Chapter 2: Moving From Traditional To Modern Manufacturing Environments

LEARNING OBJECTIVES

After studying this chapter, you should be able to:

1. Describe the traditional batch manufacturing environment
2. Define the world-class manufacturing (WCM), or Lean environment.
3. List and describe the characteristics of Lean.
5. Describe the role of technologies in World Class Business (WCB)

INTRODUCTION

The main purpose of this chapter is to show you the difference between good and bad business practices, and to get you used to criticising bad practices. Your ability to discriminate between good and bad is one of the main tools you have in advancing your career. Unless you recognize bad practices and can improve them, you will only be floating, not advancing. On this issue, we make some provocative statements that you or your professor may not agree with. We would rather have you disagree with us than provide you with the usually bland and opinionless textbook material.

Today, almost all traditional accounting and manufacturing practices can be considered bad, or obsolete. There may be a few situations where they are still useful, but they are mostly useful when the employees and managers are ill-trained and operating at the M-level of operating doctrine. This is not to say that they were not the best practices available at one time, however they have outlived their usefulness. Although it is difficult to imagine, up until recently (1960s, or so) it was not common in North America to have employees with more than elementary school education. Additionally, you could not count on all of them being fluent in English. Trying to run a business in these circumstances was extremely difficult, so, one response was to cut up job functions into small pieces and design the pieces so that there was not much communication between them.
Although this worked, we now see that the lack of communication caused a large loss of efficiency. In other parts of the world the same result basically occurred, however the reasons were not always the same. In Europe, for example class and religious differences were more important to this dynamic, although language differences were also more important than most people realize.

Before the 1970s you could work in the old cut-up way and still make money, however that has changed. As it became easier to engage in international trade, business became more competitive. One of the leaders in this competition was Japan, which has as one advantage that the culture, language and social class of employees is extremely homogeneous\(^1\). So, some Japanese companies were able to improve the communication between business elements remarkably. In fact, one way to look at many Japanese techniques is to consider them to be mainly communications improvement methods. Comparing Japanese culture with current North American or European culture it is obvious that the degree of homogenization and the level of education in the western countries is now such that they can expect to equal or exceed Japanese communication effectiveness.

Since we will live our professional lives in organizations which are moving from traditional to modern methods, we must be the masters of both. We must maintain the traditional systems while moving to more modern systems in sensible ways. We must also respect the traditional systems for the value they brought to our society, and keep those parts that are still useful. It should also be obvious that if you tell people their system is bad that they will not cooperate with you! So, only in this book are you likely to see such clear identifications of these methods as good and bad.

During your career you will have the obligation to improve your work and that of others. Since the late 1960s the rate of change, and our ability to change, have skyrocketed. We have a knowledgebase of advanced accounting and production methods that is extremely large. Japanese, North American, and European methods have developed in scope to such an extent that we now have the tools to solve most problems we encounter, if we can use them effectively. In the last twenty years we have also learned to look around the world for new ideas and to use them. Many of these tools are extremely well developed and so carefully described that they, in effect, constitute independent technologies. Because of the complexity and competitiveness of commerce today, the key to consistent business success is to be effective in selecting and using combinations of these technologies. In fact, the most difficult barrier we now face is management’s and workers’ ability to work together and work smart.

Roughly speaking, there are 7 basic technologies that concern us here: system technologies, business technologies, cost technologies, engineering technologies, human technologies, mathematical technologies, and quality technologies. Keep in mind, however, that this list is a moving target. Each of these technologies is explained in the Competitive Advantage web site. In this book we introduce each technology at the time and depth needed to help us focus our effort on using accounting to assist the pursuit of business goals.

In this textbook we start our look at good and bad practices with a focus on manufacturing problems for the first 12 or so chapters. The main reason for this focus is that accountants and engineers have been working very hard over the last 150 years to make

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1. This homogeneity is only a potential advantage, however. Japanese culture, like all culture has many facets, some which would increase communication and some which would reduce it. In Japan, the companies that tapped into the communication-increasing elements of the culture were a minority, but were so successful that we know them well: Toyota, Nissan, Matsushita (Panasonic, JVC, etc.), Hitachi, etc. The bulk of Japanese companies have never been able to move strongly in this direction.
manufacturing effective, and have largely succeeded. As a result we have a very deep pool of examples to share with you. We will also present examples from government and service businesses to the extent we can.

There are various manufacturing industries ranging from processors of basic metals, chemicals, paper, and oil and gas to commercial products manufacturers and consumer products companies. Within these industries there are a variety of manufacturing environments, as depicted in Exhibit 2-1. As this exhibit clearly indicates, no single management accounting system will fit all industries and all manufacturing environments. Cost accounting methods and various performance measurement techniques need to be adapted to be effective.

Exhibit 2-1

<table>
<thead>
<tr>
<th>Low-volume producers</th>
<th>versus</th>
<th>High-volume producers</th>
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<tr>
<td>Few products</td>
<td>versus</td>
<td>Many products</td>
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<tr>
<td>Long life cycle products</td>
<td>versus</td>
<td>Short life cycle products</td>
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<td>Fabricators</td>
<td>versus</td>
<td>Assembler</td>
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<td>Job order systems</td>
<td>versus</td>
<td>Process</td>
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<tr>
<td>Long lead (cycle) time</td>
<td>versus</td>
<td>Short lead (cycle) time</td>
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... To be successful, companies can no longer compete on a single dimension, such as cost. Instead, they must excel at ... low cost, high quality, and high customer service.... Managers seeking to prosper in this environment of tightly coupled technologies are turning to their management accounting system for new types of information....

This chapter examines manufacturing from the perspective of two different broad environments:

• The traditional batch manufacturing environment [batch-and-queue,, or PUSH]
• The lean manufacturing (LEAN) environment [pull]

We use these two environments as examples of good and bad practices in every chapter in the book. It is, of course, quite extreme, and not totally accurate, to use the terms good and bad, however our purpose is to provoke you into a more careful analysis of what you should do when proposing changes in your organization.

WHAT IS A TRADITIONAL BATCH MANUFACTURING ENVIRONMENT?

A traditional batch manufacturing environment is a PUSH system in which a subassembly or partially completed product is PUSHed to an area designated for work-in-process (WIP) to wait. Another expression is batch-and-queue, or batch-and-wait. It is also derisively called Just-in-Case inventory management. The next department takes the subassemblies or partially completed products from their WIP locations, performs an operation on them, and then PUSHes the resulting work into the next WIP location to wait once again. This procedure continues until the final product is completed, as shown in Exhibit 2-2.

In a PUSH system, instructions to make something come from a central planning function, or department. In almost all cases this function is not well connected to either sales or the production process itself.

One of the key defining features of this approach is to control risk of errors by creating a conceptual space between steps, normally by creating a buffer of partly completed items between stations called work-in-progress, or WIP. This “space” separates steps in order to reduce risks. In this way there is a lot of time to fix a problem before it has an impact on the next step.

Note the disjointed operations of the departments. The pipeline is not continuous between the three production departments. Each department is producing in large production runs, instead of producing just enough to meet the demand of the next department. This PUSH approach results in batches of WIP inventory being piled between departments throughout the plant. The cost accounting system has to accumulate and assign costs for these partially completed batches, thus adding complexity to the management accounting process. Notice that management of each of the production departments is easier because there is little or no coordination between departments. As long as production is steady, or increasing slowly, this system works well. However, if customers start demanding a variety of products at irregular times, this system cannot respond.

Four problems have become apparent in traditional batch manufacturing:

- Friction or information loss between organizational areas
- Producing and maintaining large inventories
- Producing products of low quality
- Striving for efficiency at the expense of effectiveness

**FRICTION BETWEEN ORGANIZATIONAL AREAS**

Traditional areas of engineering, manufacturing, marketing, logistics, and customer service operate in a disconnected manner, with little integration and communication between them. Engineering designs the product and PUSHes it into manufacturing, expecting manufacturing to make the product without any problems. Because of this, however, a number of engineering changes usually have to be made before the product...
becomes manufacturable because the design asks the production people to do things that are not reasonably possible.

Manufacturing finally makes the product in large lot sizes so that enough parts are on hand to keep everyone busy, without considering marketing, logistics, and customer service. Meanwhile, marketing personnel are out trying to sell a product that they had little say in designing; logistics is trying to get the product to the customer on time; and service people are out trying to repair the product without input from anyone. Nor do the service people report back about the kinds of repairs they make to the engineering and manufacturing people who could correct the reasons for the repairs.

**PRODUCING AND MAINTAINING LARGE INVENTORIES**

Traditional PUSH-type batch manufacturing environments drive products to lower average unit costs. The more products produced, the lower the average unit costs, but many products are left unsold, stacked up on factory floors and in large warehouses. Most companies produce more and more products to PUSH them into more and more warehouses. The more products produced, the greater the inventory asset, and therefore the better the balance sheet looks. So does the income statement, which shows a bigger income figure because of the lower unit costs, at least until the unsold inventory has to be written-off.

For example, when a traditional batch manufacturer buys equipment, machine utilization is the focus. If the machine costs $500,000 and production is 100,000 units, then the machine's average unit cost is $5.00. If production is increased to 200,000 units, the machine's unit cost drops to $2.50. In many traditional manufacturers, minimizing the average product cost has been the key to a successful performance evaluation for managers. So, the incentive is to produce more and more units. The production people's attitude is “It's our job to make it. It's marketing's job to figure out how to sell it.”

Although the financial statements may “look good,” the PUSH approach results in large quantities of inventory sitting on shelves in massive warehouses. The storage of these products is costly. Even worse, many items become obsolete, damaged, or stolen.

**PRODUCING PRODUCTS OF LOW QUALITY**

Although workers are encouraged to make good-quality products, rarely are they penalized for producing poor-quality work. Under the traditional batch manufacturing system, workers do not have major responsibility for quality control during their work.

Quality control is in the hands of quality control inspectors who inspect products after they have been produced. Thus, inspection does not take place in the most timely fashion, making it difficult, if not impossible, to trace where production problems arose or defects occurred. The result is excessive scrap and rework because problems cannot be identified and prevented. Instead of preventing problems, the company maintains large WIP inventories to protect against line shutdowns or work delays. The emphasis of a PUSH system is on quantity rather than quality. Thus, workers PUSH poorly produced work to the next department, which also has little incentive to make corrections or improve quality.
STRIVING FOR EFFICIENCY AT THE EXPENSE OF EFFECTIVENESS

Traditional batch manufacturers don't seem to strive for a balance between efficiency and effectiveness. **Efficiency** means performing tasks to produce the best yield at the lowest cost from the resources available. It is *doing something right*. **Effectiveness** is the degree to which an objective or target is met. It is *doing the right thing*. Being the lowest-cost producer of products that nobody wants is efficient, but not effective. Killing a fly with a sledgehammer is effective, but not efficient. Stressing efficiency over effectiveness, or vice versa, is wrong.

One of the reasons for this behavior is the use of financial accounting information (the average per unit cost of goods manufactured) for production performance evaluation. This causes a focus on “efficiency” as opposed to “effectiveness.” As someone once said, “Nothing is more wasteful than doing with great efficiency that which is totally unnecessary.”

We can see that although the “cutting-up” of jobs did solve the problems of language and education, it also had embedded in it the possibility of the entire effort spinning out of control *without anyone noticing*. That last little phrase is the kicker. All this sloppiness happened, and would still be happening, if global competition had not given us all a kick in the pants.

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<th>INSIGHTS &amp; APPLICATIONS:</th>
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<tr>
<td><strong>Producing Quantity But Not Quality</strong></td>
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<tr>
<td>At Marine Castings, a hypothetical company, workers were put on an incentive pay plan.</td>
<td>Under the new incentive system, the workers produced 50 castings an hour instead of 30 castings an hour. The workers were achieving good labor efficiency, but over 40 percent of the castings had to be scrapped because of poor quality. The controller was the one who had insisted on the installation of an incentive system. The incentive system continued until the company went out of business.</td>
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WHAT IS THE LEAN MANUFACTURING ENVIRONMENT?

**LEARNING OBJECTIVE 2**

Define the world-class manufacturing (WCM) environment.

The **world-class manufacturing (WCM) environment** is a culture of problem prevention, continuous improvement, efficiency and effectiveness, and excellence. Through time, the term **Lean Manufacturing** or **Lean Processes** has begun to be used most often to describe what WCM means today.

In this book we will show you a number of examples from the best companies in Japan, which is somewhat misleading in that the Japanese did not develop all of the techniques. However, the top Japanese companies were the first to pull together the established methods, innovate on them, and combine them in a way that created unique value for the companies involved. In most cases we can find earlier non-Japanese examples—even pre-1900—however the Japanese firms brought many things together and standardized the practices in such a way that the knowledge can be easily shared. Japanese companies also tend to be willing to share their internal knowledge quite easily, so we have good descriptions of their internal processes. The practices of the top Japanese companies is in stark contrast to the bulk of companies in Japan however, which are quite inefficient. In fact, the Japanese economy is at least 40% less efficient than the US or Canadian econ-

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omy, so overall the Japanese have more to learn from the west than vice versa. However at the high end of effectiveness and efficiency, the Japanese also have one of the largest pools of high performers.

The level of international competition was very high by the late 1970s and Japanese companies were unusually successful. As early as 1985, a US presidential commission on industrial competitiveness concluded that the United States needed to drastically improve its ability to compete in world markets. These conclusions would be echoed in most OECD countries, such as Canada and most of Europe. Their recommendations, the report stated, needed to be implemented immediately to restore the competitive edge that American manufacturing had lost. At stake was nothing less than providing an acceptable standard of living for its people. As an executive said, “American manufacturers have to automate, integrate, or evaporate.” Again, these opinions were shared in most developed countries. As China has developed since the early 1990s into a major manufacturer of low-value items, we see the same concerns surfacing once again: What do we have to do to survive when the Chinese move successfully into more complex manufacturing, which they will? And, have they already? Take a look at Haier Corporation [www.haier.com], a Chinese government owned cooperative which seems to be moving from strength to strength much like Samsung [www.samsung.com] did over the last 15 years.

WHY WE NEED FUNDAMENTAL CHANGES IN MANUFACTURING AND SERVICE

Fundamentally, traditional push organizations have had serious difficulties in four areas:

- Meeting foreign competition
- Being cost-effective against competitors
- Maintaining the level of domestic manufacturing activity for component parts
- Losing industries and companies to low labour-rate countries

At the root of these problems always seem to lie the issues of quality, customer satisfaction, responsiveness, and productivity. Let's take productivity as an example. The heyday of North American manufacturing occurred between 1948 and 1964, when the United States recorded an average annual improvement in real output per worker hour of approximately 3.2 percent\(^4\). Beginning in 1965, however, the annual increase began to drop, first to 2.4 percent, then by 1973 to below 1 percent, and finally in 1978 to negative levels.

\(^4\) For original data see the US government site at the Bureau of Labor Statistics: http://www.bls.gov/fls/home.htm

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**INSIGHTS & APPLICATIONS**

**Efficient Maybe, But Not Very Effective**

Brooke is plant manager at Widgets, incorporated. One day Brooke was talking to Marty, an engineer. “You look tired,” said Marty. “You’d look tired too if you were working 12 to 15 hours a day,” Brooke responded. “Boy, business must be good,” Marty replied.

“I wish that were true,” said Brooke. “Excuse me, Brooke, but if business is not good, why are you working 12 to 15 hours a day?” asked Marty. “Well, headquarters has told us that we’ve got to decrease the unit cost of our products. The more we produce, the less fixed overhead we have to allocate to each one, lowering the unit cost,” Brooke said confidentially. “But if you’re producing products that are not selling, what are you doing with them?” asked Marty, somewhat perplexed. “Oh, we leased two warehouses and have another one under construction to stock the inventory,” responded Brooke.
The commission report of 1985, without even mentioning Lean Manufacturing, was a clear call for implementing a Lean philosophy. Since then, numerous U.S. manufacturers have sought to achieve WCM status by pursuing a variety of methods, including Lean Processes.

Today we can see that the choice of technologies determines the relations between cost, quality, and customer service provided. By technology we mean the set of attitudes, equipment, people, analytic tools, production methods used and purpose as well as the 7 basic technologies mentioned earlier. The biggest lesson learned from the last twenty years is that it is the main job of management to focus on the technology and continuously improving it so that the cost, quality and customer service it delivers is competitive. For some exceptional companies such as Toyota, Scania, Porsche or Stiga, it means having a technology that is better than all other competitors. It is a paradox that focussing on the cost, quality, or customer service can mislead people into thinking that the technology is fixed and that it is a zero-sum game [check your economics textbook!]. In fact, it is the technology that fixes the cost, quality and level of customer service. Recognizing this shift is the key to real and sustained improvement, because you have to see that the only way to reduce costs with certainty is to change the technology.

THE BEGINNINGS OF LEAN MANUFACTURING IN NORTH AMERICA

In the early 1980s, many Canadian and U.S. companies began to seriously investigate the reasons why they were not competitive, particularly against the Japanese. Although they were looking for the very best in terms of world-class manufacturing practices, most firms found that their search ended in Japan, where the Toyota automobile company, the electronics industry, and other producers were taking a significant bite out of the market position of their European and North American counterparts. The idea was to learn from these new world-class competitors and to find out how they were able to compete and continually improve against more well-established North American companies. The North American firms found that continuous and simultaneous improvement in four competitive areas was the key:

- The lowest total cost of units sold (not lowest average cost per unit produced)
- The most consistent quality
- The most reliable delivery
- The most responsiveness to customers' needs

The difference was that the Americans had always regarded the relationship among these four areas as a trade-off. A manufacturer who wanted the lowest total cost, it was assumed, would have to trade off a certain amount of quality. Or, if greater reliability in customer deliveries was the goal, the manufacturer would require more time and be less responsive to customer needs. This reflects the attitude mentioned above: it assumes that the technology is fixed and that there is only one set of cost, quality, time relationships.

Japanese manufacturers, on the other hand, showed that simultaneous improvement in the competitive variables was possible and that one variable need not be sacrificed for another if you could change the underlying technology. If people focus on the underlying technology of the operations then the total picture would improve gradually, and with stability. The tool used to achieve this continuous improvement, or kaizen in Japanese, was the elimination of waste in all parts of production, production support, worker

5. One of the great innovations of this period, world-wide, was created in North America [both the US and Canada at the same time]: Activity Based Costing. At North American firms struggling with strong competition, they realized that they needed a more accurate way to measure cost and came up with ABC. We discuss ABC in a separate chapter later in the book.
involvement, and management practices in what we now call Lean Production. We have also seen that the Japanese had changed to an IKM operating doctrine which allows [forces, actually] the continuous improvement tools to work. Up until recently this link between the IKM operating doctrine and the tools was not known, and even now it is not widely known.

Interestingly, the Japanese had developed this industrial culture largely through observing such American operations as supermarkets and studying Henry Ford's automobile assembly concept of “taking the work to the worker, and not the worker to the work.” Following World War II, the Japanese employed several American consultants to help them rebuild the industrial sector of their economy, including Philip B. Cosby (Zero Defects) and Joseph M. Juran (Quality Management). The most notable of whom was Dr. W. Edwards Deming (Statistical Quality Control)

Many people consider Deming the “father of world-class manufacturing.” He is the capitalist revolutionary who sold Japan on the notion that quality drives profits up rather than down. The Deming Prize, a prestigious Japanese award, honors people for their contributions in the field of productivity and quality improvement. Although Deming was committed mainly to quality, we now see that Quality technologies are just one of a number of technologies that are crucial to long-term success.

What role should the modern management accountant play in this process? Michael Thomas argues that we need to participate in designing new management systems based on the following “chain of causation” for production process control evaluation:

1. For the economic goals of the organization to be satisfied, the production process must function efficiently and effectively.
2. If appropriate responses are not made to problems as they occur, the production process will not function as specified in (1).
3. If the organizational members are not committed to their roles, or lack necessary control skills, they will not respond appropriately.
4. Commitment cannot be forced or bought or incentivized. It must be designed into the jobs and roles assigned to people.
5. Appropriate information and training are necessary so that people will have the control skills required to identify and perform necessary control actions when needed.

One key ingredient for success is team involvement, achieved through a systematic approach which considers the social system (people) to be a primary component of the total organization. Thus, commitment results from having both the proper control skills and motivation to do the job right. Motivation results from rewards acceptable to the workers, and a performance evaluation system that allows workers to get rewarded. Proper evaluation requires information about the costs of production, problems that have happened, and whether they have been corrected. [italics in original]

Maryann N. Keller, an automotive industry analyst and managing director of a brokerage firm, believes that the most profound change in the American auto industry in the past ten years was the realization that “quality can cost less because you design it in rather than inspect it in.” The traditional American idea of quality is, as Keller says, to inspect it in; that is, you build a whole lot of widgets, inspect them, and separate the

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good from the bad. The bad can't be sold, but they cost a lot. Not only must all those inspectors be paid, but a bad widget takes the same amount of raw material, machinery, work time, and attention as a good widget does. That explains why, typically, about 25 percent of any traditional manufacturing plant's budget goes for repair and rework. That's why so many manufacturers think quality costs more, but what actually costs is a lack of quality.

Some people feel that Lean cannot succeed in the United States as it has in Japan due to fundamental cultural differences. The Japanese, they say, have a sense of community effort that we individualistic North Americans lack. Although differences exist, various Japanese firms have set up production operations in the United States and Canada, and have achieved excellent results using Lean Production methods. Also, the French Toyota plant appears to be very effective. It's been shown that the success of Lean is far more dependent on the culture developed within the company than on the culture of the nation as a whole. It is also true that the Japanese companies we study are not the average companies, but the extreme outliers in business practices in Japan, so they are not using normal Japanese practices, but innovative modifications of Japanese practices.

In conclusion, for those who are still not convinced, consider the following Lean success stories from some very American companies:

- **Harley-Davidson.** This motorcycle manufacturer cut inventory by $20 million, setup time (the time required to prepare and adjust machines for an assigned task) by 75 percent, reduced its break-even point by 32 percent, increased inventory turns from 6 to 20, and reduced warranty claims and defects by 24 percent.
- **General Electric.** GE trimmed inventory 70 percent and raised labor productivity 35 percent.
- **Hewlett-Packard.** HP reduced the production space for a printer line from 10,000 square feet to 2,500 square feet. Product failures dropped 21 percent. The company also reduced inventory by 60 to 80 percent, cut product lead time (the time between the beginning and end of a process) by more than 50 percent, reduced floor space by 30 to 50 percent, and cut labor cost by 20 to 50 percent. Inventory turns went from 7.5 to 45.6 in nine months.
- **Cincinnati Milacron.** The Electronic Systems Division trimmed inventory by 60 percent, reduced lead time from 12 weeks to 4 weeks, reduced manufacturing costs by 24 percent, and lowered the cost of quality from 19 percent to 14 percent.
- **General Motors.** In GM's Bay City, Michigan plant of 1,850 employees, quality is up. Productivity is up 24 percent over 18 months. Customer-reported problems with the plant's products have been reduced by 54 percent, and the cost of making the products is 15 percent less. Absenteeism is 35 percent less than GM's corporate average.
- **General Motors.** In 2004 the most efficient automobile plant in the world was the GM #1 in Oshawa Ontario, Canada. They assembled the Chevy Monte Carlo with only 17 labour hours, which beats the Toyota average by about 3.5 hours. Yeow!

Examples from almost every sector of Europe can also be cited. The following are some of the European companies that have pursued WCM status:

- **Olivetti.** This manufacturer has reduced lead time from 20 days to 3 days.
- **Michelin.** This maker of tires has reduced setup time by 90 percent.
- **Farmitalia Carlo Erba.** This large pharmaceutical enterprise has reduced WIP inventory by 60 percent.

**WHAT ARE THE CHARACTERISTICS OF WORLD-CLASS PRODUCTION?**

**LEARNING OBJECTIVE 3**

List and describe the characteristics of WCM.

The key defining characteristic of WCM in its Lean form is that it tries to reduce risk by reducing the conceptual space between steps by reducing the amount of WIP inventory as well as bringing the steps into very close physical proximity. This approach is used in
service industries like banks by bringing the desks of service reps and loan officers closer together so the loans can move directly from desk to desk instead of from floor to floor through office mail. This means that any error will have an immediate effect on all downstream steps and the attention will lead to immediate and conclusive fixing of problems. This is the opposite of the traditional approach to managing risk. In addition to this specific characteristic, there are a large number of differences which contribute to the effectiveness of this reduction of the conceptual space.

Chapter 1 introduced eight trends in modern manufacturing environments:

- High quality
- Customer service
- Low inventory
- Flexibility
- Automation
- Cross-functional team
- Forced Job rotation
- Integrated computer-based information systems (ICBISs)
- Effective use of a wide variety of technologies

These trends are also the characteristics of WCM, as Exhibit 2-3 shows. As modern manufacturers are discovering, they must aggressively pursue these characteristics if they are to achieve WCM status.

### INSIGHTS & APPLICATIONS:

**Multinational Business: Ordering from the Japanese**

For years, Generic Computer Company, a U.S. manufacturer of microcomputers, suffered from faulty components purchased from its suppliers. Ms. Peters, who just replaced the old purchasing manager, decided to switch to Gem Processing, a Japanese producer of computer chips. A little worried about their quality, she specified that defects must be limited to 1 percent of the quantity shipped. When Gem Processing received its first order for 50,000 chips, the sales manager was very confused. The company strictly enforced its policy of “zero defects.” But not wanting to offend his new American customer, the manager shipped 50,000 good chips in one box and 500 broken chips in another!

### ACHIEVING HIGH QUALITY

A good company designs a product for final production with high quality. They incur the costs up front in exhaustively designing the product and process, mainly using technologies such as Target Costing, and Quality Function Deployment (QFD). Once that product is released to the shop floor, there are no engineering changes and few, if any, process changes. There is little cost for warranty repairs or defects.7

In Lean enterprises, active quality control technologies are pervasive. Quality-oriented charts, banners, posters, and slogans, such as “Quality Is Job One,” abound.8

The Japanese approach to achieving high quality and zero defects is to regard a discovered defect is a “gem.” Their philosophy is that a defect didn't just happen. There is a cause, and the defect can lead to the cause, which in turn can be eliminated. This insis-

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tence on ferreting out and eliminating causes of defects is based on the Japanese philosophy to “pursue the last grain of rice in the lunchbox.” 9

The road to high quality starts with vendors of raw materials. Building a long-term partnership with vendors of raw materials is a key to another axiom: “Good input produces good output, cuts costs, and increases productivity.” More and more companies are hearing statements such as “Prices are only one component of total procurement costs, and the best prices often become the worst costs.”

Careful supplier selection and certification and strong vendor relationships ensure that raw materials will be of highest quality. Selection and performance criteria include on-time deliveries, price competitiveness, and high quality. When these criteria are satisfied, little formal monitoring of vendor performance is needed, further reducing raw materials costs.10

ACHIEVING CUSTOMER SERVICE

The customer is the final judge as to whether or not a manufacturer has attained WCM status. Customers are the most important people for the enterprise. Obviously, they have a number of needs, or customer service factors, that must be satisfied. Some of the more significant factors are:

• Delivery of the right product in the right amount at the right time
• Product performance (doing what it is supposed to do)
• Product reliability
• Variety of product features
• Serviceability of the product
• Promptness and willingness to help customers

All Lean enterprises are market driven. They stay close to the customers to maintain a high level of customer service. In today's global market, unless customers are so delighted that they're not only willing to come back, but also are eager to bring their friends, the enterprise can close its doors, put up an “out-of-business” sign, and go fishing.

ACHIEVING LOW INVENTORY

As noted earlier, large raw materials, WIP, and finished goods inventories are a key characteristic of traditional PUSH-type batch manufacturing. In Lean environments, inventory is viewed as an evil, as something to eliminate. Inventory costs the company a lot of money and also camouflages problems. In Lean, the trend is, therefore, toward less inventory and smaller lot sizes, so as to move the product through the plant to the customer more quickly. The following are keys to achieving this Lean objective:

- For raw materials, vendors are needed who are in close proximity to the manufacturer and can make frequent deliveries of small lot sizes in standard containers with zero defects.

- For WIP, the manufacturer must produce zero defect products at high velocity and be able to make setups quickly.

- For finished goods, the manufacturer must know customer demand and be able to deliver products to customers quickly.

... inventories really camouflage a lot of manufacturing problems. One way we like to describe it is that inventories are evidence, and all your problems of manufacturing end up in inventory. Think about it. If you order too much, it ends up in inventory. If you've got a scheduling problem and it doesn't get fully processed, it's in your work-in-process inventory. If there are machine capacity differences within the manufacturing process, bottlenecks exist and work-in-process inventory builds in front of the bottleneck. If your customer orders don't match up with your production, it's in inventory. All your problems are in inventory.

... at Allen-Bradley, at the end of the day there is no work-in-process inventory or any finished goods inventory. The whole manufacturing process is cleared. 11

High levels of inventory are generally traceable to poor management. Even a well-managed organization, however, normally needs some level of inventory to achieve excellent customer service and maximum operating efficiency. Only under ideal conditions

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would no WIP inventory be needed. Exhibit 2-4 lists the reasons for having high and low levels of inventory.

Holding inventory incurs several costs including the following:

• Cost of having money tied up in inventory. This is a cost of capital because this money could otherwise be invested in something that would generate a return to the enterprise.
• Costs of deterioration, damage, shrinkage, spoilage, and obsolescence.
• Costs of storage and handling.
• Insurance premiums for the policies that are directly related to the value of the inventory.
• Taxes assessed based on the value of the inventory.

Costs of not having finished goods inventory available when it is needed, or WIP to meet production schedules, are called stockout costs and include:

• Costs due to customers' ill will
• Costs of back ordering and special handling
• Costs incurred because of idle production capacity and schedule disruptions

According to many accounting authorities, however, the main reason some manufacturers produce large quantities is because the financial accounting system makes management look very good to stockholders and creditors. Having high levels in the three inventories on the balance sheet (raw materials, WIP, and finished goods) increases assets. Moreover, the more finished goods produced, the less their per unit cost, and the greater the gross margin on the income statement. The better the financial statements look, the better management looks—at least in the stockholders' eyes.

ACHIEVING FLEXIBILITY

Flexibility is the ability to be responsive to changing conditions. Lean environments provide the ability for both workers and equipment to meet changing customer demands. Setup times for machinery may be measured in minutes, whereas in traditional plants, days or weeks may be required. Customers want greater variety in products and want these products faster. Indeed, the rate of new product introduction has increased as product life cycles have shortened. The old Ford Model T assembly line approach was, “you can have it in any kind of color you want just as long as it's black.” That approach is not competitive in today's market. More sophisticated consumers throughout the world expect products to be tailored to their specific needs. Lean enterprises are using flexible equipment and reducing setup times and lot sizes.

... at Nissan, they take only 15 minutes to change the tools on a 3,200 ton press that bangs out steel parts.... In an older U.S. plant, it probably would have taken 4, 6, or 8 hours to change over that size press.... In terms of paint lines, they are able to make paint color changes in 15 seconds.... Think about that—a car that comes down the line; you want it red. The next one comes down the line behind it, and you want it blue.... They can do that.

Underlying flexibility is reduction in lead times, or the time it takes to convert raw materials into finished goods. Reducing lead times allows the manufacturer to offer a variety of products and to deliver them to customers quicker. In service organizations, insurance companies are seeking ways to shorten the underwriting process, while banks are reducing the hours spent in the loan approval process. Reductions in lead time also lessen the risk that the product will be obsolete by the time it reaches the market. The correspond

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13. Ibid., pp. 11-12.
ing reduction in WIP inventories means that the company can be more responsive to its customers and the market as a whole.

To achieve greater flexibility and reduction in manufacturing lead time, Lean organizations are changing their plant layouts. Most manufacturing plants have evolved in a piecemeal fashion. They also are predominantly organized by function (e.g., drilling, milling, finishing), resulting in a manufacturing flow that resembles a complicated maze. Lean enterprises are putting more emphasis on how products flow through the plant rather than thinking in terms of functional departments.

The mushroom concept also adds substantially to flexibility. The mushroom concept keeps processes and products standardized for as long as possible, creating a product structure that is diversified only at the final production stage. Rather than having specific subassemblies for specific products, subassemblies (and processes) are designed so they can be used in a larger variety of finished products. The goal is “all-purpose” subassemblies that can be used for many products. The result is that lead time for any given product can be reduced to the amount of time necessary for completing final assembly. One of the most effective companies in the world at this is Scania16 in Sweden, which is the 3rd [or so] largest truck maker in the world and clearly the most profitable. They have focussed for more than 40 years on designing the interfaces between parts so that they can use modules to build 10 different truck bodies on one production line using only about 9 body components. The mushroom concept is presented in Exhibit 2-4. Take a look at the Scania truck cabs at: http://www.scania.com/global/trucks/main-components/cabs/exterior/ All the trucks on this page are made from the same components, just adding extra pieces. Also they are made in order of the customer’s final order, or lot-size-1.

Exhibit 2-4 Structure of the Mushroom Concept

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look at the Scania truck cabs at: http://www.scania.com/global/trucks/main-components/cabs/exterior/ All the trucks on this page are made from the same components, just adding extra pieces. Also they are made in order of the customer’s final order, or lot-size-1.

Benetton, the Italian sportswear company, has not only automated the knitting process, but also integrated its entire supply chain—from raw materials through the retail outlets

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that sell its wares. By doing so, it is able to respond rapidly to changing demands all over the world.\textsuperscript{17}

More and more manufacturers are automating every day so they can achieve high quality, deliver customized products on time, minimize inventory, and increase flexibility. One of the most obvious characteristics of the Lean era is less direct labor, which is the result of both automation and the effort to use people's brains as well as their muscles. On the other hand, indirect labor has increased mostly to support the automated, technological environment.

**CREATING A TEAM CONCEPT**

In one model of Lean, people are paid according to the number of types of tasks they can perform, rather than by their seniority or the number of parts they make. Master workers can perform every job for a product. The more flexibility in the work force, the easier it is to move people around and handle bottlenecks.\textsuperscript{18} For example, a worker at Nucor Steel may operate a crane today and a rolling mill tomorrow.

With the team concept, no one gets credit for producing finished goods until customers receive the products and are satisfied. The team concept discourages bad behavior. The manufacturer does not want workers in one department producing a lot of unneeded parts just to make themselves look good.

Indeed, Lean organizations are managed differently from traditional organizations. In fact, installation of the team concept is considered a fundamental requirement for changing to a Lean organization. The old-style foreman, who sat in a glass office and was master of the area surveyed (the “boss”), has given way to the foreman as team leader, coach, and facilitator. In some Lean enterprises, it is difficult to determine where the office begins and the factory ends, as managers and workers are not separated by physical boundaries.\textsuperscript{19} Similarly, all traditional distinctions, such as company cars, private parking spaces, and executive restrooms, are eliminated.

\begin{itemize}
  \item 18. Ibid., p. 8.27.
  \item 19. Seed, op. cit., p. 17.
\end{itemize}
Workers are viewed as a resource rather than as a cost. Workers *are* the company. To harness this resource, Lean organizations use worker-manager teams, quality circles (a group of four to ten persons who share the same work area), incentive pay programs, and guaranteed employment policies. Increasingly, the entire plant's work force is put on salary, eliminating a fundamental difference between workers and managers. The primary objective of all of this is to foster teamwork to achieve common goals.\(^\text{20}\) The team is responsible for training new workers and for firing incompetents.

According to Fujio Cho, a past president of Toyota, “only line workers add value. The main job of management is to support the line worker”.

In traditional manufacturing environments, organization charts depict “pyramids” of positions with precise job descriptions at each level and large bureaucracies, as shown in Exhibit 2-5a. There is a sharp demarcation between line employees who are directly responsible for achieving an organization's goals and objectives and staff employees responsible for providing advice, guidance, and service to line employees. Boundaries between departments are precise, and management is exercised by authoritative levels and rules.

<table>
<thead>
<tr>
<th>INSIGHTS &amp; APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rewards Drive Actions</strong></td>
</tr>
<tr>
<td>Management needs to promote a company perspective rather than a departmental perspective. Everyone should be focused on profits in the broadest sense, and not on expenses. If the maintenance department thinks they have to work overtime to get a piece of equipment fixed, but that piece of equipment is critical to the operation and, therefore, will get the operation back on line, they'll spend the money and won't even “bat an eyelash.” But if they look at their expense budget, and that's going to cause them to go over into the red, and their boss is going to climb all over their backs for spending too much, then they're not going to work that overtime. People select an action because of the reward system in place. If the reward system is based on budget performance only, the system will yield dysfunctional results.(^\text{a})</td>
</tr>
<tr>
<td>(^\text{a})Howell, op. cit., pp. 2.15 and 2.16</td>
</tr>
</tbody>
</table>

The preceding description of organizational structure is anathema to Lean. The pyramid is turned upside down as shown in Exhibit 2-5b. In a Lean environment, classical organization charts found in traditional management textbooks are irrelevant because the emphasis is not on boundaries between functions, job descriptions, and organizational levels. The idea is that “many brains used properly are better than a few brains.” Line and staff functions tend to merge together, management hierarchies are flattened, and management is generally by consensus.

A model for the team concept involves seven stages:

- **Orientation.** The team purpose and mandate are spelled out.
- **Trust building.** Rapport between team members is established and cultivated.
- **Goal and role clarification.** What each team member is to do is defined.
- **Commitment.** Necessary resources and tools are made available to team members so they can get the job done.
- **Implementation.** A schedule is prepared showing when activities must be performed.
- **High performance.** The work on activities is performed at maximum efficiency.
- **Renewal.** An effective and smooth transition is made from one project to another.\(^\text{21}\)

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\(^{20}\) Ibid.

The first four stages are the “creating stages.” The last three stages are the “sustaining stages.” The team concept requires large doses of communication, encourages meetings, and emphasizes employee empowerment. Employees call meetings. They virtually run the enterprise.

The team concept can result in several interpersonal benefits:

- Full participation by everyone
- Increased respect for colleagues
- Increased understanding and improved relations between employees and managers
- Reduced potential for conflict between work areas
- Decreased suboptimal behavior
- Increased understanding by everyone about the mission, goals, and strategies of the enterprise

**INSIGHTS & APPLICATIONS**

**Going Upside Down**

Use a “reverse pyramid” organization chart, with front-line people “on top” and supervisors and middle managers (minders) below them in a support-and-facilitator role. The principal challenge is to empower people to take new initiatives.

Also, dramatically shift reward and evaluation systems for middle managers in order to emphasize “making things happen” across formerly sacred functional boundaries. Middle managers are to be responsible for seeking out and battering down the very functional barriers that they were formerly paid to protect.

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**IMPLEMENTING INTEGRATED COMPUTER-BASED INFORMATION SYSTEMS**

Integrated computer-based information systems (ICBISs) connect information technology, including computers, software, and telecommunications, throughout the enterprise to gather data online and process it into relevant information for internal users in real-time. ICBISs are also used by financial accounting for transaction processing and for external reporting.

**OVERVIEW OF ICBISs.** ICBISs have six components:

- Input

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*Adapted from: Mark Louis Smith, “Production Planning Simplicity,” in Strategic Manufacturing: Dynamic New Directions for the 1990s, ed. Patricia E. Moody (Homewood, Ill.: Business ONE Irwin, 1990), p. 256.*

*Exhibit 2-5  The Old-Style Management Pyramid and the New Team Concept*

*Adapted from: Mark Louis Smith, “Production Planning Simplicity,” in Strategic Manufacturing: Dynamic New Directions for the 1990s, ed. Patricia E. Moody (Homewood, Ill.: Business ONE Irwin, 1990), p. 256.*

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Exhibit 2-7 shows how these components interrelate.

Input enters the data to be processed. The **process** component manipulates the data in accordance with accounting and operational procedures. **Output** is the information disseminated to internal and external users via printers, video screens, or electronic data interchange (discussed in the next chapter). The **database** is the repository of financial and management accounting and operational data stored on magnetic disk, optical disk, or magnetic tape. **Controls** are those physical devices and procedures that safeguard the information system from destruction, interruption, fraud, and inaccuracies. The **technology platform** supports the foregoing five components.

**HOW TO PUT IT ALL TOGETHER TO FORM AN ICBIS.** If the entire telecommunications network is in the same room or building, it is commonly called a **local area network (LAN)**, as illustrated in Exhibit 2-8. Typical hardware devices connected to form the LAN are workstations, printers, and harddrives containing accounting data.

If computer devices, such as PCs, servers, mainframes, printers, and auxiliary storage devices, are distributed throughout a large area, possibly throughout the country or internationally, the network is termed a **wide area network (WAN)**. Multinational enterprises typically need LANs connected together to form a WAN.

For example, assume that the WAN in Exhibit 2-9 is for Module Manufacturing Company's ICBIS. The company's corporate headquarters is located in Cleveland, Ohio. Part of the headquarters building is occupied by financial accounting, supported by LAN 1. Large amounts of both financial and management accounting data are transmitted to administration's LAN 2, which processes these data into long-range strategic planning information. Management accounting, through LAN 4, interacts with manufacturing personnel, supported by LAN 3. Both of these LANs are located in Module's factory in Dallas, Texas. Management accounting also transmits manufacturing data to financial...
accounting's LAN. Financial accounting uses these and other manufacturing data to prepare various financial reports.

Exhibit 2-8 Wide Area Network (WAN) for Module Manufacturing Company's Integrated Computer-Based Information System (ICBIS)
JUST-IN-TIME MANUFACTURING

To achieve Lean status, many believe the production process must be redesigned as a JIT just-in-time (JIT) manufacturing is a PULL-THROUGH system of production unlike the traditional batch manufacturing PUSH-THROUGH system. The JIT manufacturing system is a continuous, synchronized production flow process that can be compared to a pipeline, as depicted in Exhibit 2-10. Unlike the PUSH manufacturing pipeline illustrated earlier in Exhibit 2-2, JIT can be viewed as a vacuum pipeline, or a PULL system; that is, products are made in response to downstream (end of the line) needs. As products are withdrawn at the finished goods end of the pipeline, raw materials are input and drawn through the pipeline in a synchronized conversion process. Unlike traditional batch manufacturing systems in which products are based on a planned schedule and PUSHed downstream, JIT is based on the PULL of downstream operations.

JIT manufacturing is dedicated to eliminating waste and producing the right products at the right time, as they are needed, rather than when they can be made. In a JIT manufacturing system, production equals sales to the greatest extent possible; that is, products are not produced until they can be sold. The idea is: If you don't need it now, don't make it now. Produce each day only what is sold each day. In this way, market demand PULLS production. Furthermore, suppliers deliver small batches of raw materials, sometimes directly to the appropriate department just-in-time, or right-on-time, to meet production demands. These techniques reduce the need for expediters, dispatchers, inventory con-

Exhibit 2-9  Just-in-Time (JIT) Manufacturing System

trol people, large factory floor space, and warehouses. This approach results in lower raw materials, WIP, and finished goods inventories.

JIT manufacturing has been called a journey of continuous improvement—a management philosophy of doing business. JIT is, indeed, a journey that pursues seven objectives:

- Synchronized operations
- Zero inventories
- Zero setup time
- Zero lead time
- Zero defects
- Visual factory
- Computer-integrated manufacturing (CIM)

**INSIGHTS & APPLICATIONS**

**No-Excuse Delivery**

A visitor was touring a Toyota plant in Japan. The visitor watched as a worker opened a loading dock door to reveal a parked truck loaded with transmissions that were taken directly to the assembly line. Knowing that parts arrived on a tight schedule, the visitor asked his guide what would happen if the truck were late. “Door open, truck there,” the guide said. “Suppose the truck broke down?” asked the visitor. “Door open, truck there,” the guide said. “Suppose there is a traffic jam?” asked the visitor. “Door open, truck there,” the guide said. The lesson soon learned by the visitor is that it is the vendor's duty to make sure the transmissions are there when needed.

**PURSUING SYNCHRONIZED OPERATIONS**

**Synchronized operations** exist when input equals output, and tasks are coordinated, or synchronized, to the rate that finished goods are withdrawn at the end of the pipeline. For example, today's demand is 1,000 units. The first operation in production makes 1,000 units, and the last operation makes 1,000.

Vendors (or suppliers) play an important role in synchronized operations, because they are an integral part of the production process. In traditional PUSH systems, vendors are often given “freedom of the week” to make deliveries. If raw materials arrive sometime between Monday morning and Friday afternoon, they are counted as “on time.” JIT has radically altered purchasing's notion of on-time delivery. Vendors are given the precise time during a specific day in which to show up. Early deliveries are penalized as much as late deliveries. The Honda plant in Marysville, Ohio, keeps three hours of raw materials on hand. The on-time delivery window at Toyota's assembly plant in Georgetown, Kentucky, is one hour.23

Physical layouts of plants also are changed to support a continuous, synchronized process. More and more support areas and people, such as purchasing, maintenance, engineering, and management accounting, are being moved out of remote offices and integrated into the production process on the factory floor. A total team approach is fostered.

The principle of synchronized operations is the foundation upon which JIT manufacturing systems are built. Grouping a variety of machines in the sequence required to make the product, and flowing one product at a time through them, is a major change in manufacturing philosophy. This new approach has made the old “one process” department found in traditional batch manufacturing systems practically obsolete. No longer are all of the punch presses in the punch press department, all of the lathes in the lathe department, and all of the milling machines in the milling department. Instead, these depart-

ments are replaced by a mixed lineup, usually U-shaped, of machines forming a workcenter. These U-shaped workcenters are often called “cells.”

Exhibit 2-11 illustrates the difference between the traditional process and cellular manufacturing, also called “group technology.” It is an often-used configuration in computer-integrated manufacturing (CIM). Cellular manufacturing uses a miniproduction line, usually conceptualized as a U-shaped loop (although it can take on any basic configuration). The main objective of cellular manufacturing is to minimize wait and move time by arranging machines sequentially. Two significant features of cellular manufacturing are:

- Production families
- Cross training

Exhibit 2-10 Comparison between a Straight Production Line and a U-Shaped Production Cell

In a manufacturing plant that makes hundreds of different products, these products are divided into production families. Each production family follows the same production flow path of a particular synchronized manufacturing cell. One family's path may go from blanking to grinding to drilling to painting through a U-shaped loop that contains computer-controlled process-to-process devices that perform these tasks. The result is a miniproduction line for a specific family of products, as shown in Exhibit 2-12.

Cellular manufacturing often requires cross training of workers so they can perform a variety of tasks within the manufacturing cell. The company's pay structure for its production personnel can be used to motivate workers to take on additional training. A worker's pay level, for example, could be tied to the number of different tasks she is trained and certified to perform. Moreover, because workers are responsible for more things, they are less likely to be bored than workers in traditional plants who perform single-task work that is narrowly focused and repetitive. Cross training may therefore provide higher job satisfaction.
Cross training also provides production management with increased flexibility in the event of an absence, because another employee can fill in for the absent worker. This flexibility in staffing is extremely important to both CIM and JIT systems, where the lack of WIP inventories can quickly bring the production line to a halt in the event of a missing worker.

When it is technologically feasible to do so, it is advisable to create U-shaped production lines rather than the straight lines typically used by PUSH-type manufacturers. The U-shaped production line offers the following advantages:

- Shorter lead times
- Better response time

The U-shaped line also has some disadvantages compared to the straight line:

- Possibility of having to increase the total number of machines
- Need for versatile personnel and cross training (some manufacturers do not consider this a disadvantage)

Usually, the advantages of the U-shaped production line decisively outweigh the disadvantages.

**PURSUING ZERO INVENTORIES**

In a traditional batch manufacturing process, large buffers of WIP inventories are often needed. If work stops in one department, the WIP inventory enables “downstream”

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**Exhibit 2-11  A Cellular Manufacturing Configuration for Production Families from Independent Cells**

- Less move time and material handling
- Minimum work-in-process inventory
- Less space
- Better coordination

The U-shaped line also has some disadvantages compared to the straight line:

- Possibility of having to increase the total number of machines
- Need for versatile personnel and cross training (some manufacturers do not consider this a disadvantage)

Usually, the advantages of the U-shaped production line decisively outweigh the disadvantages.
departments to continue working. Thus, the WIP is said to provide a “buffer” (protection) from problems between departments.

**INSIGHTS & APPLICATIONS:**  
**Becoming a Standard Way of Reaping Benefits**

Standard Motor Products is reaping the benefits of introducing JIT cellular manufacturing to its molding and finishing operations in Long Island City, NY. “We're avoiding hundreds of thousands of dollars a month in inventory costs overall for the five JIT cells that we're operating,” says Ray Donovan, manager of computer-integrated manufacturing at the firm. “That savings goes right to our bottom line.” At the same time, work-in-process has been cut by 94 percent and floor space by 66 percent. Lead time has fallen from 20 days to 4 days for all products manufactured in the cells. Standard knew it had to slim down on finished goods inventory. But its reputation has been based on being able to fill 97 percent of all orders for all of its many products. But to do that, it kept large inventories in finished goods, at great cost to the company, in its 400,000 square-foot distribution center in Virginia.

In its Long Island City plant, Standard manufactured products in a 75-year-old, six-story building. Two miles away was a 200,000 square-foot warehouse. The company stored finished goods, components, and raw materials there. Following the implementation of JIT, Standard eliminated the New York warehouse. The company now makes and stores raw materials and components in the factory.

Before JIT procedures were instituted, Standard’s molding facility was located in the factory's basement, while the assembly and packing operations were on the first floor. The molders would mold caps and rotors. Some went directly to the assembly and packing departments, while others were shipped to the warehouse. For those that went to the warehouse, the finisher would have to order them back when needed. “The molders, and the finishers were not synchronized,” said Donovan. The molder was manufacturing many different products. To avoid setting up a 300-ton molding machine for an order of 300 parts, he would make 3,000 parts-as much as 10 months' demand. This would then sit, unfinished, in the New York warehouse waiting to be assembled. “What we wanted to do was work strictly to customer demand and only make what the customer needs,” says Donovan. “We also wanted to integrate finishing and molding into one operation. This would cut floor space and help reduce raw materials, work-in-process, and finished goods inventories.” But to do this required radical changes in the company’s operations, from configuration of the shop floor layout, to training and attitude changes for all levels of employees and management.

“Not only did Standard use JIT, they implemented cellular manufacturing in the molding department,” says Donovan. “Families of parts are produced and finished entirely in one, dedicated 'cell' of machinery and people. A cell is so self-contained that it is really a factory within a factory.”

Under the old system, on an average day, there would be 15,000 caps as work-in-process for this family of products before the finisher could get to them. Today, it’s down to about 100 per cell. On products manufactured within the JIT cells, finished goods inventories have been reduced from two to three months to one month or less. These inventory levels have been consistently maintained for more than 10 months. Vendors now deliver raw materials weekly in small quantities instead of once every two months in large shipments. If a machine goes down, maintenance fixes it in a matter of minutes or hours instead of days. If the warehouse in Virginia actually has the desired inventory level of a product and there is no customer demand, then that product will not be manufactured. Consequently, levels of inventory at that location are now beginning to be reduced. Donovan believes any manufacturer can benefit from at least considering if JIT would help his operation. “Take a good look at your basic operation. See where the value added to a product really takes place,” he says. “Then cut out the rest. That's how you save money.”

JIT proponents disagree with the buffer approach. They believe that the philosophy of using inventories to overcome work stoppages or defects is a way of ignoring production problems. JIT reduces inventories in order to recouple sequential workcenters into cells, forcing workers to solve problems, such as defects, as they arise. If a problem is not solved, it affects all workers, causing a large amount of disruption. In a JIT, everyone strives to eliminate problems, maintain production equipment, and increase quality to prevent a shutdown of operations.

**USING KANBANS TO REDUCE INVENTORIES.** Kanban, loosely translated from the Japanese, means “visible signal,” “card,” or “sign.” It can be an electronic signal with a LAN. Kanban, as used in manufacturing, is an order for additional material, or a

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part to be produced, in either paper-based or computer-based form, sent from a using workcenter to a supplying workcenter (i.e., moving upstream). Under this PULL system, the only authorized production is that ordered by the kanban, as illustrated in Exhibit 2-13.

The kanban orders kanban containers to be filled. Kanban containers are receptacles that hold materials or parts for movement from one workcenter to another. In some plants, the kanban card is attached to the kanban container.

When all workcenters are interconnected through kanbans, PULL is created, and production is drawn “downstream” through the plant to the customer. The flow of kanbans is initiated by the last stage of the production process. In other words, nothing is made until it is needed for a specific customer order. Even the vendors are affected by the PULL, as they must deliver raw materials only when needed. Thus, plants controlled by kanbans are self-regulating, because each stage of production is activated by demand.24

Only in the most highly synchronized and automated factories are wait times between operations actually reduced to zero. In many operations, small buffers may be necessary to smooth production flow. Kanban containers specify the size of these buffers. Compared with the WIP inventories of traditional PUSH-type batch manufacturing, the capacity of a kanban container is truly minuscule, perhaps only two to five units. They are just big enough to permit the production line to continue operating smoothly despite minor interruptions at individual workcenters, such as a worker leaving his machine to go to the restroom or a brazing machine being shut down temporarily to replace an empty roll of solder. In a JIT environment, the product flow is visible, constant, and free of large WIP buffers.25

HOW DOES KANBAN WORK? As an example, consider two machines in a workcenter. The JIT philosophy dictates that these machines should be physically close together, perhaps as part of a U-shaped workcenter or cell, as shown in Exhibit 2-14. Now, the workers at these two machines are able to communicate and coordinate their work. The worker at machine A can easily see when his co-worker at machine B will require another part. Also, and more importantly, the worker at machine B can immediately tell his co-worker if there is a problem with the quality of the parts coming from machine A.

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This prevents the buildup of large quantities of defective WIP—any problem always gets “nipped in the bud.”

The kanban container between the two machines might hold four individual parts from machine A, perhaps in a bin with four divided cells for easy visual reference. As long as the kanban container is not full, the worker at machine A continues to produce parts, placing them in the kanban container. When the kanban container is full, that's it! Machine A stops producing until parts are needed again.

Having an idle worker may seem wasteful, but the reduction in WIP inventory and the elimination of defects that JIT provides are always worth it. When idle time occurs, the worker performs repairs and maintenance on the machine or engages in training activities. This reduces downtime and backlogs resulting from machine breakdowns and the need to get service people to fix it (usually from another department in a traditional factory). As the JIT line is fine-tuned and machine breakdowns are eliminated, each step can be synchronized to the point that workers are seldom idle and kanban container sizes can be further reduced.

As an example of such fine-tuning, consider the two machines A and B in Exhibit 2-14. If the step performed at machine A takes half as long as machine B’s, the machine A operator would be idle much of the time.

This situation might be corrected by creating a Y-shaped layout, as in Exhibit 2-15. Here, machine A feeds two machine B’s, resulting in better synchronization and a reduction or elimination of idle time.

Another option, which retains the original layout, would be to change the amount of work done by each operator until they have about the same amount to do (in terms of time). The worker currently at machine A might take on some of B’s tasks, for example. In more automated facilities, a kanban container will have a mechanism that automatically shuts down upstream machines when it becomes full and then restarts them once the downstream machines catch up.
PURSUING ZERO SETUP TIME

Setup time is the amount of time required to adjust equipment and to retool for the production of a different product. Setup time is one of the worst forms of waste in production because the entire company continues to incur costs while no value is being added to production (the worth, or value, of the product does not increase from this activity). In many JIT enterprises, setups take less than five minutes. Some JIT automobile manufacturers can change from one car model to another in two minutes, even though a complete retooling is required.

The reduction or elimination of WIP inventories is dependent on reducing setup times. Without a large buffer inventory, as in a traditional PUSH-type batch process, a lengthy setup at a JIT workcenter will bring the synchronized flow of the plant to a halt. A JIT system, therefore, seeks to reduce both the frequency and the time required to perform setups. For example, automatic calibration of equipment can be substituted for manual calibration. Some setup activities can be eliminated entirely by redesigning the products so that equipment (e.g., a drill press) does not have to be reset each time a different product is to be made.

<table>
<thead>
<tr>
<th>Total manufacturing lead time:</th>
<th>Nonvalue-added time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value-added time</td>
<td>Move time</td>
</tr>
<tr>
<td>•Time spent actually processing the raw materials into a finished product; that is, “time under the machine”</td>
<td>Wait time</td>
</tr>
<tr>
<td></td>
<td>Inspection time</td>
</tr>
</tbody>
</table>

PURSUING ZERO LEAD TIME

Lead time, also called cycle time, is how long it takes to produce a product or provide a service from start to finish. Lead time is composed of two kinds of times, summarized in Exhibit 2-16:

• Value-added time
• Nonvalue-added time

Value-added time represents activities performed by machines and people who work directly on making a product or providing a service. Nonvalue-added time comes from

26. This definition of value added and non-value added is a primitive one that is useful for this purpose, however it is not a complete definition, which you will come across later.
activities performed by people and machines that do not work on the product. Non-value-added time, which is wasted time, includes the following:

- **Move time** is the amount of time it takes to transfer the product from one location to another. Moving material around is not only a non-value-added activity, it can result in misrouting or damaging the material. Reducing move time is largely a function of the plant layout. A straight-line layout is often the simplest, but may not be the best. Generally, a U-shaped cell is more effective and efficient, because it makes communication between workers easier and enables multi-skilled workers to move from one workstation to the other, performing different tasks.

- **Wait time** is the amount of time that the product sits around waiting for somebody to process it, move it, inspect it, rework it, or the amount of time finished products spend in storage waiting to be sold and shipped. Wait time is embodied in the queues of material just sitting at each workcenter. Is there value in having these large queues? No, the crew in the workcenter can only work on one order at a time. The objective is to reduce the queues by using kanbans and JIT principles. With these approaches, bottlenecks and imbalances are easier to see and deal with.

- **Final inspection time** is the amount of time spent making sure the product is defect-free, or the amount of time actually spent reworking the product to an acceptable quality level. Reducing inspection time and rework is a function of the quality of raw material inputs, the quality of product design, and the quality of production.

Thus, the lead time formula is:

\[
\text{Lead time} = \text{Process time} + \text{Move time} + \text{Wait time} + \text{Inspection time}
\]

**REDUCING LEAD TIME BY REDUCING NONVALUE-ADDED TIME.** Non-value-added time is wasted time and is costly. Moving the product, waiting for something to happen to the product, and inspecting and reworking the product are wasteful, non-value-added activities. In many traditional PUSH-type batch manufacturing environments, the product is having value added to it only 5 percent of the time or less; 95 percent or more of the time the product is waiting, being moved, or being inspected and reworked.

**Exhibit 2-16 Continuous Improvement as Illustrated by the Total Lead Time**

If managers know what their lead time (or cycle time) is, they can improve it. Otherwise, they are managing by intuition. The management accountant is responsible for identify-
ing and reporting on value-added and nonvalue-added times so that management can strip out nonvalue-added, useless activities and continuously improve operations. Management accountants can use two methods to help managers and workers focus on, and visualize, the progress (or lack of progress) in a continuous improvement campaign. Both methods emphasize that reducing nonvalue-added time is a continuous improvement campaign.

The total lead time method shows the absolute amount of each element in the lead time formula over time. The graph in Exhibit 2-17 shows clearly how well management has improved operations by decreasing nonvalue-added times over a six-month period.

The lead time efficiency (LTE) ratio is computed using the following formula:

\[
\text{LTE ratio} = \frac{\text{Processing time}}{\text{Processing time} + \text{Move time} + \text{Wait time} + \text{Inspection time}}
\]

This ratio is a simple and powerful measure of how well production efficiency is improving over time. Many companies have chosen the LTE ratio as a dominant measure of performance. For example, assume a company determines that it spends the following times manufacturing a product:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing time</td>
<td>4 hours</td>
</tr>
<tr>
<td>Move time</td>
<td>6 hours</td>
</tr>
<tr>
<td>Wait time</td>
<td>28 hours</td>
</tr>
<tr>
<td>Final inspection time</td>
<td>2 hours</td>
</tr>
<tr>
<td>Total lead time</td>
<td>40 hours</td>
</tr>
</tbody>
</table>

Exhibit 2-17  Continuous Improvement as Illustrated by the Lead Time Efficiency (LTE) Ratio

The lead time efficiency ratio is computed as follows:

\[
\text{LTE ratio} = \frac{4}{4+6+28+2} = .10
\]

More efficient manufacturers have increased their LTE ratios to as much as .60 and .70, with an ideal of 1.0 computed as:

\[
\text{LTE ratio} = \frac{\text{Processing time}}{\text{Processing time} + 0}
\]

The graph of the LTE ratio over time, as illustrated in Exhibit 2-18, indicates management's continuous improvement over a period of six months.

Traditional PUSH-type manufacturing, where performance evaluation stresses minimizing average per unit production cost, sends a loud and clear message: “Build more prod-
uct!” This message encourages manufacturing to push more inventory into the pipeline to reduce fixed overhead cost per unit and to provide WIP buffers when defects and breakdowns are frequent. JIT manufacturing, on the other hand, sends a different message: “Focus on the process.”

**Focusing on the right thing.** Assume that Old Fashions Company does not consider value-added and nonvalue-added times, so the management accountant does not report total lead time or an LTE ratio. Instead, Old Fashions management tries to make non-value-added activities more efficient.

Old Fashions Company carries very large raw materials, WIP, and finished goods inventories. Management has not considered that reducing these inventories would also decrease lead time. Instead, the focus is on efficient handling and movement of these inventories, so management makes a large investment in automatic storage and material-handling equipment.

But having inventories in the first place results in large nonvalue-added costs. So, now Old Fashions Company has nonvalue-added costs in inventories, automatic equipment, and, possibly, additional people to service the equipment.

If managers had the proper information based on total lead time or the LTE ratio, their original decision would have been different. They would have changed to a production process that does not require large inventories, and the large investments in automatic material-handling equipment would not be needed.

**WARNING:** the value-added/non-value-added distinction is actually a bit more subtle than described here. This example uses a situation where the non-value-added time is clearly waste, which will not always be the case. There are many times where something that is non-value-added is not waste. For example payroll accounting is clearly non-value-added, but cannot be eliminated because it is necessary. The concept of non-value-added still helps us with the payroll accounting situation, however. Non-value-added actions are easier to change because the customer cannot tell the difference, so outsourcing or automating the payroll accounting function is a lot easier than changing the product. Our goal should be to reduce all costs, value-added costs are usually much more difficult to change.

**PURSUING ZERO DEFECTS**

**Zero defects** means that there are no rejected materials, parts, or finished products, and no rework. It is a state of perfection and total quality. The idea of zero defects is the culmination of a problem prevention strategy.

While zero defects may seem an unattainable goal, it is important to believe that this level of quality can and will be achieved, no matter how difficult. The electronic components industry measures the level of manufacturing defects in items per trillion components produced.27

The journey toward zero defects is driven by **total quality management (TQM), or Six Sigma (6σ)** which focuses on preventing problems and “getting it right the first time.” A TQM program is supported by the following techniques:

---

• Design of experiment (DOE)
• Total preventive maintenance (TPM)
• Statistical process control (SPC)
• Jidoka

As a general rule, over 40 percent of all quality problems originate in the design stage. The term **design of experiment (DOE)** is used to describe an ongoing program aimed at improving engineering's ability to create problem-free designs that meet customer requirements. DOE reviews various types of scientific experimentation, where the experiments are used to discover an unknown effect or to test a particular design feature.

The customer is not just the end user of the product once it has become a finished good. Every worker involved in the enterprise is thought of as “the customer.” All these customers must be satisfied along the way, or the end customer will never be satisfied.

**Total preventive maintenance (TPM)** aims at extending equipment life and maximizing effectiveness throughout the machine's entire useful life. TPM motivates people to improve plant maintenance through small-group activities that range from the development of a maintenance system to education in basic housekeeping and problem-solving skills. Under TPM, the machine operator is frequently responsible for the maintenance of his own machine instead of assigning this responsibility to a repairs and maintenance department.

**Statistical process control (SPC)** uses statistical techniques, such as random sampling and control charts, to analyze a production process. The nature of this type of control is preventive. It seeks to catch problems before the process or activity can create defective products.

Jidoka is a Japanese term that means “stop *everything* when something goes wrong.” This work ethic mandates that each person is responsible for finding and correcting his or her own errors before passing the product on to the next stage. If a defect is passed along, the worker who receives the defective product has the ability to stop the entire production line until the problem causing the defect is corrected. Such production line stoppages are very disruptive, so everyone works together to prevent problems from occurring, instead of trying to correct a problem after it occurs.

<table>
<thead>
<tr>
<th><strong>INSIGHTS &amp; APPLICATIONS:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implementing the Five Ss</strong></td>
<td>The plant manager explained the plant's everything-in-its-place philosophy, and said she would have another rack built to hold enough bottles to meet demand. A short time later, she noticed both racks filled and two bottles sitting on the floor. She waited for the water vendor to arrive, and as he watched, the plant manager smashed both bottles with a hammer. The lesson: To implement the five S's, apply them to all aspects of plant operation, even water bottle storage.</td>
</tr>
<tr>
<td>During a plant tour, the plant manager noticed two water bottles on the floor next to a full rack of bottles. The water service vendor explained that the two bottles were there to meet demand.</td>
<td></td>
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</table>

**DEVELOPING THE VISUAL FACTORY**

Production may be stopped manually or automatically by sensors installed on machines. JIT production facilities usually incorporate a visual control system, known in Japanese as **andon**, to help managers and workers know the status of production. Andon embodies the principle that “Problems must be seen in order to be solved.” Indeed, as Yogi Berra said, “You can see a lot by observing.”

Andon is the concept behind what some people call the **visual factory** where problems, abnormalities, defects, and all types of waste are immediately recognized at a single glance. The following five S's are fundamental to the visual factory:
• *Seiri* (organization) is distinguishing between needed and unneeded items. It is the elimination of unnecessary parts, adjustments, documents, and paper flow. It is an everything-in-its-place philosophy.

• *Seiton* (orderliness) is organizing the necessary items close to where they are needed and in such a way that any waste, nonvalue-added activity, or abnormality is apparent. Locations are clear and self-explanatory so that everyone knows what goes where. Nothing blocks access to fire extinguishers, hoses, and emergency exits.

• *Shitsuke* (discipline) means rules are followed precisely, including coming to work on time and wearing safety equipment. Following correct procedures becomes a habit. Instructions on how to do a job properly are clearly located on every machine.

• *Seiso* (cleanliness) ensures that tools, equipment, and the entire workplace are spotless. All dirt, oil, and scrap are eliminated.

• *Seiketsu* (standardization) results when the preceding S's are practiced. Because information is displayed for all to see, abnormalities are quickly recognized and eliminated, and a new state of efficiency is achieved.

The following are examples of visual controls displayed by computer screens, lights, and large graphs throughout the facility for all to see at a glance:

• Defect rates
• Inventory levels
• Planned production versus actual production
• Green, yellow, and red lights, indicating go, caution, or no-go conditions, to signify the state of quality at each workstation
• Kanban cards
• Display boards showing production stoppages and their causes
• Work assignments clearly posted for all to see
• Graphs showing improvement of teams, thus inspiring everyone to improve

<table>
<thead>
<tr>
<th>INSIGHTS &amp; APPLICATIONS:</th>
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<tbody>
<tr>
<td><strong>Hewlett-Packard’s Visual Factory</strong></td>
</tr>
<tr>
<td>Simple graphs are everywhere in the Hewlett-Packard plant. Three large graphs are posted on a main wall near the center of the manufacturing floor. One shows AT material flow.</td>
</tr>
</tbody>
</table>

Another graph shows the total quality management (TQM) process. The third, centered between the others, shows a number of other performance measurements, such as lead times, level of WIP inventory, and several nonconformities (e.g., bent leads or missing parts). The plant is set up for visual management. Anyone, even a visiting class from a local university, can tour the plant and can readily “see” what’s right and what’s wrong.

The visual factory enables all managers, including senior management, who may know very little about specific operations, to see the status of production by merely walking through the plant and observing the easy-to-understand information displays. It is management by sight. This way, managers have a real-time picture of operations, so they can practice “preventive management” rather than “post-mortem management.”

**COMPUTER-INTEGRATED MANUFACTURING**

The ultimate step toward full factory automation is **computer-integrated manufacturing (CIM)**. CIM uses groups of technologies that are integrated plantwide and are controlled by an ICBIS, as shown in Exhibit 2-19. CIM represents a major step toward “peopleless, lights-out” factories. Typically, manufacturers will convert to JIT to gain simplicity and synchronous operations and then will go to full CIM-JIT. Indeed, many experts consider JIT a prerequisite for CIM.

A CIM enterprise is integrated from the factory floor to the executive suite. Even customers, vendors, and carriers are part of the system, which includes the following major users:
Stakeholders are the people or organizations who have a vested interest in the manufacturer’s success. A fairly steady stream of electronic information flows between the stakeholders and the manufacturer. Such a connection eliminates the need for paper flows, such as purchase orders and invoices.

Customers look to the manufacturer for a dependable source of products or services. They can be connected to the manufacturer by an ICBIS so messages and transactions can occur electronically. Customers can get information about products, prices, and deliveries. They can place orders and then track them—all electronically. In turn, the manufacturer receives information about customers’ purchase plans and also receives performance information that indicates how well customers are being serviced.

The same arrangement exists between the manufacturer and its vendors, but in reverse because the manufacturer is the buyer rather than the seller. Vendors stay in close touch with the manufacturer to ensure that raw materials are delivered just-in-time.

Carriers transport raw materials from suppliers to the manufacturer and finished products from the manufacturer to customers. By being integrated into the system through the ICBIS, these carriers can ensure that a synchronized flow of goods is maintained.

Office personnel in different areas (marketing, administration, accounting, and so forth) are linked together in an ICBIS through LANs and WANs. Computer-aided design (CAD) and computer-aided engineering (CAE) workstations support engineers in design of experiment (DOE) tasks. Computer-aided manufacturing (CAM) workstations facilitate various production tasks. A great deal of interaction takes place among engineering, management accounting, and manufacturing. More will be said about these “enabling technologies” of Lean in the next chapter.
A note on Japanese innovation. This textbook often mentions specific tools learned from the Japanese. So often, in fact, that some people get irritated, and ask: if they are so good, why don’t they take over the entire planet? The answer is simple: in this book we are trying to learn about the innovative and efficient things the Japanese have done, not the bad things. The truth is that the average Japanese company is less efficient than the average company in the OECD countries, especially the US and Canada. Many of their internal processes are extraordinarily clunky and inefficient. Additionally, their internal ideology also leads them to making unwise investments in industry segments where they have no competitive advantage. A classic example is Isuzu, which is one of the largest truck manufacturers in the world [Really! This always surprises North Americans], but has little competitive advantage in automobiles, yet is compelled to compete without success in the automobile industry for some reason that they cannot explain. So, fortunately for the rest of the world, the Japanese have their own internal problems to solve, just as we all do. In this book, however we will not be discussing Japanese problems, but trying to learn from their successes.

A note on tools in general. As noted by one of the greatest strategists of all time, Miamoto Musashi: “You should not have a favourite weapon. To become over-familiar with one weapon is as much a fault as not knowing it sufficiently well. You should not copy others, but use weapons which you can handle properly. It is bad for commanders and troopers to have likes and dislikes. These are things you must learn thoroughly”. Although this was written in 1645 as a guide to military strategy, its wisdom is clear. The key to Lean is reducing waste, not any specific tool.

SUMMARY OF LEARNING OBJECTIVES

The major goals of this chapter were to enable you to achieve four learning objectives:

Learning objective 1. Describe the traditional batch manufacturing environment.
The traditional batch manufacturing environment is a PUSH system in which the product is produced in accordance with available capacity and moved along the production line in large batches. Inspection generally occurs at the end of the process. The following are characteristics of a traditional batch manufacturing environment:

• Suboptimizing behavior between organizational areas working at cross-purposes
• Producing and maintaining large raw materials, WIT, and finished goods inventories
• Producing products of low quality and performing a great deal of rework and repairs
• Striving for efficiency at the expense of effectiveness

Learning objective 2. Define the Lean manufacturing environment.
The Lean WCM environment seeks to develop within enterprises a culture of problem prevention, continuous improvement, efficiency and effectiveness, and manufacturing excellence. Companies that don't achieve Lean status will have difficulty:

• Meeting foreign competition
• Being cost-effective against competitors
• Maintaining a high level of manufacturing activity
• Surviving as viable businesses
Practicing continuous improvement is one of the keys to attaining Lean status. Continuous improvement can result in the following:

- Lowering costs
- Improving quality
- Increasing customer satisfaction

**Learning objective 3. List and describe the characteristics of Lean.**

Lean has seven major characteristics:

- **High quality.** The product works as intended without defect or deficiencies.
- **Customer service.** Customer service factors are used to achieve complete customer satisfaction.
- **Low inventory.** Minimal amounts of inventory are ordered, processed, stored, and handled.
- **Flexibility.** The manufacturing process can adapt quickly to changes in demand.
- **Automation.** Self-acting and self-regulating technologies are used to perform a large variety of tasks.
- **Team concept.** Workers and managers work together in a cooperative manner for the overall success of the enterprise.
- **Integrated computer-based information system (ICBIS).** A system in which various information technologies are used to connect all functions throughout the enterprise.

**Learning objective 4. Describe just-in-time (JIT) manufacturing and computer-integrated manufacturing (CIM).**

JIT manufacturing is a PULL system that is demand based. Its objectives include the following:

- Synchronized operations
- Zero inventories
- Zero setup time
- Zero lead time
- Zero defects
- Visual factory
- Computer-integrated manufacturing (CIM)

The ultimate JIT uses computer-integrated manufacturing (CIM) to fully integrate information technologies, production technologies, and functions throughout the enterprise and beyond. Typically, the CIM-JIT enterprise is connected electronically to its stakeholders, such as customers, suppliers, and carriers.

Cellular manufacturing (usually U-shaped) is a configuration often used by JIT manufacturers. Two significant features of cellular manufacturing are production families and cross training.

**IMPORTANT TERMS**

- **Andon** A visual control system located on the shop (factory) floor in full view of workers and managers.
- **Buffer** Stockpiles of WIP inventory between operations or departments in traditional production systems to protect departments from problems arising in previous departments.
- **Cellular manufacturing** A layout of production resources in the form of a cell, usually U-shaped, to manufacture production families and facilitate cross training.
- **Computer-integrated manufacturing (CIM)** A full integration of information and production technologies, which is the culmination of JIT.
- **Continuous improvement** The uninterrupted striving to advance or make better the entire enterprise, especially the engineering, manufacturing, marketing, logistics,
and service functions. The ultimate aim of continuous improvement is complete
customer satisfaction.

**Controls** A component of ICBISs that includes physical devices and procedures to pro-
tect the system from a host of threats and abuses.

**Cross training** A process by which workers are trained to perform a wide array of tasks.

**Cycle time** See lead time.

**Database** A component of ICBISs that serves as a repository for all financial account-
ing, management accounting, and operational data.

**Design of experiment (DOE)** A technique used to develop problem-free designs and
meet customer requirements.

**Effectiveness** The degree to which an objective or target is met.

**Efficiency** The degree to which inputs are used in relation to a given level of outputs.

The fewer inputs used in producing a set number of products, the greater produc-
tion efficiency becomes.

**Final inspection time** The amount of time spent to make sure the product (or service) is
defect-free or the amount of time actually spent reworking the product to an accept-
able quality level.

**Flexibility** The ability to adapt quickly to changing conditions.

**Input** A component of ICBISs that captures and enters data into the system for process-
ing.

**Jidoka** A technique used to stop the entire production process when a problem-causing
defect occurs. The production process is stopped until the problem causing the
defect is corrected.

**Just-in-time (JIT) manufacturing** A PULL system of production that produces in
accordance with downstream needs.

**Kanban** A computerized or hard-copy signal to produce the next product or subassem-
bly, or to order the direct materials for the next product, used in a JIT production
process.

**Kanban container** A standard-size container used in JIT manufacturing to achieve syn-
chronized operations and minimum inventories.

**Lead time (cycle time)** The time it takes to complete a product or service from start to
finish.

**Lead time efficiency (LTE) ratio** A way management accountants report lead time
improvement, or lack of improvement, over time in ratio form.

**Local area network (LAN)** A network in which all the devices of an ICBIS are located
in the same office or building.

**Move time** The amount of time it takes to transfer a product from one location to
another.

**Mushroom concept** A production process design that keeps processes and products
standardized for as long as possible and creates a product structure that is diversi-

fied only at the final production stage.

**Nonvalue-added time** The time spent on activities that are not part of the process.

These times are categorized as move time, wait time, and inspection time.

**Output** A component of ICBISs that generates information for end users.

**Process** A component of ICBISs that manipulates data in accordance with accounting
and operational procedures.

**Production family** A group of like products that are manufactured in a synchronized
production cell.

**Setup time** The amount of time required to adjust equipment and make tool changes for the production of a different product.

**Stakeholders** Those who have a vested interest in the manufacturer's success, such as customers, suppliers, and carriers.

**Statistical process control (SPC)** Statistical techniques used to monitor and control the production process.

**Stockout costs** The costs of not having inventory when needed, including customers' ill will and the costs of back ordering, special handling, and production line disruptions.

**Synchronized operations** A method by which production and the movement of products are coordinated to the rate at which products are withdrawn from finished goods.

**Technology platform** A component of ICBISs that includes all the computer hardware, computer software, and telecommunications devices necessary to support input, process, output, database, and controls.

**Total lead time method** A way management accountants report lead time improvement, or lack of improvement, over time. It presents the total lead time in absolute amounts.

**Total preventive maintenance (TPM)** A technique employed to maximize equipment performance and extend equipment life.

**Total quality management (TQM)** A broad method that prevents problems from occurring. TQM employs four techniques: design of experiment (DOE), total preventive maintenance (TPM), statistical process control (SPC), and jidoka.

**Traditional batch manufacturing environment** A production approach characterized by suboptimal behavior, large raw materials, WIP, and finished goods inventories, low-quality products, and efficiency-oriented procedures.

**Value-added time** The time spent directly on the production of a product or the provision of a service. It is process time.

**Visual factory** A management approach in which various graphical displays, video screens, signal lights, and markers are used to indicate problems, abnormalities, and all types of waste at a single glance.

**Wait time** The amount of time that the product sits around waiting for somebody to process it, move it, or inspect it, or the amount of time finished products spend in storage waiting to be sold and shipped.

**Wide area network (WAN)** A network in which all the devices of an ICBIS are dispersed over long distances.

**World-class manufacturing (WCM) environment** Seeks to develop within manufacturing organizations a culture of problem prevention, continuous improvement, efficiency and effectiveness, and manufacturing excellence.

**Zero defects** The absence of deficiencies in operations and products.

## DEMONSTRATION PROBLEMS

**DEMONSTRATION PROBLEM 1 Reducing nonvalue-added activities through JIT raw materials delivery systems.**

Maxco is a PUSH-type manufacturer of sports equipment. Its current materials movement program is illustrated in the figure.

Marv Chen has read that Apple Computer reduced its vendors from 400 to 75, and IBM Corporation cut its vendors from 640 to 32. He understands that such a program calls for
stipulating prices and acceptable quality levels in long-term agreements with vendors, thus eliminating negotiations for each purchase transaction. He also understands that Hewlett-Packard specifies in its contracts that a vendor cannot miss a four-hour delivery window more than three times in a year; otherwise, the contract is up for renewal. Because of synchronized deliveries and long-term arrangements, Apple, IBM, and Hewlett-Packard have reduced most nonvalue-added activities associated with all inventories: raw materials, work-in-process, and finished goods.

Required:

a. Marv Chen believes he can emulate these Lean organizations by eliminating materials handling, inspection, and warehouse costs. Draw a diagram showing how materials movement will be handled at Maxco if Mr. Chen's goal is achieved.

b. Ronald Hartman, Maxco's controller, doesn't like Marv Chen's plan. He argues that the price of raw materials will increase by 10 percent. Maxco is currently spending $10,000,000 annually on the purchase of raw materials. Marv counters by stating that the emphasis is on the total cost of operations, not just on the purchase of raw materials. Marv has collected the following cost data for nonvalue-added activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Current Cost</th>
<th>Cost if new plan implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials handling</td>
<td>$ 4,000 at 20%</td>
<td>$ 800</td>
</tr>
<tr>
<td>Inspection</td>
<td>2,000 at 10%</td>
<td>200</td>
</tr>
<tr>
<td>Warehousing</td>
<td>5,000 at 10%</td>
<td>500</td>
</tr>
<tr>
<td>Rework</td>
<td>3,000 at 20%</td>
<td>600</td>
</tr>
<tr>
<td>Total cost per day</td>
<td>$14,000</td>
<td>$2,100</td>
</tr>
</tbody>
</table>

Maxco works 300 days per year. Manufacturers that have moved from traditional methods have experienced the following average results:

- 80% decrease in materials handling
- 90% decrease in inspection
- 90% decrease in warehousing
- 80% decrease in rework

From these data, compute the cost savings Mr. Chen's plan will achieve, assuming a 10 percent increase in the purchase price of raw materials.
DEMONSTRATION PROBLEM 2 Cost savings from the mushroom concept.

Western Electronics produces switching equipment used by telephone companies. The parts list that records all the parts used in switching equipment fills four volumes totaling 1,200 pages. A typical part, a screw, is described as follows:

Jim Arcaro, an engineer, recently analyzed the screws used by Western Electronics in the manufacture of switching equipment. He found 20 separately designated screws that are virtually indistinguishable. He made similar discoveries concerning other parts, components, and subassemblies that are used to make Western Electronics' finished goods.

Marjorie Lankowski, management accountant, figured the only way to understand how raw materials for Western's products are used was to go out on the assembly floor and observe what was taking place.

Jim met Marjorie and said, “Let's take a walk.”

“For what?” asked Marjorie.

“You see that plate that goes on our QFI switching element?” asked Jim.

“Yes. I'm familiar with it from the thousands of materials requisitions I process each year,” said Marjorie.

“Well, it takes five different screws to hold that plate. But they're virtually the same. What's worse, follow me and I'll show you what an operator has to do to mount the plate,” said Jim.

Jim and Marjorie took a 15-minute walk. They went out of the building, across the street, and into another building to get the five screws. On the way back, they talked to a few people, and about 20 minutes later they were back where they started.

“All of this just to get five screws to mount a plate? It seems wasteful to me,” said Marjorie.

“You want to see something that's even more wasteful?” said Jim. “I can't imagine. What?” said Marjorie.

Jim pulled a blueprint of one of the switching devices and showed Marjorie even more screws that were exactly the same as the ones they had just gotten, except that they were a tiny bit longer. Jim also showed plates that were the same except that one called for six holes, another seven, and so forth; each required differently designated screws that were all exactly the same functionally.

“Why haven't you told anybody?” asked Marjorie.

“I have. I've been telling my boss that if we changed some of our designs, we could standardize much of our raw materials and also our production process and yet still be able to
offer a variety of switching devices. Most of the differences in the switching equipment are in the electronic components mounted, not in the production process itself. But I'm just about ready to give up,” said Jim.

“Don't give up yet. I think we'll be able to make some changes after I've made some reports to senior management,” said Marjorie.

Required: Discuss how Western Electronics could save money by following the mushroom concept.

**SOLUTION TO DEMONSTRATION PROBLEM 2**

First, the engineering analysis of all parts used in Western's manufacturing operations should continue. Second, where possible, all redundant parts should be eliminated. For example, the 20 separately designated screws that are functionally the same can be reduced to one. Other parts and subassemblies would come under the same kind of analysis. The variability in the finished switching equipment would come primarily from electrical components, and even those components could be subjected to standardization. Cost savings would occur from the following:

- Less record keeping
- Less ordering and stocking
- Less time in getting the right parts to the right job
- Fewer tools needed because of standardized parts and subassemblies
- Better inventory control

**DEMONSTRATION PROBLEM 3** *Plant layout.*

Diesel Parts, Inc., makes injection equipment used in diesel motors. The following diagram details the flow of the 12-stage process used to produce this equipment:

![Diagram of the 12-stage process used to produce injection equipment](image)

Required:

- Redesign the current plant layout to gain efficiencies.
- Discuss the possible benefits of your new design.
b. In the original layout, it appears that operations are not synchronized, with long movements of WIP between workstations. Probably, to keep everyone working, large WIP buffers are present as well. With the large physical distances between operations, workers probably do not communicate, coordinate their activities, or worry very much about WIP quality.

The new U-shaped production cell can employ a kanban system, electronic sensing devices, cross-trained workers, and robots. These JIT techniques should reduce raw materials storage, work-in-process inventory, finished goods inventory and lead times between the 12 operations. Diesel now uses end-unit demand to trigger production. Thus, the products are PULLed through the production cells. The visual factory concept can be used to indicate lead times, defect rates, kanbans, and work assignments.

**REVIEW QUESTIONS**

2.1 List and give an example of the two different manufacturing environments discussed in the chapter.
2.2 Why is a traditional batch manufacturing environment called a PUSH system?
2.3 List and give an example of the four problems found in many traditional PUSH-type batch manufacturing environments.
2.4 What Japanese word means continuous improvement?
2.5 Name three American companies that are considered world-class manufacturers.
2.6 List and briefly describe the seven trends in Lean environments.
2.7 What are the reasons for having high and low levels of inventory?
2.8 Why do many world-class manufacturers consider inventory “evil”?
2.9 Explain why the mushroom concept supports flexibility and decreases costs.
2.10 Contrast the old-style management pyramid with the new-style team concept.
2.11 List and give an example of the six components of an ICBIS.
2.12 Explain why telecommunication networks, especially LANs, can facilitate the team concept.
2.13 Why is JIT referred to as a PULL system?
2.14 List and briefly explain the seven objectives of JIT.
2.15 Explain how kanbans support synchronized operations.
2.16 What are the major differences between Exhibits 2-2 and 2-10?
2.17 Differentiate between value-added and nonvalue-added times. Give an example of each.
2.18 What is the lead time formula?
2.19 What is an ideal LTE ratio? Explain your answer.
2.20 List and briefly explain the four techniques that support a total quality management (TQM) system.
2.21 List and briefly explain the five S's.
2.22 What is the purpose of the visual factory? What makes up a visual factory?
2.23 What is a kanban and how does it differ from a kanban container?
2.24 List the users integrated by an ICBIS supporting a computer-integrated manufacturing (CIM) environment.
2.25 Why is cross training important in manufacturing cells?
2.26 List the advantages and disadvantages of a U-shaped production line compared to a straight production line.

CHAPTER-SPECIFIC PROBLEMS

These problems require responses based directly on concepts and techniques presented in the text.

2.27 Comparing PUSH-type and PULL-type manufacturers. Following is a list of characteristics:

- Large raw materials inventory.
- Very small WIP inventory.
- Warehouses full of finished goods.
- Focus on efficiency at the expense of effectiveness.
- Suboptimizing behavior between organization areas.
- Kanban system.

Required: Insert the appropriate type of manufacturer next to the characteristic.

2.28 Whether to produce at or above demand. Fixed costs are $200,000. If 50,000 units are produced during the period, the fixed cost per unit is $4. If 100,000 units are produced, the fixed cost per unit is $2. But demand for the period is 20,000 units. If production equals demand, then the fixed cost per unit skyrockets to $10.

Required: Describe a situation where it would be both efficient and effective to produce at the maximum capacity of 100,000 units. Describe a situation where it would be both efficient and effective to produce at 20,000 units.

2.29 The mushroom concept at work. Kitchenhelper makes dishwashers. Currently, it makes four different-colored doors for the dishwashers. It costs $10 per door for direct labor to paint the doors. The painting facility costs $100,000. Moreover, because different colors are currently a factory-controlled variable, finished goods are always out of balance due to the wrong color being in stock. This problem adds $8 per dishwasher for inventory warehousing costs. Matthew Gilland, newly hired design engineer, has recommended eliminating the painting process. His idea is to include colored plastic sheets for all Kitchenhelper's offered colors in the shipping box. The consumer selects the desired color, inserts the sheet into the door, and discards the rest. Matthew says, “Designs should be standard throughout the early part of the procurement and manufacturing process, with all variability added as late as possible.”
Required: Justify Matthew Gilland's recommendation.

2.30 **Total vendor costs.** Vendor A's price for a key raw material is $50 per unit. Daily usage averages 1,000 units. In any month (25 days worked each month), vendor A averages 10 days' late deliveries. The cost of idle time caused by late deliveries is $40,000 per day. Vendor B’s price for the same raw material is $65 per unit with zero late deliveries.

Required: Which vendor do you recommend? Justify your answer.

2.31 **Components of ICBIS.** Following are some functions performed by an ICBIS:

- Displaying a radar chart showing profitability, safety, and productivity measures. Storage of cost and performance data.
- Bar code readers that scan subassemblies during production.
- Transmission of kanban data throughout the production facility.
- Passwords for authorized users.
- An algorithm that converts raw data into production reports.

Required: Insert the name of the appropriate ICBIS component next to the component.

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**THINK-TANK PROBLEMS**

Although these problems are based on chapter material, reading extra material, reviewing previous chapters, and using creativity may be required to develop workable solutions.

2.32 **Quality control inspection.** “We have an excellent quality control system, because we inspect the finished goods as soon as they come off the production line. Products that don't pass inspection are sent back to the beginning of the production line for rework. A few, however, are scrapped,” said Jerry Sellers, production manager at Orico, a manufacturer of semiconductors.

Required: Explain what's wrong with Mr. Sellers' quality control system. Why may such a system result in excessive scrap and rework? Describe a more effective way to ensure that good products go into finished goods.

2.33 **Behavioral ramifications.** The management accountant at Ultrix Optical Company devised the following direct labor incentive program:

<table>
<thead>
<tr>
<th>Number Of Lenses Produced Per Day</th>
<th>Amount Of Daily Bonus</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>$ 0</td>
</tr>
<tr>
<td>21-40</td>
<td>10</td>
</tr>
<tr>
<td>41-60</td>
<td>50</td>
</tr>
<tr>
<td>61-80</td>
<td>100</td>
</tr>
</tbody>
</table>

To decrease packaging and delivery time, random inspections are made by the shipping department. The performance of the shipping department is measured on the number of shipments made per day.

Required: What kind of behavior does the direct labor incentive program engender? Should inspection responsibility be placed with the shipping department? Explain your answer. Will the present system be beneficial to Ultrix? Explain your answer.

2.34 **Is the lowest price the best price?** Chauncey's is a new franchisor specializing in turkey sandwiches. Wholesaler A has quoted a price 30 percent less than Wholesaler B’s
price for rolls of turkey. The cost of turkey rolls is 15 percent of the cost of making the sandwiches.

Required: Describe the kind of analysis, both financial and nonfinancial, that should be performed before a decision is made on which wholesaler will supply the turkey rolls to Chauncey's.

2.35 Redesign plant layout and product flow. Tour De Frame makes frames for racing bicycles. The current plant layout and product flow are as follows:

![Diagram of Tour De Frame's plant layout and product flow.]


The zigzag path followed in the assembly of the bicycle frames is typical of many major production facilities in the United States. The result is an overwhelming percentage of nonvalue-added time in production. In the plant layout shown here, 99 percent of the time is spent in nonvalue-added activities and 1 percent of it in actual productive processing. The process and accounting in this traditional assembly layout are so complex that one manager noted, “if you put raw material in, eventually it will belch out as product at the end. Everything in the middle is something of a black box.”

Required:

a. Redesign the plant layout and product flow at Tour De Frame in a way that will reduce nonvalue-added activities.

b. Write a report stating how you would convert Tour De Frame to a world-class manufacturer.

c. Assume the following annual costs:

- Receiving $400,000
- Storage 900,000
- Test and repair 300,000

State how you would go about reducing these costs. Make any assumptions you deem necessary.
2.36 Discussing just-in-time. [CMA adapted] The management at Megafilters, Inc., has been discussing the possible implementation of a just-in-time (JIT) production system at its Illinois plant, where oil filters and air filters for heavy construction equipment and large, off-the-road vehicles are manufactured. The metal stamping department at the Illinois plant has already instituted a JIT system for controlling raw materials inventory, but the remainder of the plant is still discussing how to proceed with the implementation of this concept. Some of the other department managers have grown increasingly cautious about the JIT process after hearing about the problems that have arisen in the metal stamping department.

Robert Goertz, manager of the Illinois plant, is a strong proponent of the JIT production system and recently made the following statement at a meeting of all departmental managers. “Just-in-time is often referred to as a management philosophy of doing business rather than a technique for improving efficiency on the plant floor. We will all have to make many changes in the way we think about our employees, our suppliers, and our customers if we are going to be successful in using just-in-time procedures. Rather than dwelling on some of the negative things you have heard from the metal stamping department, I want each of you to prepare a list of things we can do to make a smooth transition to the just-in-time philosophy of management for the rest of the plant.”

Required:

a. The JIT management philosophy emphasizes objectives for the general improvement of a production system. Describe several important objectives of this philosophy.
b. Discuss several actions that Megafilters Inc. can take to ease the transition to a JIT production system at the Illinois plant.
c. In order for the JIT production system to be successful, Megafilters, Inc., must establish appropriate relationships with its vendors, employees, and customers. Describe each of these relationships.

2.37 Discussing cross training. Part of Lean is the concept of cross training, where production workers are able to operate more than one type of machine or perform more than one type of operation. This concept fosters flexibility in the work force. Under what circumstances might this flexibility be required? Is it always desirable?

To motivate workers to learn new jobs, a manufacturing firm might implement a pay-for-knowledge program, where people are paid according to the number of jobs they’ve been trained to perform. Could this strategy backfire on the company? How? If you were in charge of the payroll department at such a company, how would you structure the pay of manufacturing workers?

2.38 Discussing bold goals. Tom Peters lists eight bold goals in Thriving on Chaos: Hand for a Management Revolution:

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Increased by 100% to 200%</td>
</tr>
<tr>
<td>Quality</td>
<td>Defects reduced by 95%</td>
</tr>
<tr>
<td>Product development cycles</td>
<td>Shortened 75% to 80%</td>
</tr>
<tr>
<td>Lead time</td>
<td>Reduced 90%</td>
</tr>
<tr>
<td>Inventory</td>
<td>Reduced 90%</td>
</tr>
<tr>
<td>Layers of management</td>
<td>Reduced 75%</td>
</tr>
<tr>
<td>Span of control</td>
<td>Increased by a factor of 5 to 10</td>
</tr>
<tr>
<td>Continuous learning</td>
<td>Training budget increased by 200% to 300%</td>
</tr>
</tbody>
</table>

Required: Write a proposal spelling out how each of these goals can be achieved. Also, explain the synergism that may exist among the goals. As an example, consider these issues and any others you think important:
• Will continuous learning help increase productivity?
• Will the reduction in the layers of management increase span of control and help shorten product development cycles?
• How will a reduction in inventory improve quality?
• How will continuous learning improve quality and reduce lead time?