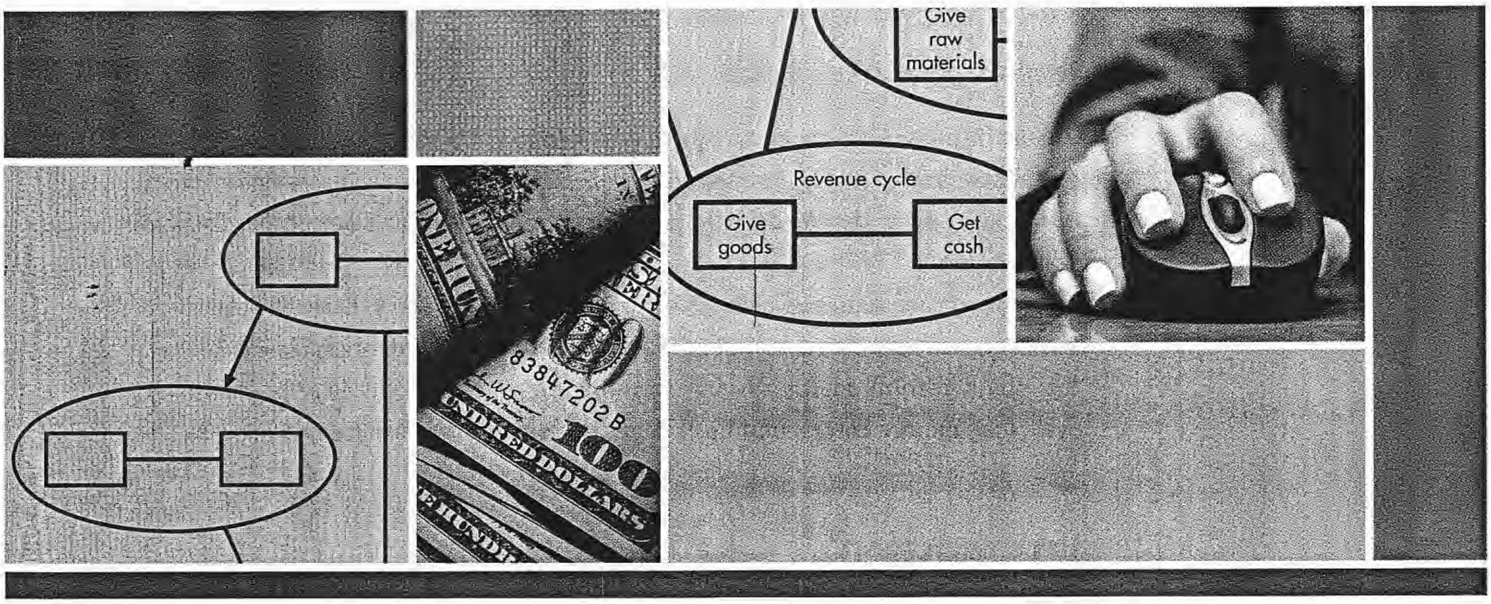
After studying this chapter, you should be able to:

1. Describe the major business activities and related information processing operations performed in the production cycle.
2. Identify major threats in the production cycle and evaluate the adequacy of various control procedures for dealing with those threats.
3. Explain how a company's cost accounting system can help it achieve its manufacturing goals.
4. Discuss the key decisions that must be made in the production cycle and identify the information required to make those decisions.

INTEGRATIVE CASE ALPHA OMEGA ELECTRONICS

LeRoy Williams, vice president for manufacturing at Alpha Omega Electronics (AOE), is concerned about problems associated with the company's change in strategic mission. Two years ago, AOE's top management decided to shift the company from its traditional position as a low-cost producer of consumer electronic products to a product differentiation strategy. Since then, AOE has increased the variety of sizes, styles, and features within each of its product lines.

To support this shift in strategic focus, AOE has invested heavily in factory automation. Top management also endorsed LeRoy's decision to adopt lean manufacturing techniques, with the goal of dramatically reducing inventory levels of finished goods. AOE's cost accounting system has not been changed, however. For example, manufacturing overhead is still allocated based on direct labor hours, even though automation has drastically reduced the amount of direct labor used to manufacture a product. Consequently, investments in new equipment and machinery have resulted in



dramatic increases in manufacturing overhead rates. This situation has created the following problems:

1. Production supervisors complain that the accounting system makes no sense and that they are being penalized for making investments that improve overall efficiency. Indeed, according to the system, some products now cost more to produce using state-of-the-art equipment than they did before the new equipment was purchased. Yet the new equipment has increased production capacity while simultaneously reducing defects.
2. The marketing and product design executives have all but dismissed the system's product cost figures as useless for setting prices or determining the potential profitability of new products. Indeed, some competitors have begun to price their products below what AOE's cost accounting system says it costs to produce that item.
3. Although a number of steps have been taken to improve quality, the cost accounting system does not provide adequate measures to evaluate the effect of those steps and to indicate areas that need further improvement. Indeed, LeRoy is frustrated by his inability to quantify the effects of the quality improvements that have occurred.
4. Performance reports continue to focus primarily on financial measures. Line managers in the factory, however, complain that they need more accurate and timely information on physical activities, such as units produced, defect rates, and production time.
5. LeRoy is frustrated because the move to lean manufacturing was successful in markedly reducing inventory levels this past year, but the traditional GAAP-based financial reports show that this has significantly lowered profitability.

LeRoy has expressed these concerns to Linda Spurgeon, AOE's president, who agrees that the problems are serious. Linda then called a meeting with LeRoy; Ann Brandt, AOE's vice president of information systems; and Elizabeth Venko, AOE's controller. At the meeting, Elizabeth and Ann agreed to study how to modify the cost

accounting system to more accurately reflect AOE's new production processes. To begin this project, LeRoy agreed to take Elizabeth and Ann on a factory tour so that they could see and understand how the new technology has affected production cycle activities.

As this case suggests, deficiencies in the information system used to support production cycle activities can create significant problems for an organization. As you read this chapter, think about how the introduction of new technology in the production cycle may require corresponding changes in a company's cost accounting system.

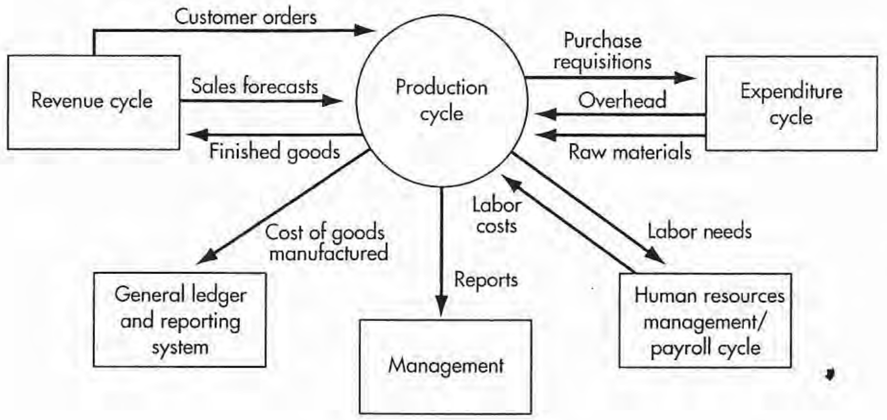
Introduction

The **production cycle** is a recurring set of business activities and related information processing operations associated with the manufacture of products. Figure 14-1 shows how the production cycle is linked to the other subsystems in a company's information system. The revenue cycle information system (see Chapter 12) provides the information (customer orders and sales forecasts) used to plan production and inventory levels. In return, the production cycle information system sends the revenue cycle information about finished goods that have been produced and are available for sale. Information about raw materials needs is sent to the expenditure cycle information system (see Chapter 13) in the form of purchase requisitions. In exchange, the expenditure cycle system provides information about raw material acquisitions and also about other expenditures included in manufacturing overhead. Information about labor needs is sent to the human resources cycle (see Chapter 15), which in return provides data about labor costs and availability. Finally, information about the cost of goods manufactured is sent to the general ledger and reporting information system (see Chapter 16).

Figure 14-2 depicts the four basic activities in the production cycle: product design, planning and scheduling, production operations, and cost accounting. Although accountants are involved primarily in the fourth step, cost accounting, they also must understand the other three processes to be able to design reports that provide management with the information needed to manage the production cycle activities of a modern manufacturing company. For example, one popular approach to improving manufacturing performance, called Six Sigma, begins with careful measurement and analysis of current processes in order to find ways to improve them. Accountants should participate in such efforts by helping to design accurate measures; their ability to do so, however, requires that they understand the production activities being measured.

This chapter explains how an organization's information system supports each of the production cycle activities. We begin by describing the design of the information system and the basic controls necessary to ensure that it provides management with reliable information to assess the efficiency and effectiveness of production cycle activities. We then discuss in detail

FIGURE 14-1
Context Diagram of the Production Cycle



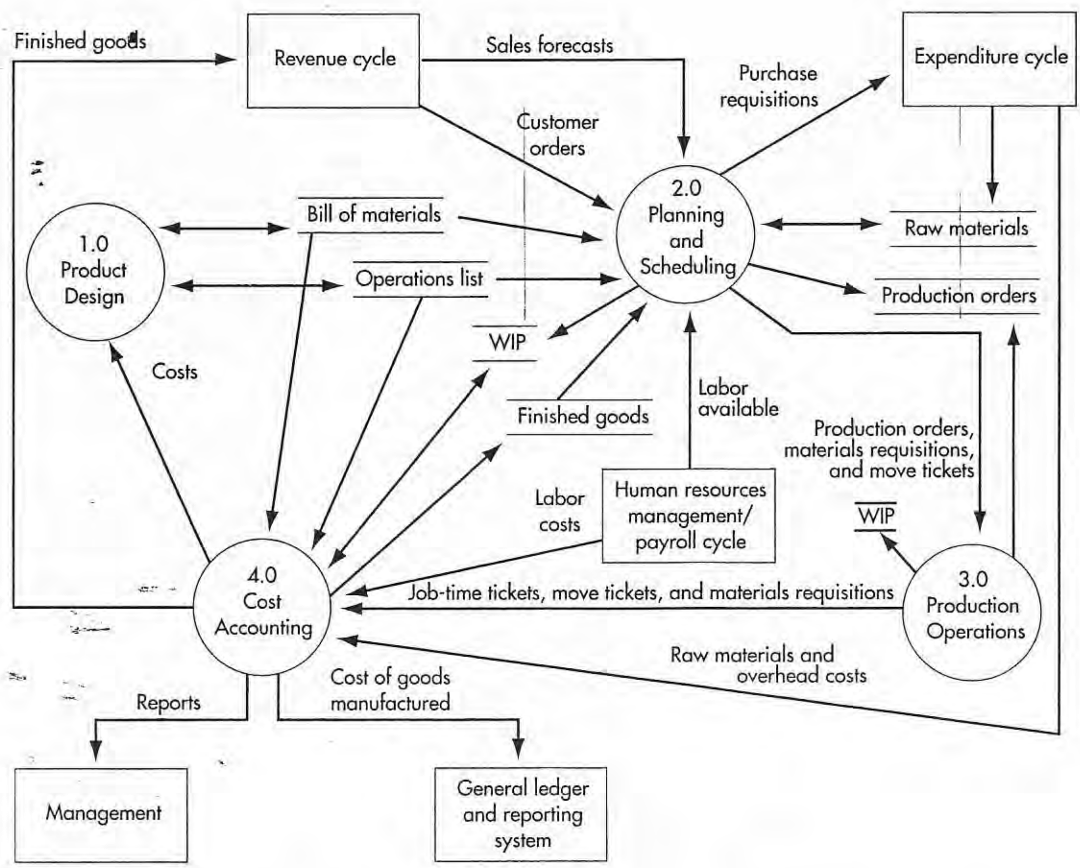


FIGURE 14-2
Level 0 Data Flow Diagram of the Production Cycle

each of the four basic production cycle activities. For each activity, we describe how the information needed to perform and manage those activities is collected, processed, and stored. We also explain the controls necessary to ensure not only the reliability of that information but also the safeguarding of the organization's resources.

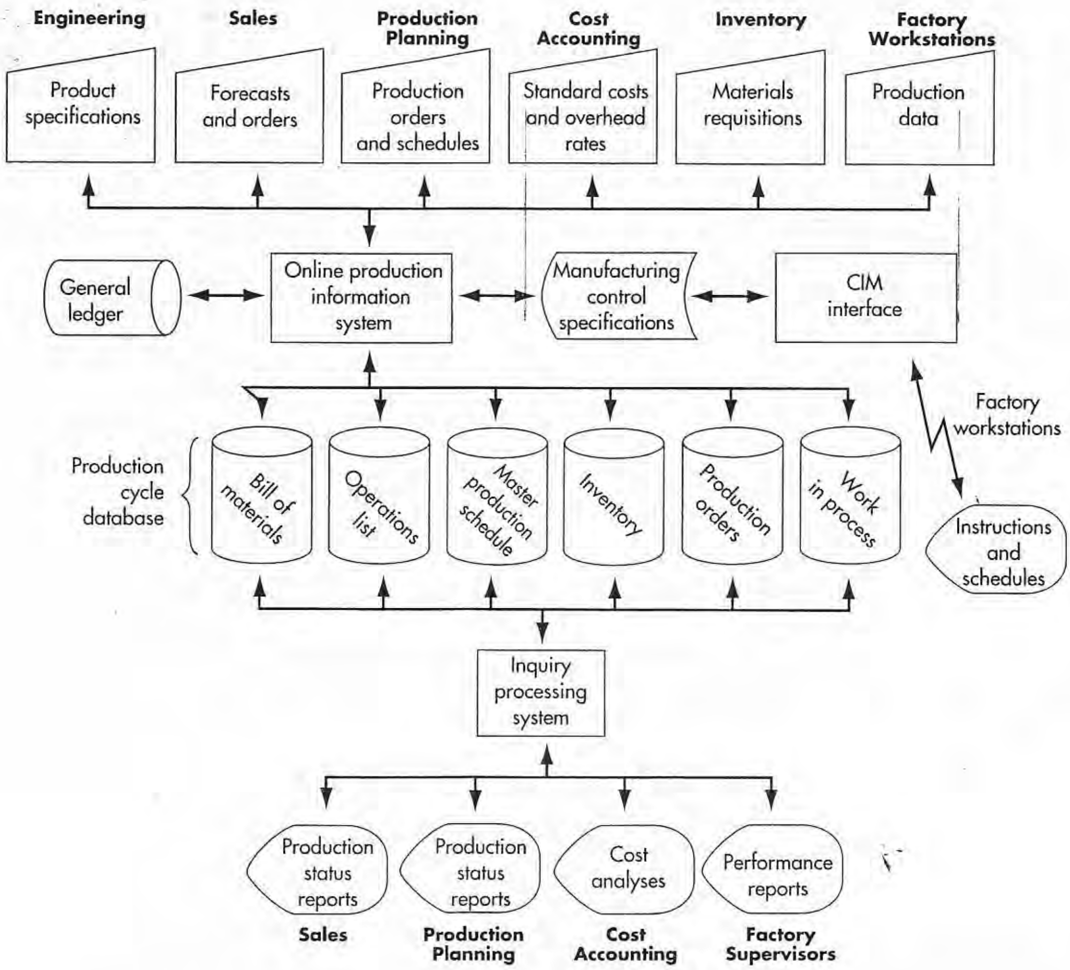
Production Cycle Information System

Figure 14-3 presents the portion of the enterprise resource planning (ERP) that supports an organization's production cycle.

Process

Notice how the production cycle information system integrates both operational and financial data from many sources. The engineering department is responsible for developing product specifications. The bill of materials file stores information about product components, and the operations list file contains information about how to manufacture each product. To develop those specifications, engineering accesses both files to examine the design of similar products. It also accesses the general ledger and inventory files for information about the costs of alternative product designs. The sales department enters information about sales forecasts and customer orders. The production planning department uses that information, plus data about current inventory levels, to develop the master production schedule and create new records in the production order file to authorize the production of specific goods. At the same time, new records are added to the work-in-process file to accumulate cost data. Materials requisitions are sent to the inventory stores department to authorize the release of raw materials. The computer-integrated manufacturing (CIM) interface sends detailed instructions to factory workstations. The CIM interface also collects cost and operational data that is used to update the work-in-process and production order files, respectively.

FIGURE 14-3
Overview of ERP System Design to Support the Production Cycle



Threats and Controls

As Figure 14-3 shows, the production cycle activities depend on and update the integrated database that contains master data about product specifications and inventory (both finished goods and raw materials). Therefore, the first threat listed in Table 14-1 is the risk of inaccurate or invalid master data. Inaccurate data about factory operations can result in incorrect costing of products and valuation of inventory. Inaccurate inventory records can result in either failure to timely manufacture finished goods or unnecessary production. Errors in product specifications (bills of materials and operations lists) can result in poorly designed products. The various processing integrity controls discussed in Chapter 10 can reduce the risk of inaccurate data entry. It is also important to restrict access to production cycle master data. Enforcing proper access controls and segregation of duties requires that the controller or CFO review and suggest appropriate configuration of user rights in integrated ERP systems. The default installation of such systems typically provides every employee with far too much power. Therefore, it is important to modify user permissions to ensure that employees are assigned only those privileges necessary to perform their specified job duties. In addition to multifactor authentication of employees, location-based access controls on devices should also be used. For example, the system should be programmed to reject any attempts to alter inventory records from a terminal located in the engineering department. Finally, logs of all activities, especially any actions involving managerial approval, such as requests for additional raw materials or overtime, should be recorded and maintained for later review as part of the audit trail.

Another threat is the unauthorized disclosure of production information, such as trade secrets and process improvements that provide a company with a competitive advantage. The various access controls discussed earlier provide one way to mitigate this threat. In addition, sensitive data, such as the precise procedures to follow in manufacturing a given product, should be

TABLE 14-1 Threats and Controls in the Production Cycle

Activity	Threat	Controls (first number refers to the corresponding threat)
General issues throughout entire production cycle	1. Inaccurate or invalid master data 2. Unauthorized disclosure of sensitive information 3. Loss or destruction of data	1.1 Data processing integrity controls 1.2 Restriction of access to master data 1.3 Review of all changes to master data 2.1 Access controls 2.2 Encryption 3.1 Backup and disaster recovery procedures
Product design	4. Poor product design resulting in excess costs	4.1 Accounting analysis of costs arising from product design choices 4.2 Analysis of warranty and repair costs
Planning and scheduling	5. Over- and underproduction	5.1 Production planning systems 5.2 Review and approval of production schedules and orders 5.3 Restriction of access to production orders and production schedules
Production operations	6. Theft of inventory 7. Theft of fixed asset 8. Poor performance 9. Suboptimal investment in fixed assets 10. Loss of inventory or fixed assets due to fire or other disasters 11. Disruption of operations	6.1 Physical access control 6.2 Documention of all inventory movement 6.3 Segregation of duties—custody of assets from recording and authorization of removal 6.4 Restriction of access to inventory master data 6.5 Periodic physical counts of inventory and reconciliation of those counts to recorded quantities 7.1 Physical inventory of all fixed assets 7.2 Restriction of physical access to fixed assets 7.3 Maintaining detailed records of fixed assets, including disposal 8.1 Training 8.2 Performance reports 9.1 Proper approval of fixed asset acquisitions, including use of requests for proposals to solicit multiple competitive bids 10.1 Physical safeguards (e.g., fire sprinklers) 10.2 Insurance 11.1 Backup and disaster recovery plans
Cost accounting	12. Inaccurate cost data 13. Inappropriate allocation of overhead costs 14. Misleading reports	12.1 Source data automation 12.2 Data processing integrity controls 13.1 Time-driven activity-based costing 14.1 Innovative performance metrics (e.g., throughput)

encrypted both while in storage and during transmission over the Internet to manufacturing plants and business partners.

The third general threat listed in Table 14-1 is the loss or alteration of production data. The production cycle database must be protected from either intentional or accidental loss or damage. As discussed in Chapter 10, regular backing up of all data files is imperative. Additional copies of key master files, such as open production orders and raw materials inventory, should be stored off-site. To reduce the possibility of accidental erasure of important files, all disks and tapes should have both external and internal file labels.

Now that we have provided an overview of the production cycle information system, let us examine each of the basic activities depicted in Figure 14-2 in more detail.

Product Design

The first step in the production cycle is product design (circle 1.0 in Figure 14-2). The objective is to create a product that meets customer requirements in terms of quality, durability, and functionality while simultaneously minimizing production costs. These criteria often conflict with one another, making product design a challenging task.

Process

The product design activity creates two outputs. The first, a **bill of materials** (Figure 14-4), specifies the part number, description, and quantity of each component used in a finished product. The second is an ***operations list*** (Figure 14-5), which specifies the sequence of steps to follow in making the product, which equipment to use, and how long each step should take.

Tools such as product life-cycle management (PLM) software can help improve the efficiency and effectiveness of the product design process. PLM software consists of three key components: computer-aided design (CAD) software to design new products, digital manufacturing software that simulates how those products will be manufactured, and product data management software that stores all the data associated with products. CAD software enables manufacturers to design and test virtual 3-D models of products, thereby eliminating the costs associated with creating and destroying physical prototypes. CAD software facilitates collaboration by design teams dispersed around the globe and eliminates the costs associated with exchanging static copies of product designs. Digital manufacturing software allows companies to determine labor, machine, and process requirements to optimally produce items in different facilities across the globe in order to minimize costs. Product data management software provides easy access to detailed engineering specifications and other product data to facilitate product redesign, modification, and post-sale maintenance. Although PLM can dramatically improve both the efficiency and effectiveness of product design, Focus 14-1 shows that reaping its full benefits requires careful supervision by senior management.

Threats and Controls

Poor product design (threat 4 in Table 14-1) drives up costs in several ways. Using too many unique components when producing similar products increases the costs associated with purchasing and maintaining raw materials inventories. It also often results in inefficient production processes because of excessive complexity in changing from the production of one product to another. Poorly designed products are also more likely to incur high warranty and repair costs.

To mitigate this threat, accountants should participate in the product design activity because 65% to 80% of product costs are determined at this stage of the production process. Accountants can analyze how the use of alternative components and changes to the production process affect costs. In addition, accountants can use information from the revenue cycle about repair and warranty costs associated with existing products to identify the primary causes of product failure and suggest opportunities to redesign products to improve quality.

FIGURE 14-4 Example of a Bill of Materials

Finished Product: DVD Player

Part Number	Description	Quantity
105	Control Unit	1
125	Back Panel	1
148	Side Panel	2
155	Top/Bottom Panel	2
173	Timer	1
195	Front Panel	1
199	Screw	6

FIGURE 14-5 Example of an Operations List

Operations List for: Create Side Panel

Operation Number	Description	Machine Number	Standard Time (minutes:seconds)
105	Cut to shape	ML15-12	2:00
106	Corner cut	ML15-9	3:15
124	Turn and shape	S28-17	4:00
142	Finish	F54-5	7:10
155	Paint	P89-1	9:30

FOCUS 14-1 Using PLM Software to Improve Product Design: The Need for Management Involvement

The potential benefits of PLM software are enormous. For example, General Motors estimates that it costs approximately $500,000 to run crash tests with real cars and hopes that CAD software can reduce the number of such tests by 85%. As Airbus learned, however, PLM software also has pitfalls. In 2006 it announced that production of the A380 superjumbo airliner would be delayed by up to two years, costing Airbus approximately $6 billion in lost profits. The problem? Use of different versions of the same CAD software by design teams in Germany and France resulted in incompatibilities between the front and rear fuselages. Each A380 contains over 300 miles of wires and more than 40,000 connectors to power everything in both the customer cabin and the cockpit. When workers tried to assemble the front and rear fuselages, they discovered that the wiring could not be properly connected.

How could using two editions of the same software create such problems? The answer is that each version treated drawings in different ways, resulting in different models. Engineers using the older version at the German plant had to manually tinker with the drawings to indicate where conduits should be placed, whereas the newer version of the software used at the French plant did this automatically. In addition, many technical notes containing key information about product specifications and units of measurement were lost when drawings were converted between the two versions of the software.

The experience of Airbus is not unique. A survey found that almost 50% of companies using CAD software had to redesign products because of incompatibilities between CAD software used by different design teams. Airbus executives did not force engineers at different plants to use the same versions of CAD software. This decision initially saved money by avoiding the need to purchase new software and the associated time and costs of retraining engineers. But those short-term savings were more than offset by the subsequent loss of profits due to production delays. This underscores the importance of management involvement and support whenever companies implement complex software such as PLM.

Planning and Scheduling

The second step in the production cycle is planning and scheduling (circle 2.0 in Figure 14-2). The objective is to develop a production plan efficient enough to meet existing orders and anticipated short-term demand while minimizing inventories of both raw materials and finished goods.

Production Planning Methods

Two common methods of production planning are manufacturing resource planning and lean manufacturing. **Manufacturing resource planning (MRP-II)** is an extension of materials resource planning (discussed in Chapter 13) that seeks to balance existing production capacity and raw materials needs to meet forecasted sales demands. MRP-II systems are often referred to as *push manufacturing*, because goods are produced in expectation of customer demand.

Just as MRP-II is an extension of MRP inventory control systems, ***lean manufacturing*** extends the principles of just-in-time inventory systems (discussed in Chapter 13) to the entire production process. The goal of lean manufacturing is to minimize or eliminate inventories of raw materials, work in process, and finished goods. Lean manufacturing is often referred to as *pull manufacturing*, because goods are produced in response to customer demand. Theoretically, lean manufacturing systems produce only in response to customer orders. In practice, however, most lean manufacturing systems develop short-run production plans. For example, Toyota develops monthly production plans so that it can provide a stable schedule to its suppliers. This strategy enables the suppliers to plan their production schedules so that they can deliver their products to Toyota at the exact time they are needed.

Thus, both MRP-II and lean manufacturing systems plan production in advance. They differ, however, in the length of the planning horizon. MRP-II systems may develop production plans for up to 12 months in advance, whereas lean manufacturing systems use much shorter planning horizons. If demand for a company's product is predictable and the product has a long life cycle, then an MRP-II approach may be justified. In contrast, a lean manufacturing approach may be more appropriate if a company's products are characterized by short life cycles, unpredictable demand, and frequent markdowns of excess inventory.

Key Documents and Forms

Information about customer orders, sales forecasts, and inventory levels of finished goods is used to determine production levels. The result is a ***master production schedule (MPS)***, which specifies how much of each product is to be produced during the planning period and when that production should occur (Figure 14-6). Although the long-range part of the MPS may be modified in response to changes in market conditions, production plans for many products must be frozen a few weeks in advance to provide sufficient time to procure the necessary raw materials, supplies, and labor resources.

The complexity of scheduling increases dramatically as the number of factories grows. For example, large manufacturing companies such as Intel and General Motors must coordinate production at many different plants in different countries. Some of those plants produce basic components, and others assemble the final products. The production information system must coordinate these activities to minimize bottlenecks and the buildup of partially completed inventories.

The MPS is used to develop a detailed timetable that specifies daily production and to determine whether raw materials need to be purchased. To do this, it is necessary to "explode" the bill of materials to determine the immediate raw materials requirements for meeting the production goals listed in the MPS (Table 14-2). These requirements are compared with current inventory levels, and if additional materials are needed, purchase requisitions are generated and sent to the purchasing department to initiate the acquisition process.

Figure 14-2 shows that the planning and scheduling activity produces three other documents: production orders, materials requisitions, and move tickets. A **production order** authorizes the manufacture of a specified quantity of a particular product. It lists the operations that need to be performed, the quantity to be produced, and the location where the finished product should be delivered. It also collects data about each of those activities (Figure 14-7). A ***materials requisition*** authorizes the removal of the necessary quantity of raw materials from the storeroom to the factory location where they will be used. This document contains the production order number, date of issue, and, based on the bill of materials, the part numbers and quantities of all necessary raw materials (Figure 14-8). Subsequent transfers of raw materials throughout the factory are documented on ***move tickets***, which identify the parts being transferred, the location to which they are transferred, and the time of transfer (Figure 14-9 shows an example of an inventory transfer data entry screen).

FIGURE 14-6
Sample of a Master Production Schedule (MPS)

MASTER PRODUCTION SCHEDULE								
Product Number	120		**Description:**		DVD Player			
Lead time:[a]	**Week Number**							
1 week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Quantity on hand	500	350[b]	350	300	350	300	450	300
Scheduled production	150[c]	300	250	300	250	400	250	300
Forecasted sales	300	300	300	250	300	250	400	250
Net available	350[d]	350	300	350	300	450	300	350

[a]Time to manufacture product (1 week for DVD player).
[b]Ending quantity on hand (net available) from prior week.
[c]Calculated by subtracting quantity on hand from sum of this week's and next week's forecasted sales, plus a 50-unit buffer stock. For example, begin week 1 with 500 units. Projected sales for weeks 1 and 2 total 600 units. Adding 50-unit desired buffer inventory yields 650 units needed by end of week 1. Subtracting beginning inventory of 500 units results in planned production of 150 units during week 1.
[d]Beginning quantity on hand plus scheduled production less forecasted sales.

TABLE 14-2 Example of "Exploding" a Bill of Materials

Step 1: Multiply the component requirements for ONE product by the number of products to be produced next period (from the MPS).

COMPONENTS IN EACH DVD PLAYER

Part No.	Description	Quantity	Number of DVD Players	Total Requirements
105	Control Unit	1	2,000	2,000
125	Back Panel	1	2,000	2,000
148	Side Panel	4	2,000	8,000
173	Timer	1	2,000	2,000
195	Front Panel	1	2,000	2,000
199	Screw	6	2,000	12,000
135	Top Panel	1	2,000	2,000
136	Bottom Panel	1	2,000	2,000

COMPONENTS IN EACH CD PLAYER

Part No.	Description	Quantity	Number of CD Players	Total Requirements
103	Control Unit	1	3,000	3,000
120	Front Panel	1	3,000	3,000
121	Back Panel	1	3,000	3,000
173	Timer	1	3,000	3,000
190	Side Panel	4	3,000	12,000
199	Screw	4	3,000	12,000
135	Top Panel	1	3,000	3,000
136	Bottom Panel	1	3,000	3,000

Step 2: Calculate total component requirements by summing products.

Part No.	DVD Player	CD Player	Total
103	0	3,000	3,000
105	2,000	0	2,000
120	0	3,000	3,000
121	0	3,000	3,000
125	2,000	0	2,000
148	8,000	0	8,000
173	2,000	3,000	5,000
190	0	12,000	12,000
195	2,000	0	2,000
199	12,000	12,000	24,000
135	2,000	3,000	5,000
136	2,000	3,000	5,000

Step 3: Repeat steps 1 and 2 for each week during planning horizon.

Part No.	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
103	3,000	2,000	2,500	3,000	2,500	3,000
105	2,000	2,000	2,500	2,500	2,000	3,000
120	3,000	2,000	2,500	3,000	2,500	3,000
121	3,000	2,000	2,500	3,000	2,500	3,000
125	2,000	2,000	2,500	2,500	2,000	3,000
148	8,000	8,000	10,000	10,000	8,000	12,000
173	5,000	4,000	5,000	5,500	4,500	6,000
190	12,000	12,000	10,000	12,000	10,000	12,000
195	2,000	2,000	2,500	2,500	2,000	3,000
199	24,000	20,000	25,000	27,000	22,000	30,000
135	5,000	5,000	5,000	5,000	5,000	5,000
136	5,000	5,000	5,000	5,000	5,000	5,000

FIGURE 14-7
Sample Production Order for Alpha Omega Electronics

Alpha Omega Engineering **PRODUCTION ORDER**									**4587**
Order No. 2289	**Product No. 4430**		**Description:** Cabinet Side Panel			**Production Quantity** 1000			
Approved by: PJS	**Release Date:** 02/24/2011		**Issue Date:** 02/25/2011	**Completion Date:** 03/09/2011		**Deliver to:** Assembly Department			
Work Station No.	**Product Operation No.**	**Quantity**	**Operation Description**	**Start Date & Time**		**Finish Date & Time**			
MH25	100	1,003	Transfer from stock	02/28	0700	02/28	0800		
ML15-12	105	1,003	Cut to shape	02/28	0800	02/28	1000		
ML15-9	106	1,002	Corner cut	02/28	1030	02/28	1200		
S28-17	124	1,002	Turn & shape	02/28	1300	02/28	1700		
F54-5	142	1,001	Finish	03/01	0800	03/01	1100		
P89-1	155	1,001	Paint	03/01	1300	03/02	1300		
QC94	194	1,001	Inspect	03/02	1400	03/02	1600		
MH25	101	1,000	Transfer to assembly	03/02	1600	03/02	1700		

Explanation of numbers in Quantity column:

1. *Total of 1,003 sheets of raw material used to produce 1,000 good panels and 3 rejected panels.*
2. *One panel not cut to proper shape, thus only 1,002 units had operations 106 and 124 performed on them.*
3. *One panel not properly turned and shaped; hence only 1,001 panels finished, painted, and received final inspection.*
4. *One panel rejected during final inspection; thus only 1,000 good panels transferred to assembly department.*

Notice that many of the documents used in the production cycle track the movement and usage of raw materials. The use of bar-coding and RFID tags provides opportunities to improve the efficiency and accuracy of these materials handling activities by eliminating the need for manual entry of data. RFID also facilitates locating specific inventory because the scanning devices are not limited to reading only those items that are directly in line-of-sight. This can be especially useful in large warehouse and storage facilities, where items may get moved around to make room for new shipments.

Finally, accurate production plannning requires integrating information about customer orders (from the revenue cycle) with information about purchases from suppliers (from the expenditure cycle), along with information about labor availability (from the HR/payroll cycle). Figure 14-10 illustrates how an ERP system provides this integration. The system first checks inventory on hand to determine how much needs to be produced to fill the new order. It then

FIGURE 14-8
Sample Materials Requisition for Alpha Omega Electronics

MATERIALS REQUISITION				**No. 2345**
Issued To: Assembly	**Issue Date:** 08/15/2011		**Production Order Number:** 62913	
Part Number	**Description**	**Quantity**	**Unit Cost $**	**Total Cost $**
115	Calculator Unit	2,000	2.95	5,900.00
135	Lower Casing	2,000	.45	900.00
198	Screw	16,000	.02	320.00
178	Battery	2,000	.75	1,500.00
136	Upper Casing	2,000	.80	1,600.00
199	Screw	12,000	.02	240.00
Issued by: AKL				10,460.00
Received by: GWS		Costed by: ZBD		

Note: Cost information is entered when the materials requisition is turned in to the cost accounting department. Other information, except for signatures, is printed by the system when the document is prepared.

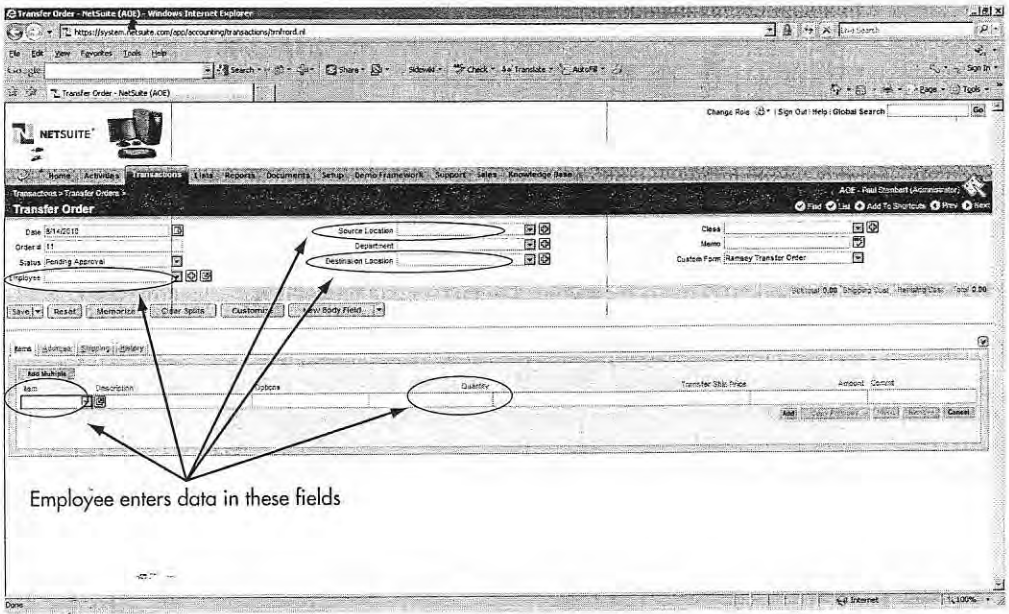


FIGURE 14-9
Example of Inventory Transfer Screen

calculates labor needs and determines whether there is a need to schedule overtime or hire temporary help in order to meet the promised fill date. At the same time, information in the bill of materials is used to determine what components, if any, need to be ordered. Any necessary purchase orders are sent to suppliers via electronic data interchange (EDI). The master production schedule is then adjusted to include the new order. Notice how this sharing of information across the revenue, production, and expenditure cycles in the manner just described enables companies to efficiently manage inventories by timing their purchases to meet actual customer demand.

Threats and Controls

Table 14-1 shows that the primary threat in the planning and scheduling activity is over- or underproduction. Overproduction can result in a supply of goods in excess of short-run demands, thereby creating potential cash flow problems because resources are tied up in

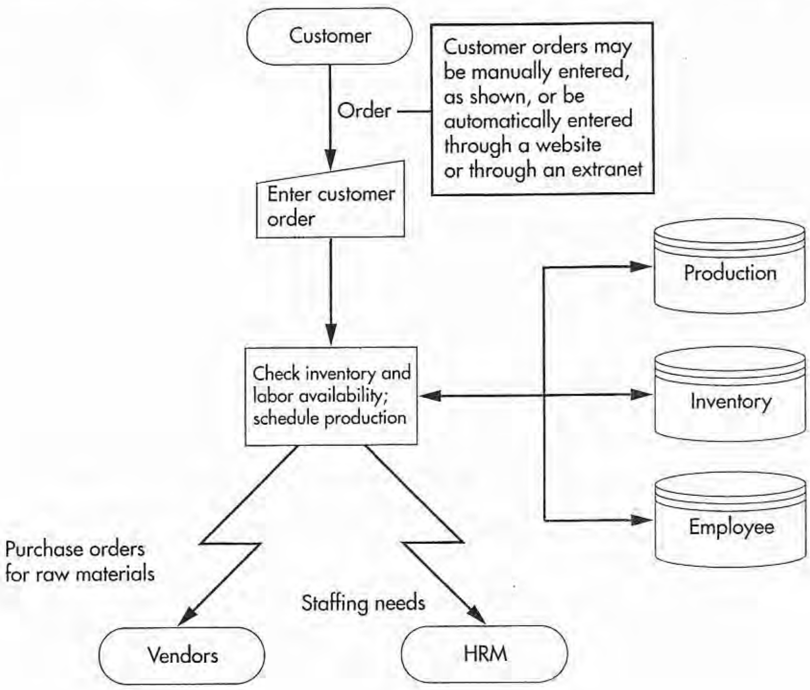


FIGURE 14-10
Illustration of How ERP Systems Integrate Production Cycle Information with Data from Other Cycles

inventory. Overproduction also increases the risk of carrying inventory that becomes obsolete. Conversely, underproduction can result in lost sales and customer dissatisfaction because of lack of availability of desired items. These threats are especially important for companies that produce new, innovative products, such as current fashion clothing, because the demand for such products is much more volatile than the demand for staples and commodities, such as food or office supplies.

Production planning systems can reduce the risk of over- and underproduction. Improvement requires accurate and current sales forecasts and data about inventory stocks, information that the revenue and expenditure cycle systems can provide. In addition to improved forecasts, information about production performance, particularly concerning trends in total time to manufacture each product, should be regularly collected. These data sources should be used periodically to review and adjust the master production schedule.

Proper approval and authorization of production orders is another control to prevent over- or underproduction of specific items. The risk of unauthorized production orders can be reduced by restricting access to the production scheduling program. Careful review and approval also ensures that the correct production orders are released.

Production Operations

The third step in the production cycle is the actual manufacture of products (circle 3.0 in Figure 14-2). The manner in which this activity is accomplished varies greatly across companies, differing according to the type of product being manufactured and the degree of automation used in the production process.

Using various forms of information technology (IT) in the production process, such as robots and computer-controlled machinery, is referred to as **computer-integrated manufacturing (CIM)**. CIM can significantly reduce production costs. For example, Northrop Grumman Corporation once used 16,000 sheets of paper to record shop-floor work instructions related to the manufacture of plane fuselages. Installation of online terminals at each assembly station eliminated that paper flow and improved efficiency, reducing costs by 30%.

Accountants need not be experts on every facet of CIM, but they must understand how it affects both operations and cost accounting. One operational effect of CIM is a shift from mass production to custom-order manufacturing. For example, every Northrop Grumman product is assembled to order. Each product, however, can use any of about 256,000 separate components. Thus, CIM requires redesign of inventory management systems and work flows to facilitate quick changes in production. As we will discuss in the final section of this chapter, such flexibility in manufacturing operations also has implications for the design of cost accounting systems.

Threats and Controls

Theft of inventories (threat 6) and fixed assets (threat 7) are major concerns (see Table 14-1). In addition to the loss of assets, thefts also result in overstated asset balances, which can lead to erroneous analyses of financial performance and underproduction.

To reduce the risk of inventory loss, physical access to inventories should be restricted, and all internal movements of inventory should be documented. Thus, materials requisitions should be used to authorize the release of raw materials to production. Both the inventory control clerk and the production employee receiving the raw materials should sign the requisition to acknowledge release of the goods to production. Requests for additional materials in excess of the amounts specified in the bill of materials should be documented and authorized by supervisory personnel. Move tickets should be used to document subsequent movement of inventory through various stages of the production process. The return of any materials not used in production also should be documented. Wherever feasible, RFID tags or bar codes should be used to automate the tracking of inventories.

Proper segregation of duties is important to safeguard inventory. Maintaining physical custody of the raw materials and finished goods inventories is the responsibility of the inventory stores department. Department or factory supervisors have primary responsibility for work-in-process inventories. The authorization function, represented by the preparation of production orders, materials requisitions, and move tickets, is the responsibility of the production planners or, increasingly, of the production information system itself. RFID equipment, bar-code scanners, and online terminals can be used to record movement of inventory, thereby maintaining accurate perpetual inventory records. Consequently, proper access controls and compatibility tests are important to ensure that only authorized personnel have access to those records (control 6.4). Finally, an employee without any custodial responsibility should periodically count inventory on hand. Any discrepancies between these physical counts and recorded amounts should be investigated.

Similar controls are needed to safeguard fixed assets. First, all fixed assets must be identified and recorded (control 7.1) so that managers can be assigned responsibility and accountability for fixed assets under their control. RFID tags provide a cost-effective way to monitor the location of fixed assets. As with inventory, security measures should be in place to control physical access to fixed assets. Because manufacturing machinery and equipment are often replaced before they are completely worn out, it is important to formally approve and accurately record their sale or disposal. A report of all fixed-asset transactions should be printed periodically and sent to the controller, who should verify that each transaction was properly authorized and executed. The cost accounting system also needs to maintain accurate records of acquisition cost, any improvements, and depreciation in order to properly calculate the gain or loss arising from such transactions.

Poor performance is another threat to production operations. Training is one way to mitigate this threat. Indeed, surveys of manufacturing companies report a direct relationship between time spent on training and overall productivity. It is also important to regularly prepare and review reports on performance in order to identify when additional training is needed.

Another threat associated with production cycle activities is suboptimal investment in fixed assets. Overinvesting in fixed assets can create excess costs; underinvestment can impair productivity. Both problems reduce profitability. Thus, proper authorization of fixed-asset transactions is important.

Acquisitions of fixed assets represent a special type of expenditure and follow the same basic processes (order the fixed asset, receive it, and pay for it) and control procedures discussed in Chapter 13. Nonetheless, the size of most fixed-asset transactions necessitates some modifications of the processes used to acquire inventory and miscellaneous supplies. A supervisor or manager, who provides details about expected cash flows and other costs and benefits of the proposed expenditure, should first recommend large capital expenditures. All such recommendations should be reviewed by a senior executive or by an executive committee and the various projects ranked by priority. Smaller capital expenditures (e.g., those costing $10,000 or less) usually can be purchased directly out of departmental budgets, which avoids a formal approval process. Holding managers accountable for their department's return on the fixed assets provides additional incentive to control such expenditures.

Another difference is that orders for machinery and equipment almost always involve a formal request for competitive bids by potential suppliers. A document called a ***request for proposal (RFP)***, which specifies the desired properties of the asset, is sent to each prospective supplier. The capital investments committee should review the responses and select the best bid. Once a supplier has been selected, the acquisition of the asset may be handled through the regular expenditure cycle process, as described in Chapter 13. Specifically, a formal purchase order is prepared, receipt of the asset is formally documented using a receiving report, and a disbursement voucher is used to authorize payment to the supplier. The same set of processing controls and edit checks employed for other purchases also should be used for fixed-asset acquisitions (for details, refer back to the discussion in Chapter 13).

Another threat noted in Table 14-1 is that both inventories and fixed assets are subject to loss due to fire or other disasters. Physical safeguards, such as fire suppression systems, are designed to prevent such disasters. However, because preventive controls are never 100% effective, organizations also need to purchase adequate insurance to cover such losses and provide for replacement of those assets.

A related concern is disruption of production activities (threat 11). The high level of automation in production cycle activities means that disasters, such as the power outages experienced in California in recent years, not only interrupt the functioning of information systems but can also disrupt manufacturing activities. Backup power sources, such as generators, and uninterruptible power supply devices should be acquired to ensure that critical equipment and machinery is not damaged by sudden unexpected loss of power and that important production processes can continue on schedule. Companies also need to investigate the disaster preparedness of key suppliers and identify alternative sources for critical components. This is especially important for companies that practice lean manufacturing; they maintain low inventories of both raw materials and finished goods, so any disruptions to either their manufacturing activities or those of their suppliers can quickly result in lost sales.

Cost Accounting

The final step in the production cycle is cost accounting (circle 4.0 in Figure 14-2). The three principal objectives of the cost accounting system are (1) to provide information for planning, controlling, and evaluating the performance of production operations; (2) to provide accurate cost data about products for use in pricing and product mix decisions; and (3) to collect and process the information used to calculate the inventory and cost of goods sold values that appear in the company's financial statements.

Process

To successfully accomplish the first objective, the cost accounting system must be designed to collect real-time data about the performance of production activities so that management can make timely decisions. To accomplish the other two objectives, the cost accounting system must classify costs by various categories and then assign those costs to specific products and organizational units. This requires careful coding of cost data during collection, because often the same costs may be allocated in multiple ways, for several different purposes. For example, factory supervisory costs may be assigned to departments for performance evaluation purposes but to specific products for pricing and product mix decisions.

Most companies use either job-order or process costing to assign production costs. **Job-order costing** assigns costs to specific production batches, or jobs, and is used when the product or service being sold consists of discretely identifiable items. For example, construction companies use job-order costing for each house being built. Similarly, public accounting and law firms use job-order costing to account for the costs of individual audits or cases, respectively. AOE currently uses job-order costing.

In contrast, **process costing** assigns costs to each process, or work center, in the production cycle, and then calculates the average cost for all units produced. Process costing is used when similar goods or services are produced in mass quantities and discrete units cannot be readily identified. For example, breweries accumulate the costs associated with the various processes (e.g., mashing, primary fermentation, filtering, and bottling) in producing a batch of a particular kind of beer and then compute the average total unit cost for that product. Similarly, mutual funds accumulate the costs associated with handling customer deposits and withdrawals and then compute the per-unit costs of those transactions.

The choice of job-order or process costing affects only the method used to *assign* costs to products, not the methods used to collect that data. Let us now examine how data about raw materials used, labor hours expended, machine operations performed, and manufacturing overhead are collected.

RAW MATERIALS USAGE DATA When production is initiated, the issuance of a materials requisition triggers a debit to work in process for the raw materials sent to production. If additional materials are needed, another debit is made to work in process. Conversely, work in process is credited for any materials not used and returned to inventory. Many raw materials are bar-coded so that usage data can be collected by scanning the products when released from, or returned to, inventory. Increasingly, manufacturers are using RFID tags to further improve the efficiency of tracking materials usage. In fact, if RFID tags are applied to individual products, companies may, if they desire, adopt the specific identification method for tracking inventory. It is difficult, however, to use bar codes or RFID tags for some items, such as liquids. Inventory clerks and factory workers must use online terminals to enter usage data for such items.

DIRECT LABOR COSTS In the past, AOE and other manufacturers used a paper document called a ***job-time ticket*** to collect data about labor activity. This document recorded the amount of time a worker spent on each specific job task. Now, as shown in Figure 14-3, workers enter this data using online terminals at each factory workstation. To further improve the efficiency of this process, AOE is considering switching to coded identification cards, which workers would run through a badge reader or bar-code scanner when they start and finish any task. The time savings associated with using bar-coding to automate data collection can be significant. For example, Consolidated Diesel Company found that using bar-code scanners to capture data about materials usage and labor operations saved about 12 seconds per workstation, per activity. Although this may not seem like much, when multiplied by the hundreds of workstations and multiple activities performed daily by hundreds of employees, the change resulted in a permanent 15% increase in productivity.

MACHINERY AND EQUIPMENT USAGE As companies implement CIM to automate the production process, an ever larger proportion of product costs relate to the machinery and equipment used to make that product. Data about machinery and equipment usage are collected at each step in the production process, often in conjunction with data about labor costs. For example, when workers record their activities at a particular workstation, the system can also record information identifying the machinery and equipment used and the duration of such use. Until recently, this data was collected by wiring the factory so that each piece of equipment was linked to the computer system. This limited the ability to quickly and easily redesign the layout of the shop floor to improve production efficiency. Consequently, many manufacturing companies are replacing such wired connections with wireless technology. Doing so enables them to use new 3-D simulation software to evaluate the effects of modifying shop-floor layout and workflow and to easily and quickly implement beneficial changes.

MANUFACTURING OVERHEAD COSTS Manufacturing costs that are not economically feasible to trace directly to specific jobs or processes are considered **manufacturing overhead.** Examples include the costs of water, power, and other utilities; miscellaneous supplies; rent, insurance, and property taxes for the factory plant; and the salaries of factory supervisors. Most of these costs are collected by the expenditure cycle information system (see Chapter 13), with the exception of supervisory salaries, which are processed by the human resources cycle information system (see Chapter 15).

Accountants can play a key role in controlling overhead costs by carefully assessing how changes in product mix affect total manufacturing overhead. They should go beyond merely collecting such data, however, and identify the underlying factors that drive the changes in total costs. This information then can be used to adjust production plans and factory layout to maximize efficiency and profitability. As the AOE case illustrates, to do this effectively requires that the cost accounting system be redesigned to collect and report costs in a manner consistent with the production planning techniques of the company. For example, lean manufacturing emphasizes working in teams and seeks to maximize the efficiency and synergy of all teams involved in making a particular product. Consequently, Elizabeth Venko realizes that collecting and reporting labor variances at the individual or team level may create dysfunctional incentives to maximize local performance at the expense of plantwide performance. Therefore, she plans to redesign AOE's cost accounting system so that it collects and reports costs in a manner that highlights the *joint* contributions of all teams that make a particular product.

Threats and Controls

As the AOE case illustrated, inaccurate cost data (threat 12 in Table 14-1) can diminish the effectiveness of production scheduling and undermine management's ability to monitor and control manufacturing operations. For example, inaccurate cost data can result in inappropriate decisions about which products to make and how to set current selling prices. Errors in inventory records can lead to either over- or underproduction of goods. Overstated fixed assets increase expenses through extra depreciation and higher property taxes. Understated fixed assets also can cause problems; for example, inaccurate counts of the number of personal computers in use can cause a company to unknowingly violate software license requirements. Inaccuracies in financial statements and managerial reports can distort analyses of past performance and the desirability of future investments or changes in operations.

The best control procedure to ensure that data entry is accurate is to automate data collection using RFID technology, bar-code scanners, badge readers, and other devices. When this is not feasible, online terminals should be used for data entry and should employ the various data entry edit controls discussed in chapter 10. For example, check digits and closed-loop verification should be used to ensure that information about the raw materials used, operations performed, and employee number is entered correctly. Validity checks, such as comparing part numbers of raw materials to those listed in the bill of materials file, provide further assurance of accuracy. Finally, to verify the accuracy of database records, periodic physical counts of inventories and fixed assets should be made and compared with recorded quantities.

Accurate cost data are not sufficient, however. As the AOE case showed, poorly designed cost accounting systems misallocate costs to products (threat 13) and produce misleading reports about production cycle activities (threat 14), both of which can lead to erroneous decisions and frustration. The following two subsections explain how activity-based costing systems and innovative performance metrics can mitigate these problems.

IMPROVED CONTROL WITH ACTIVITY-BASED COSTING SYSTEMS Traditional cost systems use volume-driven bases, such as direct labor or machine hours, to apply overhead to products. Many overhead costs, however, do not vary directly with production volume. Purchasing costs, for example, vary with the number of purchase orders processed. Similarly, receiving costs vary with the number of shipments from suppliers. Setup and materials handling costs vary with the number of different batches that are run, not with the total number of units produced. Thus, allocating these types of overhead costs to products based on output volume overstates the costs of products manufactured in large quantities. It also understates the costs of products manufactured in small batches.

In addition, allocating overhead based on direct labor input can distort costs across products. As investments in factory automation increase, the amount of direct labor used in production decreases. Consequently, the amount of overhead charged per unit of labor increases dramatically. As a result, small differences in the amount of labor used to produce two products can result in significant differences in product costs.

Activity-based costing[1] can refine and improve cost allocations under both job-order and process cost systems. It attempts to trace costs to the activities that create them, such as grinding or polishing, and only subsequently allocates those costs to products or departments. An underlying objective of activity-based costing is to link costs to corporate strategy. Corporate strategy results in decisions about what goods and services to produce. Activities must be performed to produce these goods and services, which in turn incur costs. Thus, corporate strategy determines costs. Consequently, by measuring the costs of basic activities, such as materials handling or processing purchase orders, activity-based costing provides information to management for evaluating the consequences of strategic decisions.

Activity-based costing systems differ from conventional cost accounting systems in three important ways:

1. Activity-based cost systems attempt to directly trace a larger proportion of overhead costs to products. Advances in IT make this feasible. For example, RFID technology and barcoding facilitate tracking the exact quantities of miscellaneous parts used in each product or process stage. When implementing activity-based costing systems, accountants observe production operations and interview factory workers and supervisors to obtain a better understanding of how manufacturing activities affect costs.
2. Activity-based cost systems use a greater number of cost pools to accumulate indirect costs (manufacturing overhead). Whereas most traditional cost systems lump all overhead costs together, activity-based costing systems distinguish three separate categories of overhead:
   - **Batch-related overhead.** Examples include setup costs, inspections, and materials handling. Activity-based cost systems accumulate these costs for a batch and then allocate them to the units produced in that batch. Thus, products produced in large quantities have lower batch-related overhead costs per unit than products produced in small quantities.

[1]In this section, we provide an overview of activity-based costing, its effects on the cost accounting system, and its benefits. For additional details on the mechanics of activity-based costing, see any cost accounting textbook.

- **Product-related overhead.** These costs are related to the diversity of the company's product line. Examples include research and development, expediting, shipping and receiving, environmental regulations, and purchasing. Activity-based cost systems try to link these costs to specific products when possible. For example, if a company produces three product lines, one of which generates hazardous waste, an activity-based cost system would charge only that one set of products for all the costs of complying with environmental regulations. Other costs, such as purchasing raw materials, might be allocated across products based on the relative number of purchase orders required to make each product.
- **Companywide overhead.** This category includes such costs as rent or property taxes. These costs apply to all products. Thus, activity-based cost systems typically allocate them using departmental or plant rates.

3. Activity-based cost systems attempt to rationalize the allocation of overhead to products by identifying cost drivers. A **cost driver** is anything that has a cause-and-effect relationship on costs. For example, the number of purchase orders processed is one cost driver of purchasing department costs; that is, the total costs of processing purchase orders (e.g., purchasing department salaries, postage) vary directly with the number of purchase orders that are processed. As in this example, cost drivers in activity-based cost systems are often nonfinancial variables. In contrast, traditional costing systems often use financial variables, such as dollar volume of purchases, as the bases for allocating manufacturing overhead.

ERP systems make it easier to implement activity-based costing because they provide detailed information about the steps required to process a transaction. For example, the time (and therefore the cost) of requisitioning the raw materials needed to manufacture a product depends upon the number of components in the finished product. Accountants and engineers can observe and calculate the average time it takes to retrieve one component from inventory. That time measure can then be multiplied by the number of line items in a production order (automatically recorded by the ERP system) to calculate the materials requisition costs for each different finished product.

Proponents of activity-based costing argue that it provides two important benefits: More accurate cost data result in better product mix and pricing decisions, and more detailed cost data improve management's ability to control and manage total costs.

Better Decisions Traditional cost systems tend to apply too much overhead to some products and too little to others, because too few cost pools are used. This leads to two types of problems, both of which AOE experienced. First, companies may accept sales contracts for some products at prices below their true cost of production. Consequently, although sales increase, profits decline. Second, companies may overprice other products, thereby inviting new competitors to enter the market. Ironically, if more accurate cost data were available, companies would find that they could cut prices to keep competitors out of the market and still make a profit on each sale. Activity-based cost systems avoid these problems because overhead is divided into three categories and applied using cost drivers that are causally related to production. Therefore, product cost data are more accurate.

Activity-based costing also makes better use of production data to improve product design. For example, the costs associated with processing purchase orders can be used to calculate the purchasing-related overhead associated with each component used in a finished product. Engineering can use this information, along with data on relative usage of components across products, to identify unique components that could be replaced by lower-cost, more commonly used parts.

Finally, activity-based cost data improve managerial decision making by providing information about the costs associated with specific activities, instead of classifying those costs by financial statement category. Table 14-3 shows an example of how this rearrangement of data can improve managerial analysis by focusing attention on key processes. Notice how the traditional cost report draws attention to the fact that travel and software costs are above budget. The activity-based cost report, in contrast, shows which *activities* (training, testing, maintenance and systems analysis) are running over budget, and which are not.

Improved Cost Management Proponents argue that another advantage of activity-based costing is that it clearly measures the results of managerial actions on overall profitability. Whereas

TABLE 14-3 Comparison of Reports Based on Activity-Based and Traditional Cost Systems

TRADITIONAL COST REPORTS, BASED ON GENERAL LEDGER ACCOUNT CATEGORIES			
	Budget	Actual	Variance
Salaries	$386,000	$375,000	$11,000
Computer software	845,000	855,000	(10,000)
Travel	124,000	150,000	(26,000)
Supplies	25,000	20,000	5,000
Total	$1,380,000	$1,400,000	($20,000)

ACTIVITY-BASED COSTING ANALYSIS			
	Budget	Actual	Variance
Systems analysis	$200,000	$210,000	($10,000)
Coding	440,000	400,000	40,000
Testing	235,000	250,000	(15,000)
Maintenance	250,000	275,000	(25,000)
User support	90,000	50,000	40,000
Reports	87,000	75,000	12,000
Training	78,000	140,000	(62,000)
Total	$1,380,000	$1,400,000	($20,000)

traditional cost systems only measure spending to acquire resources, activity-based cost systems measure both the amount spent to acquire resources and the consumption of those resources. This distinction is reflected in the following formula:

$$\text{Cost of activity capability} = \text{Cost of activity used} + \text{Cost of unused capacity}$$

To illustrate, consider the receiving function at a manufacturing firm such as AOE. The total monthly employee cost in the receiving department, including salaries and benefits, represents the cost of providing this function—receiving shipments from suppliers. Assume that the salary expense of the receiving department is $100,000, and assume that the number of employees is sufficient to handle 500 shipments. The cost per shipment would be $200. Finally, assume that 400 shipments are actually received. The activity-based cost system would report that the cost of the receiving activity used is $80,000 ($200 × 400 shipments) and that the remaining $20,000 in salary expense represents the cost of unused capacity.

In this way, performance reports that activity-based cost systems generate help direct managerial attention to how policy decisions made in one area affect costs in another area. For example, a purchasing department manager may decide to increase the minimum size of orders to obtain larger discounts for bulk purchases. This would reduce the number of incoming shipments that the receiving department must handle, thereby increasing its unused capacity. Similarly, actions taken to improve the efficiency of operations, such as requiring vendors to send products in bar-coded containers, increase practical capacity and create additional unused capacity. In either case, activity-based cost performance reports highlight this excess capacity for managerial attention. Management can then try to improve profitability by applying that unused capacity to other revenue-generating activities.

IMPROVED CONTROL WITH INNOVATIVE PERFORMANCE METRICS Modern approaches to production, such as lean manufacturing, differ significantly from traditional mass production. One major difference is a marked reduction in inventory levels of finished goods, because production is scheduled in response to customer demand instead of projections based on prior years. Although this is beneficial in the long run, it often creates a short-term decline in reported profitability. The reason: Traditional financial accounting treats inventory as an asset. Thus, the costs of producing inventory are not recognized until the products are sold. When a company switches from mass production to lean manufacturing, it reduces existing inventory levels, with the result that costs incurred in prior periods to create that inventory are now expensed. In addition, because lean manufacturing seeks to minimize the creation of additional inventories, almost all labor and overhead costs are expensed in the current period, instead of being allocated to inventory and thereby treated as an asset and deferred to future periods. The combined effect of these changes often results in a marked increase in expenses in the year of transitioning to lean accounting. Although this effect is only temporary, it can create significant concern among managers, particularly if their performance evaluations are based primarily on the company's reported financial statements.

To address these problems, CPAs who work for and with companies that have adopted lean manufacturing techniques advocate supplementing traditional financial reports based on GAAP with additional reports based on lean accounting[2] principles. One suggested change involves assigning costs to product lines instead of departments. For example, all the costs incurred to design, produce, sell, deliver, process customer payments, and provide postsales support are grouped by product. Another change involves reporting overhead costs as a separate item, rather than including them in the calculation of the cost of goods sold. Lean-accounting reports also identify the change in inventory as a separate expense item, to more clearly reveal the effect of inventory levels on reported profits.

In addition to changing the structure of performance reports, accountants should also develop and refine new measures designed to focus on issues important to production cycle managers. Two particularly important issues are the level of usable output produced per unit of time and measures of quality control.

Throughput: A Measure of Production Effectiveness Throughput represents the number of good units produced in a given period of time. It consists of three factors, each of which can be separately controlled, as shown in the following formula[3]:

$$\text{Throughput} = (\text{Total units produced/Processing time}) \times (\text{Processing time/Total time}) \times (\text{Good units/Total units})$$

Productive capacity, the first term in the formula, shows the maximum number of units that can be produced using current technology. Productive capacity can be increased by improving labor or machine efficiency, by rearranging the factory-floor layout to expedite the movement of materials, or by simplifying product design specifications. *Productive processing time*, the second term in the formula, indicates the percentage of total production time used to manufacture the product. Productive processing time can be improved by improving maintenance to reduce machine downtime or by more efficient scheduling of material and supply deliveries to reduce wait time. *Yield*, the third term in the formula, represents the percentage of good (nondefective) units produced. Using better-quality raw materials or improving worker skills can improve yield.

Quality Control Measures Information about quality costs can help companies determine the effects of actions taken to improve yield and identify areas for further improvement. Quality control costs can be divided into four areas:

1. *Prevention costs* are associated with changes to production processes designed to reduce the product defect rate.
2. *Inspection costs* are associated with testing to ensure that products meet quality standards.
3. *Internal failure costs* are associated with reworking, or scrapping, products identified as being defective prior to sale.
4. *External failure costs* result when defective products are sold to customers. They include such costs as product liability claims, warranty and repair expenses, loss of customer satisfaction, and damage to the company's reputation.

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[2]The introductory material in this section is based on an article by Karen M. Kroll, "The Lowdown on Lean Accounting," *Journal of Accountancy* (July 2004): 69–76.

[3]This formula was developed by Carole Cheatham in "Measuring and Improving Throughput," *Journal of Accountancy* (March 1990): 89–91.

The ultimate objective of quality control is to "get it right the first time" by manufacturing products that meet customer specifications. This often requires trade-offs among the four quality cost categories. For example, increasing prevention costs can lower inspection costs as well as internal and external failure costs. Many companies have found, however, that increased spending to prevent defects reduces total manufacturing costs. In addition, improved quality control can also help companies become "greener." For example, when the Subaru plant in Indiana redesigned its manufacturing process, it reduced the amount of electricity required to produce a car by 14% and totally eliminated waste sent to landfills.

Summary and Case Conclusion

The production cycle consists of four basic activities: product design, production planning and scheduling, production operations, and cost accounting. Companies are continually investing in IT to improve the efficiency of the first three activities. However, for a business to reap the full benefit of these changes, corresponding modifications must also be made to the cost accounting system. In addition, accountants need to modify financial reports and develop new measures that more accurately reflect and measure manufacturing performance.

After completing her tour of the factory, Elizabeth Venko was convinced that some major changes were required in AOE's cost accounting system. For example, although AOE's production operations were highly automated, manufacturing overhead was still being allocated based on direct labor hours. This resulted in distorted product costs due to small differences in the amount of direct labor used to assemble each item. Elizabeth decided that the solution was to do more than merely change the allocation base. Instead, AOE would implement activity-based costing. A number of different pools would be used to accumulate overhead costs, and the appropriate cost drivers would be identified for use in assigning those costs to specific products. Based on her research, including conversations with a controller at another company that had recently implemented an activity-based costing system, Elizabeth believed that these changes would solve AOE's problems with product pricing and mix decisions and more accurately reflect the effects of investments in factory automation.

Elizabeth also decided that three other major changes were needed in the reports the production cycle information system produced. First, data about all the costs associated with quality control, not just those involving rework and scrap, should be collected and reported. Second, performance reports should include nonfinancial measures, such as throughput, in addition to financial measures. Third, lean accounting principles, rather than GAAP, could be used to create financial reports intended for internal use. She discussed with LeRoy the likely behavioral effects of these changes. They agreed that identifying the different components of quality control costs should encourage continued investments that would be likely to improve the overall yield rate. Further, separately showing the effect of changes in inventory levels on profits would make it easier to reward efforts to reduce inventory levels. They also agreed on the need to closely monitor the effects of any new performance reports and make appropriate modifications to them.

Ann Brandt realized that Elizabeth's proposed changes would necessitate a redesign of AOE's production cycle database. In addition, the desire for more timely and accurate information would require additional investments in RFID technology to replace the use of bar codes wherever feasible.

Elizabeth and Ann presented their plans at the next executive meeting. LeRoy Williams was satisfied that the changes would indeed address his complaints about AOE's current production cycle information system. Linda Spurgeon supported the proposal and agreed to fund the necessary changes. She then told Elizabeth and Ann that their next task was to look at ways to improve AOE's HR and payroll process.

Key Terms

AIS IN ACTION

Chapter Quiz

1. Most costs are locked in at which stage in the production cycle?
   a. product design
   b. production planning
   c. production operations
   d. cost accounting
2. Which of the following is an advantage of bar-coding over RFID?
   a. speed
   b. accuracy
   c. cost
   d. safety
3. Which document lists the components needed to manufacture a specific product?
   a. operations list
   b. master production schedule
   c. bill of materials
   d. production order
4. Which document captures information about labor used in production?
   a. move ticket
   b. job-time ticket
   c. operations list
   d. bill of materials
5. An increase in which component of quality costs is most likely to result in a decrease in the other three components?
   a. prevention costs
   b. inspection costs
   c. internal failure costs
   d. external failure costs
6. Activity-based costing can be used to refine which of the following?
   a. job-order costing
   b. process costing
   c. both job-order and process costing
   d. neither job-order nor process costing
7. Which system is most likely to be used by a company that mass-produces large batches of standard items in anticipation of customer demand?
   a. MRP-II
   b. lean manufacturing
   c. activity-based costing
   d. throughput
8. The development of an MPS would be most effective in preventing which of the following threats?
   a. recording and posting errors
   b. loss of inventory
   c. production of poor-quality goods
   d. excess production
9. Which control procedure is probably *least* effective in reducing the threat of inventory loss?
   a. limiting physical access to inventory
   b. documenting all transfers of inventory within the company

c. regular materials usage reports that highlight variances from standards
d. periodically counting inventory and investigating any discrepancies between those counts and recorded amounts

10. What is the number of good units produced in a given period of time called?
a. productive capacity
b. productive processing time
c. yield
d. throughput

Discussion Questions

14.1. When activity-based cost reports indicate that excess capacity exists, management should either find alternative revenue-enhancing uses for that capacity or eliminate it through downsizing. What factors influence management's decision? What are the likely behavioral side effects of each choice? What implications do those side effects have for the long-run usefulness of activity-based cost systems?

14.2. Why should accountants participate in product design? What insights about costs can accountants contribute that differ from the perspectives of purchasing managers and engineers?

14.3. Some companies have eliminated the collection and reporting of detailed analyses on direct labor costs broken down by various activities. Instead, first-line supervisors are responsible for controlling the total costs of direct labor. The justification for this argument is that labor costs represent only a small fraction of the total costs of producing a product and are not worth the time and effort to trace to individual activities. Do you agree or disagree with this argument? Why?

14.4. Typically, McDonald's produces menu items in advance of customer orders based on anticipated demand. In contrast, Burger King produces menu items only in response to customer orders. Which system (MRP-II or lean manufacturing) does each company use? What are the relative advantages and disadvantages of each system?

14.5. Some companies have switched from a "management by exception" philosophy to a "continuous improvement" viewpoint. The change is subtle, but significant. Continuous improvement focuses on comparing actual performance to the ideal (i.e., perfection). Consequently, all variances are negative (how can you do better than perfect?). The largest variances indicate the areas with the greatest amount of "waste," and, correspondingly, the greatest opportunity for improving the bottom line. What are the advantages and disadvantages of this practice?

Problems

14.1. Match the terms in the left column with their definitions from the right column:

___ 1. Bill of materials	a. A factor that causes costs to change
___ 2. Operations list	b. A measure of the number of good units produced in a period of time
___ 3. Master production schedule	c. A list of the raw materials used to create a finished product
___ 4. Lean manufacturing	d. A document used to authorize removal of raw materials from inventory
___ 5. Production order	e. A cost accounting method that assigns costs to products based on specific processes performed
___ 6. Materials requisition	f. A cost accounting method that assigns costs to specific batches or production runs and is used when the product or service consists of uniquely identifiable items

____ 7. Move ticket	g. A cost accounting method that assigns costs to each step or work center and then calculates the average cost for all products that passed through that step or work center
____ 8. Job-time ticket	h. A document that records labor costs associated with manufacturing a product
____ 9. Job-order costing	i. A document that tracks transfer of inventory from one work center to another
____10. Cost driver	j. A document that authorizes manufacture of a finished good
____11. Throughput	k. A document that lists the steps required to manufacture a finished good
____12. Computer-integrated manufacturing	l. A document that specifies how much of a finished good is to be produced during a specific time period
	m. A production planning technique that is an extension of the just-in-time inventory control method
	n. A production planning technique that is an extension of the materials requirement planning inventory control method
	o. A term used to refer to the use of robots and other IT techniques as part of the production process

14.2. What internal control procedure(s) would best prevent or detect the following problems?

a. A production order was initiated for a product that was already overstocked in the company's warehouse.
b. A production employee stole items of work-in-process inventory.
c. The "rush-order" tag on a partially completed production job became detached from the materials and lost, resulting in a costly delay.
d. A production employee entered a materials requisition form into the system in order to steal $300 worth of parts from the raw materials storeroom.
e. A production worker entering job-time data on an online terminal mistakenly entered 3,000 instead of 300 in the "quantity-completed" field.
f. A production worker entering job-time data on an online terminal mistakenly posted the completion of operation 562 to production order 7569 instead of production order 7596.
g. A parts storeroom clerk issued parts in quantities 10% lower than those indicated on several materials requisitions and stole the excess quantities.
h. A production manager stole several expensive machines and covered up the loss by submitting a form to the accounting department indicating that the missing machines were obsolete and should be written off as worthless.
i. The quantity-on-hand balance for a key component shows a negative balance.
j. A factory supervisor accessed the operations list file and inflated the standards for work completed in his department. Consequently, future performance reports show favorable budget variances for that department.
k. A factory supervisor wrote off a robotic assembly machine as being sold for salvage but actually sold the machine and pocketed the proceeds.
l. Overproduction of a slow-moving product resulted in excessive inventory that had to eventually be marked down and sold at a loss.

14.3. Use Table 14-1 to create a questionnaire checklist that can be used to evaluate controls for each of the basic activities in the production cycle (product design, planning and scheduling, production operations, and cost accounting).

Required

a. For each control issue, write a Yes/No question such that a "No" answer represents a control weakness.
b. For each Yes/No question, write a brief explanation of why a "No" answer represents a control weakness.

14.4. You have recently been hired as the controller for a small manufacturing firm that makes high-definition televisions. One of your first tasks is to develop a report measuring throughput.

Required

Describe the data required to measure throughput and the most efficient and accurate method of collecting that data.

14.5. The Joseph Brant Manufacturing Company makes athletic footwear. Processing of production orders is as follows: At the end of each week, the production planning department prepares a master production schedule (MPS) that lists which shoe styles and quantities are to be produced during the next week. A production order preparation program accesses the MPS and the operations list (stored on a permanent disk file) to prepare a production order for each shoe style that is to be manufactured. Each new production order is added to the open production order master file stored on disk.

Each day, parts department clerks review the open production orders and the MPS to determine which materials need to be released to production. All materials are bar-coded. Factory workers work individually at specially designed U-shaped work areas equipped with several machines to assist them in completely making a pair of shoes. Factory workers scan the bar codes as they use materials. To operate a machine, the factory workers swipe their ID badge through a reader. This results in the system automatically collecting data identifying who produced each pair of shoes and how much time it took to make them.

Once a pair of shoes is finished, it is placed in a box. The last machine in each work cell prints a bar-code label that the worker affixes to the box. The completed shoes are then sent to the warehouse.

Required

a. Prepare a data flow diagram of all operations described.
b. What control procedures should be included in the system?

14.6. The XYZ Company's current production processes have a scrap rate of 15% and a return rate of 3%. Scrap costs (wasted materials) are $12 per unit; warranty/repair costs average $60 per unit returned. The company is considering the following alternatives to improve its production processes:

- Option A: Invest $400,000 in new equipment. The new process will also require an additional $1.50 of raw materials per unit produced. This option is predicted to reduce both scrap return rates by 40% from current levels.
- Option B: Invest $50,000 in new equipment, but spend an additional $3.20 on higher-quality raw materials per unit produced. This option is predicted to reduce both scrap and return rates by 90% from current levels.
- Option C: Invest $2 million in new equipment. The new process will require no change in raw materials. This option is predicted to reduce both scrap and return rates by 50% from current levels.

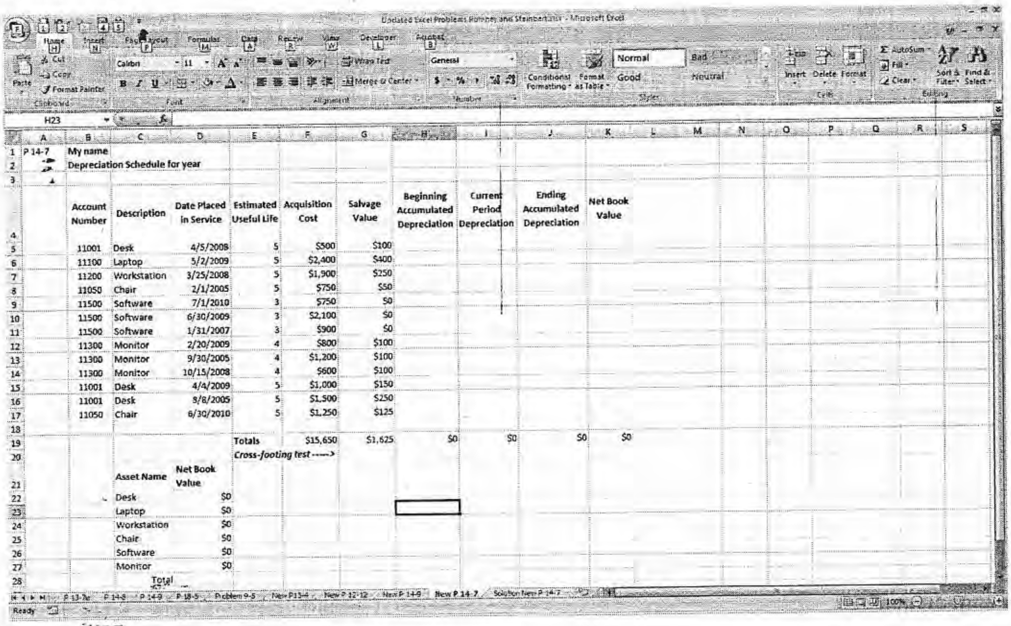
Required

a. Assume that current production levels of 1 million units will continue. Which option do you recommend? Why?
b. Assume that all of the proposed changes will increase product quality such that production will jump to 1.5 million units. Which option do you recommend? Why?

14.7. Excel Problem

Required

a. Create the following spreadsheet (next page):



	A	B	C	D	E	F	G	H	I	J	K
1	P 14-7	My name									
2		Depreciation Schedule for year									
3											
4		Account Number	Description	Date Placed in Service	Estimated Useful Life	Acquisition Cost	Salvage Value	Beginning Accumulated Depreciation	Current Period Depreciation	Ending Accumulated Depreciation	Net Book Value
5		11001	Desk	4/5/2008	5	$500	$100				
6		11100	Laptop	5/2/2009	5	$2,400	$400				
7		11200	Workstation	3/25/2008	5	$1,900	$250				
8		11050	Chair	2/1/2005	5	$750	$50				
9		11500	Software	7/1/2010	3	$750	$0				
10		11500	Software	6/30/2009	3	$2,100	$0				
11		11500	Software	1/31/2007	3	$900	$0				
12		11300	Monitor	2/20/2009	4	$800	$100				
13		11300	Monitor	9/30/2005	4	$1,200	$100				
14		11300	Monitor	10/15/2008	4	$600	$100				
15		11001	Desk	4/4/2009	5	$1,000	$150				
16		11001	Desk	9/8/2005	5	$1,500	$250				
17		11050	Chair	6/30/2010	5	$1,250	$125				
18											
19					Totals	$15,650	$1,625	$0	$0	$0	$0
20					*Cross-footing test ----->*						
21			Asset Name	Net Book Value							
22			Desk	$0							
23			Laptop	$0							
24			Workstation	$0							
25			Chair	$0							
26			Software	$0							
27			Monitor	$0							
28			Total								

b. Create formulas to calculate the following:
   - Accumulated depreciation (all assets use the straight-line method; all assets acquired any time during the year get a full year's initial depreciation)
   - Current year's depreciation (straight-line method, full amount for initial year in which asset acquired)
   - Ending accumulated depreciation
   - Net book value at end of period
   - Current year in the cell to the right of the phrase "Depreciation schedule for year"
   - Column totals for acquisition cost, beginning depreciation, current depreciation, ending accumulated depreciation, net book value
   - In the cell to the right of the arrow following the text "Cross-footing test," create a formula that checks whether the sum of the net book value column equals the sum of acquisition costs minus the sum of ending accumulated depreciation. If the two values match, the formula should display the text "Okay"; otherwise, it should display the text "Error."

c. Create a table at the bottom of your worksheet that consists of two columns: (1) asset name (values should be chair, desk, laptop, monitor, software, and workstation); and (2) net book value (create a formula to calculate this number), assuming that the current date is 06/30/2011. Then:
   - Create a formula that sums the total net book values for all classes of assets.
   - In the cell to the right of the total net book values for all asset classes, create a formula that compares the total net book values for all classes of assets to the sum of all net book values in the top portion of the spreadsheet. The formula should return "Okay" if the two totals match or "Error: Sum of net book values by asset class does not equal sum of all net book values" if the two totals do not equal one another.

d. Enter your name in row 1 in the cell to the right of the text "Name."

14.8. Excel Problem

Task: Use Excel and the Solver add-in to explore the effect of various resource constraints on the optimal product mix.

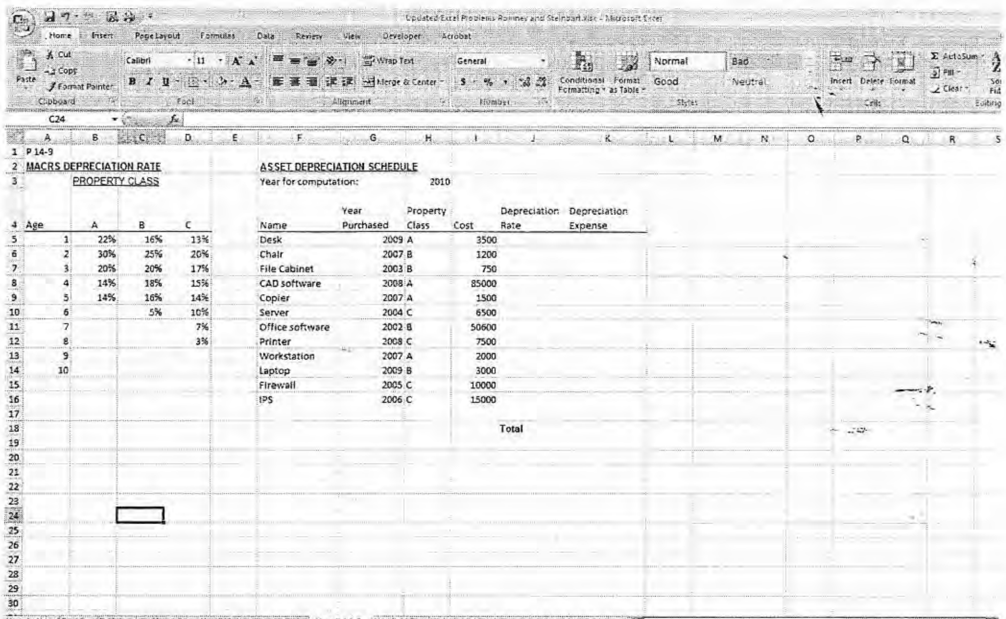
a. Read the article "Boost Profits With Excel," by James A. Weisel in the December 2003 issue of the *Journal of Accountancy* (available online at the AICPA's Web site, www.aicpa.org).
b. Download the sample spreadsheet discussed in the article, and print out the screenshots showing that you used the Solver tool as discussed in the article.
c. Rerun the Solver program to determine the effect of the following actions on income (print out the results of each option):
   - Double market share limitations for all three products
   - Double market share limitations for all three products plus the following constraint: sauce case sales cannot exceed 50% of the sum of soup and casserole case sales

14.9. Excel Problem

Required

Create the spreadsheet shown in Figure 14-11. Write formulas to calculate the total depreciation expense and to display the correct values in the following three columns: Age, Depreciation Rate, and Depreciation Expense. (*Hint:* You will need to use the VLOOKUP and MATCH functions to do this. You may also want to read the article "Double-Teaming In Excel," by Judith K. Welch, Lois S. Mahoney, and Daniel R. Brickner, in the November 2005 issue of the *Journal of Accountancy*, from which this problem was adapted.)

FIGURE 14-11
Spreadsheet for Problem 14-9



P 14-9

MACRS DEPRECIATION RATE

PROPERTY CLASS

Age	A	B	C
1	22%	16%	13%
2	30%	25%	20%
3	20%	20%	17%
4	14%	18%	15%
5	14%	16%	14%
6		5%	10%
7			7%
8			3%
9			
10			

ASSET DEPRECIATION SCHEDULE

Year for computation: 2010

Name	Year Purchased	Property Class	Cost	Depreciation Rate	Depreciation Expense
Desk	2009	A	3500		
Chair	2007	B	1200		
File Cabinet	2003	B	750		
CAD software	2008	A	85000		
Copier	2007	A	1500		
Server	2004	C	6500		
Office software	2002	B	50600		
Printer	2008	C	7500		
Workstation	2007	A	2000		
Laptop	2009	B	3000		
Firewall	2005	C	10000		
IPS	2006	C	15000		
				Total	

Case 14-1 The Accountant and CIM

Examine issues of the *Journal of Accountancy*, *Strategic Finance*, and other business magazines for the past three years to find stories about current developments in factory automation. Write a brief report that discusses the accounting implications of one development: how it affects the efficiency and accuracy of data collection and any new opportunities for improving the quality of performance reports. Also discuss how the development affects the risks of various production cycle threats and the control procedures used to mitigate those risks.

AIS IN ACTION SOLUTIONS

Quiz Key

1. Most costs are locked in at which stage in the production cycle?
   ▶ a. product design (Correct. Decisions made during product design determine the majority of costs.)
   b. production planning (Incorrect. Decisions made during product design determine the majority of costs.)
   c. production operations (Incorrect. Decisions made during product design determine the majority of costs.)
   d. cost accounting (Incorrect. Decisions made during product design determine the majority of costs.)
2. Which of the following is an advantage of bar-coding over RFID?
   a. speed (Incorrect. RFID technology can read information from multiple items at the same time, whereas bar-code scanners can read only one item at a time. In addition, employees spend time aligning the bar codes on each item with the reader.)
   b. accuracy (Incorrect. In certain applications, RFID is more accurate than bar-coding. For example, in retail stores, when checking out items that are similar but not identical—for example, different flavors of soda—clerks frequently enter the bar code for one item and then enter a quantity of, say, 7, rather than scanning the bar codes of each item; an RFID reader, in contrast, would identify which seven specific products were sold.)
   ▶ c. cost (Correct. Bar-coding is currently less expensive than RFID.)
   d. safety (Incorrect. There is no difference in the safety of bar-coding and RFID.)
3. Which document lists the components needed to manufacture a specific product?
   a. operations list (Incorrect. This document lists the sequence of steps to manufacture the product.)
   b. master production schedule (Incorrect. This document is used to plan production activities.)
   ▶ c. bill of materials (Correct. The bill of materials lists the components of a finished product.)
   d. production order (Incorrect. This document authorizes production activities.)
4. Which document captures information about labor used in production?
   a. move ticket (Incorrect. The move ticket documents movement of materials.)
   ▶ b. job-time ticket (Correct. The job-time ticket records time spent on each activity.)
   c. operations list (Incorrect. The operations list specifies the sequence of steps to manufacture a product.)
   d. bill of materials (Incorrect. The bill of materials identifies the components used to manufacture a product.)

5. An increase in which component of quality costs is most likely to result in a decrease in the other three components?
   - ▶ a. prevention costs (Correct. Increases in prevention costs often reduce the time and cost of inspecting products, as well as the proportion of defective products.)
   - b. inspection costs (Incorrect. Increases in inspection costs do not necessarily reduce the other three quality control costs.)
   - c. internal failure costs (Incorrect. Increases in internal failure costs do not have any effect on prevention or inspection costs.)
   - d. external failure costs (Incorrect. Increases in external failure costs do not reduce other components of quality costs.)
6. Activity-based costing can be used to refine which of the following?
   - a. job-order costing (Incorrect. Activity-based costing can be used with either job-order or process costing.)
   - b. process costing (Incorrect. Activity-based costing can be used with either job-order or process costing.)
   - ▶ c. both job-order and process costing (Correct. Activity-based costing can be used with either job-order or process costing.)
   - d. neither job-order nor process costing (Incorrect. Activity-based costing can be used with either job-order or process costing.)
7. Which system is most likely to be used by a company that mass-produces large batches of standard items in anticipation of customer demand?
   - ▶ a. MRP-II (Correct. MRP-II is a push form of manufacturing that is appropriate for mass production of standardized items for which demand is predictable.)
   - b. lean manufacturing (Incorrect. Lean manufacturing seeks to minimize inventories by producing only in response to customer orders.)
   - c. activity-based costing (Incorrect. Activity-based costing is a cost allocation system, not a production planning technique.)
   - d. throughput (Incorrect. Throughput is a measure of efficiency.)
8. The development of an MPS would be most effective in preventing which of the following threats?
   - a. recording and posting errors (Incorrect. Data validation and processing controls would best minimize recording and posting errors.)
   - b. loss of inventory (Incorrect. Access controls and frequent physical counts of inventory would best reduce the risk of inventory theft.)
   - c. production of poor-quality goods (Incorrect. Product design addresses this issue.)
   - ▶ d. excess production (Correct. An MPS schedules production to satisfy demand and, therefore, reduces the chance of overproduction.)
9. Which control procedure is probably *least* effective in reducing the threat of inventory loss?
   - a. limiting physical access to inventory (Incorrect. Physical access controls are an important method for reducing the risk of inventory theft.)
   - b. documenting all transfers of inventory within the company (Incorrect. Adequate documentation is an important control to reduce the risk of inventory theft.)
   - ▶ c. regular materials usage reports that highlight variances from standards (Correct. Although variances could indicate theft, they are more likely to reflect changes in efficiency.)
   - d. periodically counting inventory and investigating any discrepancies between those counts and recorded amounts (Incorrect. Periodic counts of inventory are an important control for reducing the risk of inventory theft.)

10. What is the number of good units produced in a given period of time called?
   a. productive capacity (Incorrect. Productive capacity is a component of throughput that represents the total number of units, both good and bad, produced per unit of time.)
   b. productive processing time (Incorrect. Productive processing time is the component of throughput that measures the proportion of time actually spent producing output.)
   c. yield (Incorrect. Yield is the component of throughput that measures the proportion of good units produced per batch.)
   ▶ d. throughput (Correct. Throughput is the measure of the number of good units produced per unit of time.)