

Part One

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DEFINING REQUIREMENTS

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INTRODUCTION

Facilities planning has taken on a whole new meaning in the past 10 years. In the past, facilities planning was primarily considered to be a science. In today's competitive global marketplace, facilities planning is a strategy. Governments, educational institutions, and businesses no longer compete against one another individually. These entities now align themselves into cooperatives, organizations, associations, and ultimately synthesized supply chains, to remain competitive by bringing the customer into the process.

The subject of facilities planning has been a popular topic for many years. In spite of its long heritage, it is one of the most popular subjects of current publications, conferences, and research. The treatment of facilities planning as a subject has ranged from checklist, cookbook-type approaches to highly sophisticated mathematical modeling. In this text, we employ a practical approach to facilities planning, taking advantage of empirical and analytical approaches using both traditional and contemporary concepts. It should be noted that facilities planning, as addressed in this text, has broad applications. For example, the contents of this book can be applied equally to the planning of a new hospital, an assembly department, an existing warehouse, or the baggage department of an airport. Whether the activities in question occur in the context of a hospital, production plant, distribution center, airport, retail store, school, bank, office, or any portion of these facilities, or whether in a modern facility in a developed country or an outdated facility in an emerging country, the material presented in this text should be useful in planning. It is important to recognize that contemporary facilities planning considers the facility as a dynamic entity and that a key requirement for a successful facilities plan is its adaptability and its ability to become suitable for new use.

1.1 FACILITIES PLANNING DEFINED

The facilities we plan today must help an organization achieve supply chain excellence. Supply chain excellence is a process with six steps, or levels. These steps are business as usual, link excellence, visibility, collaboration, synthesis, and velocity.

Business as usual is when a company works hard to maximize the individual functions of the supply chain (buy-make-move-store-sell). The goal of individual departments, such as finance, marketing, sales, purchasing, information technology, research and development, manufacturing, distribution, and human resources, is to be the best department in the company. Organizational effectiveness is not the emphasis. Each organizational element attempts to function well within its individual silo.

Only after one's link achieves performance excellence can he or she begin to pursue supply chain excellence. To achieve *link excellence*, companies must tear down the internal boundaries until the entire organization functions as one. Companies usually have numerous departments and facilities, including plants, warehouses, and distribution centers (DCs). If an organization hopes to pursue supply chain excellence, it must look within itself, eliminate and blur any boundaries between departments and facilities, and begin a neverending journey of continuous improvement. It must have strategic and tactical initiatives at the department, plant, and link levels for design and systems.

Supply chain excellence requires everyone along the supply chain to work together. Everyone in the supply chain cannot work together, however, if they cannot see one another. *Visibility*, the third level of supply chain excellence, brings to light all links in the supply chain. It minimizes supply chain surprises because it provides the information links needed to understand the ongoing status. It could be considered the first real step toward supply chain excellence.

Through visibility, organizations come to understand their roles in a supply chain and are aware of the other links. An example is an electronics company with a Web site that allows its customers to view circuit boards and then funnels information about those customers to suppliers. Visibility thus requires sharing information so that the links understand the ongoing order status and thus minimize supply chain surprises.

Once a supply chain achieves visibility, it can move to collaboration, the fourth level of supply chain excellence. Through collaboration, the supply chain can determine how best to meet the demands of the marketplace. The supply chain works as a whole to maximize customer satisfaction while minimizing inventories. Collaboration is achieved through the proper application of technology and true partnerships. Various collaboration technologies exist, and, as with visibility software, the supply chain must choose the right technology or combination of technologies if it hopes to collaborate properly. True partnerships require total commitment from all the links in the supply chain and are based on trust and a mutual desire to work as one for the benefit of the supply chain.

After collaboration is in place, the supply chain then must pursue the continuous improvement process of *synthesis*. Synthesis is the unification of all supply chain links to form a whole. It creates a complete pipeline from a customer perspective. The results of synthesis are as follows:

- *Increased ROA*. This is achieved by maximizing inventory turns, minimizing obsolete inventory, maximizing employee participation, and maximizing continuous improvement.
- *Improved customer satisfaction*. This is achieved because synthesis creates companies that are responsive to the customer's needs through customization.

They understand value-added activity. They also understand the issue of flexibility and how to meet ever-changing customer requirements. They completely comprehend the meaning of high quality and strive to provide high value.

- *Reduced costs.* This is achieved by scrutinizing transportation costs, acquisition costs, distribution costs, inventory carrying costs, reverse logistics costs, packaging costs, and so on and continually searching for ways to drive down the total delivered-to-customer cost.
- *An integrated supply chain.* This is achieved by using partnerships and communication to integrate the supply chain and focus on the ultimate customer.

Synthesis is not achieved overnight. It takes time to take the links of a supply chain and remove the boundaries between them. However, if all links are visible and all collaborate, then synthesis is within reach.

Velocity is synthesis at the speed of light. Today's business environment demands speed. The Internet has created immediate orders, and customers expect their products to arrive almost as quickly. Synthesis with speed creates multilevel global networks that meet these demands—these are complex entities that can meet the demands of today's economy through a combination of partnerships, flexibility, robust design, and ongoing adaption to marketplace requirements.

Facilities are critical components of the multilevel global networks necessary for supply chain excellence. Each organization in the supply chain should therefore plan facilities with its supply chain partners in mind. Proper facilities planning along the supply chain ensures that the product will follow the supply chain series buy-make-move-store-sell to the satisfaction of the ultimate customer. Therefore, all facilities in the supply chain have the following characteristics:

- *Flexibility.* Flexible facilities are able to handle a variety of requirements without being altered.
- *Modularity.* Modular facilities are those with systems that cooperate efficiently over a wide range of operating rates.
- *Upgradability.* Upgraded facilities gracefully incorporate advances in equipment systems and technology.
- *Adaptability.* This means taking into consideration the implications of calendars, cycles, and peaks in facilities use.
- *Selective operability.* This means understanding how each facility segment operates and allows contingency plans to be put in place.
- *Environmental and energy friendliness.* This involves adopting the process of leadership in energy and environmental design (LEED). A whole-building approach to sustainability recognizes performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

Creating these facilities requires a holistic approach. The elements of this approach are as follows:

- *Total integration*—the integration of material and information flow in a true, top-down progression that begins with the customer.

- *Blurred boundaries*—the elimination of the traditional customer/supplier and manufacturing/warehousing relationships, as well as those among order entry, service, manufacturing, and distribution.
- *Consolidation*—the merging of similar and disparate business entities that results in fewer and stronger competitors, customers, and suppliers. Consolidation also includes the physical merging of sites, companies, and functions.
- *Reliability*—the implementation of robust systems, redundant systems, and fault-tolerant systems to create very high levels of uptime.
- *Maintenance*—a combination of preventive maintenance and predictive maintenance. Preventive maintenance is a continuous process that minimizes future maintenance problems. Predictive maintenance anticipates potential problems by sensing the operations of a machine or system.
- *Economic progressiveness*—the adoption of innovative fiscal practices that integrate scattered information into a whole that may be used for decision making.

In this regard, for a facilities planner, the notion of continuous improvement for supply chain excellence must be an integral element of the facilities planning cycle. The continuous improvement facilities planning cycle shown in Figure 1.1 details this concept. Whether you are involved in planning a new facility or planning to update an existing facility, the process of facilities planning is unchanged.

Facilities planning determines how an activity's tangible fixed assets best support achieving the activity's objective. For a manufacturing firm, facilities planning involves the determination of how the manufacturing facility best supports production. In the case of an airport, facilities planning involves determining how the airport facility is to support the passenger-airplane interface. Similarly, facilities planning for a hospital determines how the hospital facility supports providing medical care to patients.

It is important to recognize that we do not use the term *facilities planning* as a synonym for such related terms as *facilities location*, *facilities design*, *facilities layout*, or *plant layout*. As depicted in Figure 1.2, it is convenient to divide a facility into its location and its design components.

The *location* of the facility refers to its placement with respect to customers, suppliers, and other facilities with which it interfaces. The location in the context of the global supply chain must take into consideration global transportation economics, ports of entry, fuel costs, and the total delivered costs of products to the ultimate consumer. Also, the location includes its placement and orientation on a specific plot of land.

The design *components* of a facility consist of the facility systems, the layout, and the handling system. The facility systems consist of the structural systems, the atmospheric systems, the enclosure systems, the lighting/electrical/communication systems, the life safety systems, and the sanitation systems. The layout consists of all equipment, machinery, and furnishings within the building envelope; the handling system consists of the mechanisms needed to satisfy the required facility interactions. The facility systems for a manufacturing facility may include the envelope (structure and enclosure elements), power, light, gas, heat, ventilation, air conditioning, water,

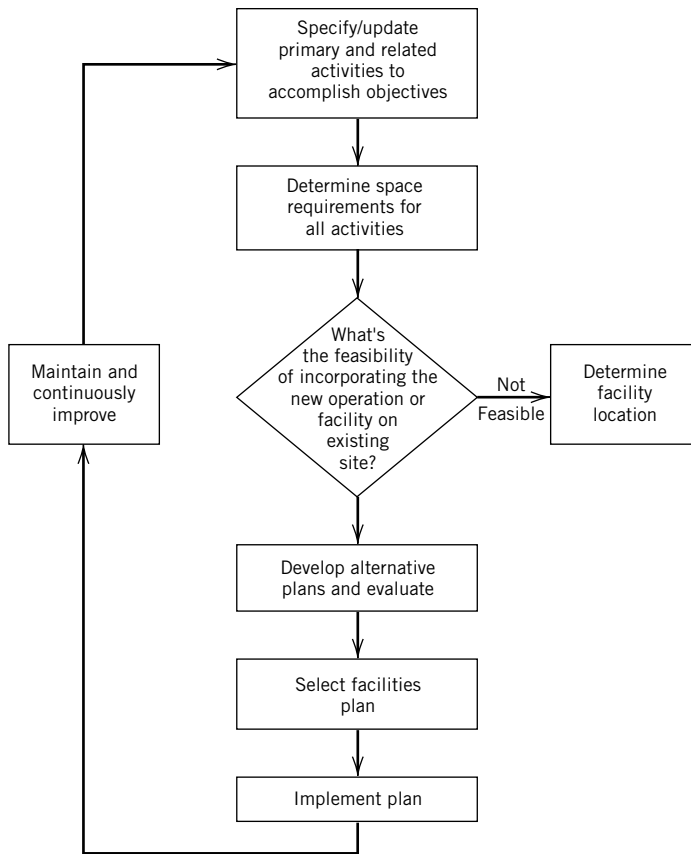


Figure 1.1 Continuous improvement facilities planning cycle.

and sewage needs. The layout consists of the production areas, production-related or support areas, and personnel areas within the building. The handling system consists of the materials, personnel, information, and equipment-handling systems required to support production.

Determining how the *location* of a facility supports meeting the facility's objectives is referred to as *facilities location*. The determination of how the design components of a facility support achieving the facility's objectives is referred to as *facilities design*. Therefore, facilities planning may be subdivided into the subjects of facilities location and facilities design. Facilities location addresses the macro-issues, whereas facilities design looks at the microelements.

The general terms facilities planning, facilities location, facilities design, facility systems design, layout design, and handling system design are utilized to indicate the breadth of the applicability of this text. In Figure 1.3, the facilities planning hierarchy is applied to a number of different types of facilities. It is because of its breadth of application that we employ a unified approach to facilities planning.

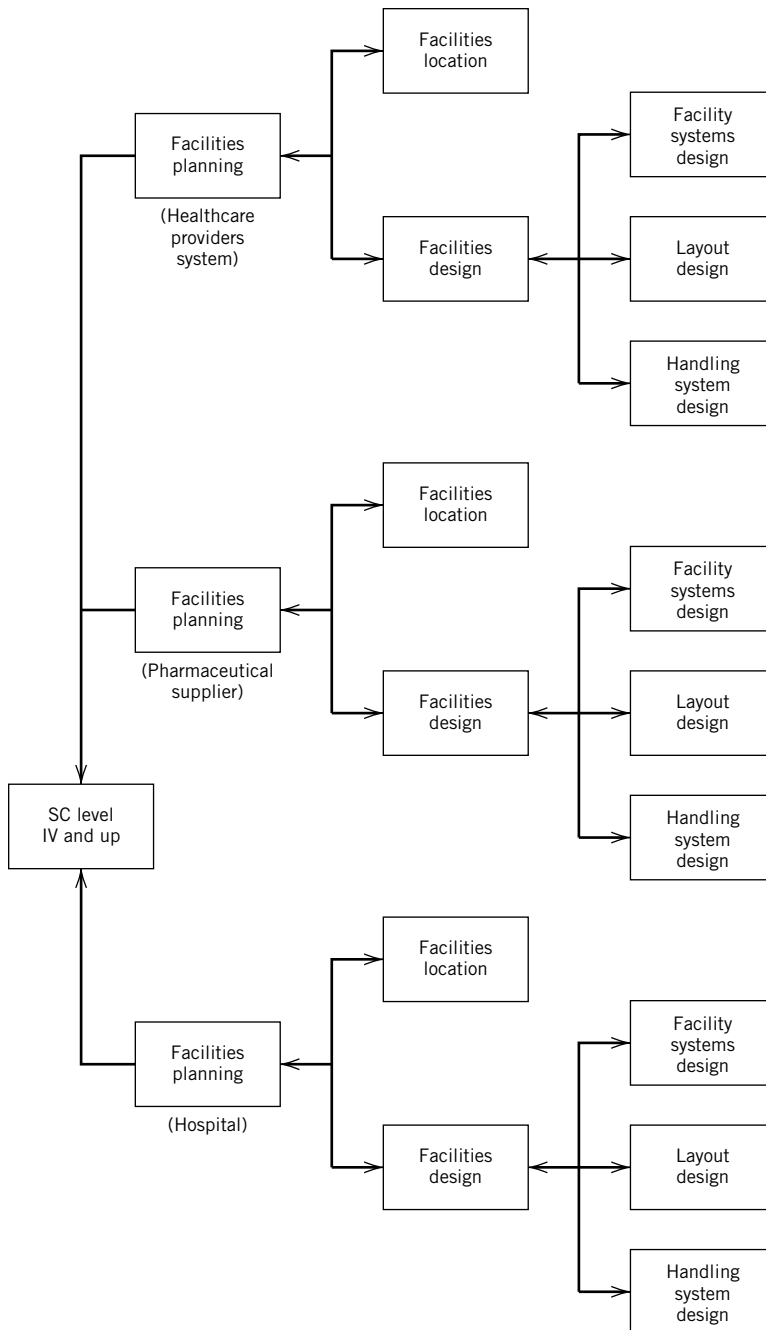


Figure 1.2 Facilities planning as part of supply chain excellence. Continuous improvement of each operation within each supply chain link takes an organization through the first three levels of supply chain excellence. To move to levels 4, 5, and 6, the links must collaborate, as illustrated above, to synthesize their operations and continue to improve the chain.

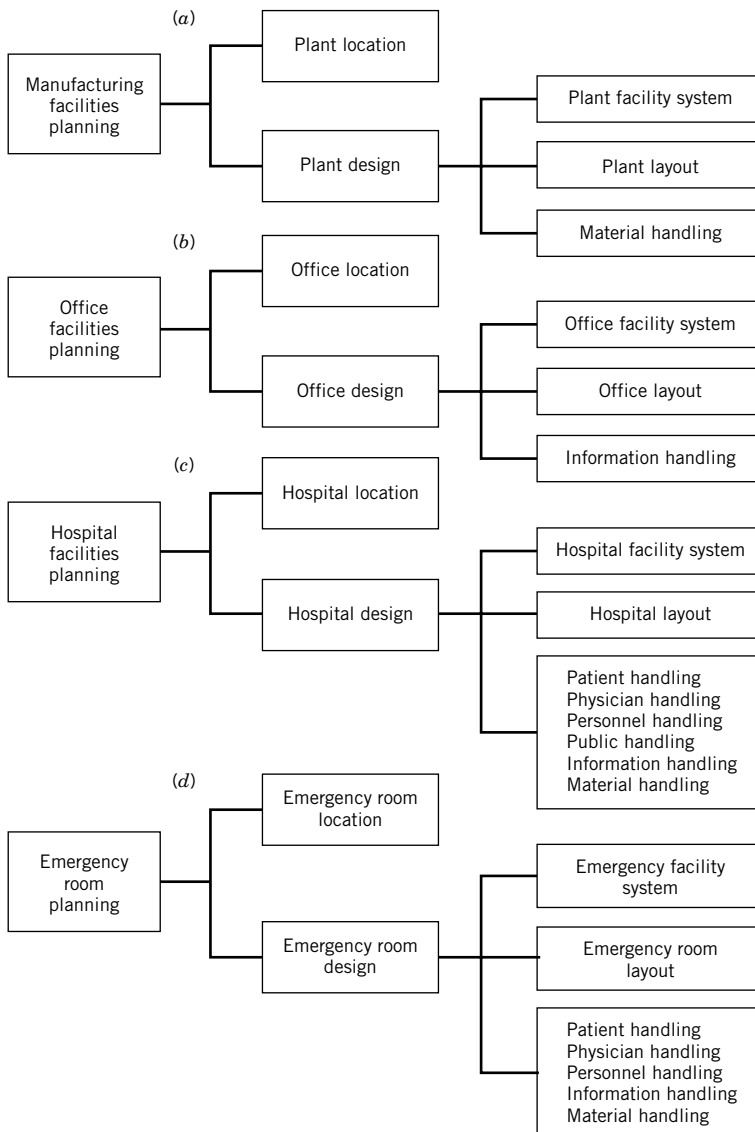


Figure 1.3 Facilities planning for specific types of facilities. (a) Manufacturing plant. (b) Office. (c) Hospital. (d) Emergency room.

1.2 SIGNIFICANCE OF FACILITIES PLANNING

According to the U.S. Census, U.S. businesses invested over a trillion dollars in capital goods per year for the last five years. Of that money, over 30% was spent on structures, with over 25% being spent on new structures.

Since 1955, approximately 8% of the gross national product (GNP) has been spent annually on new facilities in the United States. Table 1.1 indicates the typical expenditures, in percentage of GNP, for major industry groupings. The size of the

Table 1.1 *Percentage of the Gross National Product (GNP) by Industry Grouping Typically Expended on New Facilities between 1955 and Today*

Industry	GNP Percentage
Manufacturing	3.2
Mining	0.2
Railroad	0.2
Air and other transportation	0.3
Public utilities	1.6
Communication	1.0
Commercial and other	1.5
All industries	8.0

investment in new facilities each year makes the field of facilities planning important. As stated previously, contemporary facilities planning must include the notion of continuous improvement in the design approach. The importance of adaptability, as a key design criterion, is evidenced by the ever-increasing performance of previously purchased facilities, which are modified each year and require replanning. For these reasons, it seems reasonable to suggest that over \$300 billion will be spent annually in the United States alone on facilities that will require planning or replanning.

Although the annual dollar volume of the facilities planned or replanned indicates the scope of facilities planning, it does not appear that adequate planning is being performed. Based on our collective experience, it appears that there exists a significant opportunity to improve the facilities planning process as practiced today.

To stimulate your thoughts on the breadth of the facilities planning opportunities, consider the following questions:

1. What impact does facilities planning have on handling and maintenance costs?
2. What impact does facilities planning have on employee morale, and how does employee morale impact operating costs?
3. In what do organizations invest the majority of their capital, and how liquid is their capital once invested?
4. What impact does facilities planning have on the management of a facility?
5. What impact does facilities planning have on a facility's capability to adapt to change and satisfy future requirements?
6. What impact does facilities planning have on a facility's resilience, environmental impact, energy efficiency, and sustainability?

Although these questions are not easily answered, they tend to highlight the importance of effective facilities planning. As an example, consider the first question. Between 20 and 50% of the total operating expenses within manufacturing is attributed to material handling. Furthermore, it is generally agreed that effective facilities planning can reduce these costs by at least 10 to 30%. Hence, if effective facilities planning were applied, the annual manufacturing productivity in the United States would increase approximately three times more than it has in any year in the past 15 years. The impact of facilities planning on distribution centers is even greater where the proper order picking systems and equipment have been known to reduce the total cost of the operation by 30%.

It is difficult to make similar projections for the other sectors of our economy. However, there is reason to believe that facilities planning will continue to be one

of the most significant fields of the future. It represents one of the most promising areas for increasing the rate of productivity improvement.

Economic considerations force a constant reevaluation and recognition of existing systems, personnel, and equipment. New machines and processes render older models and methods obsolete. Facilities planning must be a continuing activity in any organization that plans to keep abreast of developments in its field.

With the rapid changes in manufacturing and distribution systems, techniques, and equipment that have taken place in the recent past and those that are expected in the future, very few companies will be able to retain their old facilities or layouts without severely damaging their competitive position in the marketplace. Productivity improvements must be realized as quickly as they become available for implementation.

One of the most effective methods for increasing productivity and reducing costs is to reduce or eliminate all activities that are unnecessary or wasteful. A facilities design should accomplish this goal in terms of material handling, personnel and equipment utilization, reduced inventories, and increased quality.

If an organization continually updates its operations to be as efficient and effective as possible, then there must be continuous relayout and rearrangement. Only in very rare situations can a new process or piece of equipment be introduced into a system without disrupting ongoing activities. A single change may have a significant impact on integrated technological, management, and personnel systems, resulting in suboptimization problems that can be avoided or resolved only through the redesign of the facility.

Employee health and safety is an area that has become a major source of motivation behind many facilities planning studies. In 1970, the Occupational Safety and Health Act (OSHA) became law and brought with it a far-reaching mandate: "to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources."

Because the act covers nearly every employer in a business affecting commerce that has 10 or more employees, it has had and will continue to have a significant impact on the structure, layout, and material handling systems of any facility within its scope. Under the law, an employer is required to provide a place of employment free from recognized hazards and to comply with occupational safety and health standards set forth in the act.

Because of these stringent requirements and attendant penalties, it is imperative during the initial design phase of a new facility or the redesign and revamping of an existing facility to give adequate consideration to health and safety norms and to eliminate or minimize possible hazardous conditions within the work environment.

Equipment and/or processes that may create hazards to workers' health and safety must be in areas where the potential for employee contact is minimal. By incorporating vital health and safety measures into the initial design phase, the employer may avoid fines for unsafe conditions and losses in money and human resources resulting from industrial accidents.

Energy conservation is another major motivation for the redesign of a facility. Energy has become an important and expensive raw material. Equipment, procedures, and materials for conserving energy are introduced to the industrial marketplace as fast as they can be developed. As these energy-conserving measures are introduced, companies should incorporate them into their facilities and manufacturing process. Since its introduction in 2000, LEED has become an important factor in assuring that the environmental and energy implications of facilities planning are fully addressed.

These changes often necessitate changes in other aspects of the facility design. For example, in some of the energy-intensive industries, companies have found it economically feasible to modify their facilities to use the energy discharged from the manufacturing processes to heat water and office areas. In some cases, the addition of ducting and service lines has forced changes in material flows and the relocation of in-process inventories.

If a company is going to retain a competitive edge today, it must reduce its consumption of energy. One method of doing this is to modify facilities or redesign material handling systems and manufacturing processes to accommodate new energy-saving measures.

Other factors that motivate investment in new facilities or the alteration of existing facilities are community considerations, fire protection, security, and the Americans with Disabilities Act (ADA) of 1990. Community rules and regulations regarding noise, air pollution, and liquid and solid waste disposal are frequently cited as reasons for the installation of new equipment that requires modification of facilities and systems operating policies.

One of the most significant challenges to facilities planners today is how to make the facility “barrier free” in compliance with the ADA. The enactment of this legislation has resulted in a significant increase in the alteration of existing facilities and has radically shaped the way facilities planners approach planning and design. The act impacts all elements of the facility, from parking space allocation and space design, ingress and egress ramp requirements, and restroom layout to drinking-fountain rim heights. Companies are aggressively spending billions of dollars to comply with the law, and those involved with facilities planning must be the leaders in pursuing the required changes.

On nearly a daily basis, a search on the Internet will yield a report of a fire that significantly interrupts a facility’s operation. In many instances, these fires can be attributed to poor housekeeping or poor facilities design. Companies are now carefully seeking modifications to existing material handling systems, storage systems, and manufacturing processes to lower the risk of fire.

Pilferage is yet another major and growing problem in many industries today. Several billion dollars’ worth of merchandise is stolen annually from companies in the United States. The amount of control designed into material handling, flow of materials, and design of the physical facility can help reduce losses to a firm.

Another factor in today’s global supply chain that needs to be taken into consideration is the customization of facilities required when building facilities around the world. In a recent study of global facility costs, it was concluded that the investment in a China facility can be as little as 50–60% of a comparable facility in the United States and can produce a good quality product. The customization has to do with process modification based upon China’s labor costs, lower construction costs in China, and savings resulting from lower Chinese equipment purchase prices.

1.3 OBJECTIVES OF FACILITIES PLANNING

As previously mentioned, facilities planning must be done within the context of the supply chain to maintain a strategic competitive advantage. Just as supply chain synthesis is driven by customer satisfaction, so too should customer satisfaction be

the primary objective of facilities planning. This will ensure that the other objectives are in alignment with what drives the enterprise, namely revenues and profits from customers. Many entities lose sight of the importance their customers have to their existence. Looking at customers as an internal element of the supply chain allows the focus to sustain itself indefinitely. Too many companies, governmental agencies, educational institutions, and services become so focused on the other internal elements and issues that the primary end-customer focus is lost. Many cannot properly define who their primary end customers are, and they fail as a result. The term business-to-business (B2B) should be viewed as B2B2B2B2B2C, with the “C” representing the customer. By incorporating the primary end customer into the supply chain and building the communication links and other infrastructure, the primary end customer is now a part of the entire supply chain, as it should be. As a result, the facilities planning process will take place with this primary end customer as the focus. The facilities planning objectives are to

- Improve customer satisfaction by being easy to do business with, conforming to customer promises, and responding to customer needs.
- Increase return on assets (ROA) by maximizing inventory turns, minimizing obsolete inventory, maximizing employee participation, and maximizing continuous improvement.
- Maximize speed for quick customer response.
- Reduce costs and grow the supply chain profitability.
- Integrate the supply chain through partnerships and communication.
- Support the organization’s vision through improved material handling, material control, and good housekeeping.
- Effectively utilize people, equipment, space, and energy.
- Maximize return on investment (ROI) on all capital expenditures.
- Be adaptable and promote ease of maintenance.
- Provide for employee safety, job satisfaction, energy efficiency, and environmental responsibility.
- Assure sustainability and resilience.

It is not reasonable to expect that one facility design will be superior to all others for every objective listed. Some of the objectives conflict. Hence, it is important to evaluate carefully the performance of each alternative, using each of the appropriate criteria.

1.4 FACILITIES PLANNING PROCESS

The facilities planning process is best understood by placing it in the context of a facility life cycle. Although a facility is planned only once, it is frequently replanned to synchronize the facility and its constantly changing objectives. The facilities planning and replanning processes are linked by the continuous improvement facilities planning cycle shown in Figure 1.1. This process continues until a facility is torn down. The facility is continuously improved to satisfy its constantly changing objectives.

Even though facilities planning is not an exact science, it can be approached in an organized, systematic way. The traditional engineering design process can be applied to facilities planning as follows:

1. Define the problem.
 - *Define (or redefine) the objective of the facility.* Whether planning a new facility or the improvement of an existing facility, it is essential that the product(s) to be produced and/or service(s) to be provided be specified quantitatively. Volumes or levels of activity are to be identified whenever possible. The role of the facility within the supply chain must also be defined.
 - *Specify the primary and support activities to be performed in accomplishing the objective.* The primary and support activities to be performed and requirements to be met should be specified in terms of the operations, equipment, personnel, and material flows involved. Support activities allow primary activities to function with minimal interruption and delay. As an example, maintenance is a support activity for manufacturing.
2. Analyze the problem.
 - *Determine the interrelationships among all activities.* Establish whether and how activities interact with or support one another within the boundaries of the facility and how this is to be undertaken. Both quantitative and qualitative relationships should be defined.
3. *Determine the space requirements for all activities.* All equipment, material, and personnel requirements must be considered when calculating space requirements for each activity. Generate alternative designs.
 - *Generate alternative facilities plans.* The alternative facilities plans will include both alternative facilities locations and alternative designs for the facility. The facilities design alternatives will include alternative layout designs, structural designs, and material handling system designs. Depending on the particular situation, the facility location decision and the facility design decision can be decoupled.
4. Evaluate the alternatives.
 - *Evaluate alternative facilities plans.* On the basis of accepted criteria, rank the plans specified. For each, determine the subjective factors involved and evaluate whether and how these factors will affect the facility or its operation.
5. Select the preferred design.
 - *Select a facilities plan.* The problem is to determine which plan, if any, will be the most acceptable in satisfying the goals and objectives of the organization. Most often, cost is not the only major consideration when evaluating a facilities plan. The information generated in the previous step should be utilized to arrive at the final selection of a plan.
6. Implement the design.
 - *Implement the facilities plan.* Once the plan has been selected, a considerable amount of planning must precede the actual construction of a facility

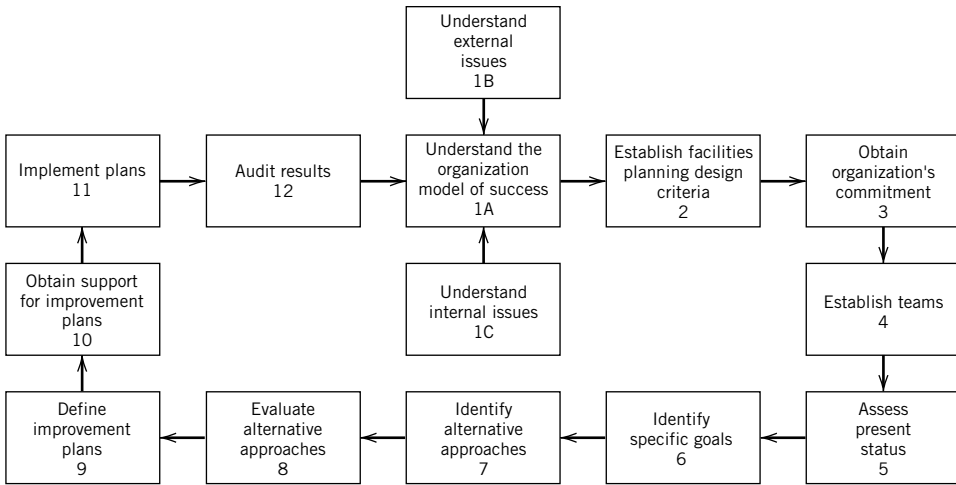


Figure 1.4 Winning facilities planning process.

or the layout of an area. Supervising installation of a layout, getting ready to start up, actually starting up, running, and debugging are all part of the implementation phase of facilities planning.

- *Maintain and adapt the facilities plan.* As new requirements are placed on the facility, the overall facilities plan must be modified accordingly. It should reflect any energy-saving measures or improved material handling equipment that becomes available. Changes in product design or mix may require changes in handling equipment or flow patterns that, in turn, require an updated facilities plan.
- *Redefine the objective of the facility.* As indicated in the first step, it is necessary to identify the products to be produced or services to be provided in specific, quantifiable terms. In the case of potential modifications, expansions, and so on for existing facilities, all recognized changes must be considered and integrated into the layout plan.

A novel approach to contemporary facilities planning is the winning facilities planning process, as shown in Figure 1.4. A more detailed explanation of the winning facilities planning process is shown in Table 1.2.

The model of success referred to in Figure 1.4 presents a clear direction for where a business is headed. Experience has shown that in order for the facilities plan to be successful, a clear understanding is needed of not only the vision but also the mission, the requirements of success, the guiding principles, and the evidence of success. It is the total of these five elements (vision, mission, requirements of success, guiding principles, and evidence of success) that forms an organization's model of success.

The definitions of these five elements are

1. *Vision:* A description of where you are headed
2. *Mission:* How to accomplish the vision

Table 1.2 *Explanation of Winning Facilities Planning Process*

Step	Function	Comment
1A	Understand the organization model of success.	This requires an education program for all levels of an organization. Understanding an organization's model of success is a prerequisite for successful facilities planning.
1B	Understand external issues.	This requires external outreach via professional society involvement; participation in trade shows, seminars, and conferences; and reading magazines and books. A coordinated effort is required if external issues are to be well understood.
1C	Understand internal issues.	A winning organization must understand not only the model of success, but also the organization's business plan, resources, and constraints, and the objectives of the overall supply chain. A prerequisite to winning is understanding a company's future.
2	Establish facilities planning design criteria.	To implement improvements, an organization must have focus. This step requires that management determine the facilities planning design criteria.
3	Obtain organizational commitment.	Management must make a clear commitment to implement the justified improvements consistent with the facilities planning design criteria. This commitment must be uncompromised.
4	Establish teams.	Teams having a broad-based representation and the ability to make decisions should be established for each design requirement. These teams must be uncompromised.
5	Assess present status.	This assessment will result in the baseline against which improvements will be measured. Both quantitative and qualitative factors should be assessed.
6	Identify specific goals.	Identify clear, measurable, time-related goals for each design criterion—for example, "Reduce raw material inventory to \$300,000 by June 1."
7	Identify alternative approaches.	The creative process of identifying alternative systems, procedures, equipment, or methods to achieve the specified goals. The investigation of all feasible alternatives.
8	Evaluate alternative approaches.	The economic and qualitative evaluation of the identified alternatives. The economic evaluation should adhere to corporate guidelines while estimating the full economic benefit of pursuing each alternative.
9	Define improvement plans.	Based upon the evaluation done in step 8, select the best approach. Define a detailed implementation and cash flow schedule.
10	Obtain support for improvement plans.	Sell the improvement plans to management. Document the alternatives, the evaluation, and the justification. Help management visualize the improved operation.
11	Implement plans.	Oversee development, installation, soft load, startup, and debugging. Train operators and assure proper systems utilization. Stay with effort until results are achieved.
12	Audit results.	Document actual systems operation. Compare results with the specified goal and anticipated performance. Identify and document discrepancies. Provide appropriate feedback.

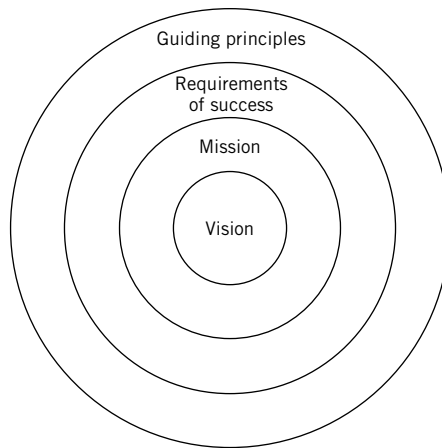


Figure 1.5 The model of success “winning circle.”

3. *Requirement of Success*: The science of your business
4. *Guiding Principles*: The values to be used while pursuing the vision
5. *Evidence of Success*: Measurable results that will demonstrate when an organization is moving toward its vision

To help people understand where their organization is headed, it is often useful to illustrate the first four elements of the model of success in graphical form, as shown in Figure 1.5. This graphical representation is often called the winning circle and is viewed as the organization’s bull’s eye.

In Table 1.3, the traditional engineering design process and the winning facilities planning process are compared. The first phases of the facilities planning process involve either the initial definition of the objectives of a new facility or the updating of an existing facility. These first phases are undertaken by the people charged with overall responsibility for facilities planning and management of the facility.

The second phase of the facilities planning process is assessing the present status, identifying specific goals, identifying alternative approaches, evaluating alternative approaches, defining improvement plans, and obtaining support for improvement. The final phase consists of implementing the plans and auditing the results. In applying the facilities planning concepts, an iterative process is often required to develop satisfactory facilities plans. The iterative process might involve considerable overlap, backtracking, and cycling through the analysis, generation, evaluation, and selection steps of the engineering design process.

At this point, a word of caution seems in order. You should not infer from our emphasis on a unified approach to facilities planning that the process of replanning a pantry in a cafeteria is identical to planning a new manufacturing facility. The scope of a project does affect the intensity, magnitude, and thoroughness of the study. However, the facility planning process described above and depicted in Figure 1.6 should be followed.

Table 1.3 *Comparison of the Engineering Design Process, Facilities Planning Process, and Winning Facilities Planning Process*

Phase	The Engineering Design Process	The Facilities Planning Process	The Winning Facilities Planning Process
Phase I	Define problem.	1. Define or redefine objective of the facility. 2. Specify primary and support activities.	1A. Understand the organization model of success. 1B. Understand external issues. 1C. Understand internal issues. 2. Establish facilities planning design criteria. 3. Obtain organizational commitment.
Phase II	Analyze the problem. Generate alternatives. Evaluate the alternatives. Select the preferred design.	3. Determine the interrelationships. 4. Determine space requirements. 5. Generate alternative facilities plan. 6. Evaluate alternative facilities plan. 7. Select a facilities plan.	4. Establish teams. 5. Assess present status. 6. Identify specific goals. 7. Identify alternative approaches. 8. Evaluate alternative approach. 9. Define improvement plans. 10. Obtain support for improvement plans.
Phase III	Implement the design.	8. Implement the plan. 9. Maintain and adopt the facilities plan. 10. Redefine the objective of the facility.	11. Implement plans. 12. Audit results.

1.5 STRATEGIC FACILITIES PLANNING

While it is true that the concerns of facilities planning are the location and the design of the facility, there exists another primary responsibility—*planning*! The importance of planning in facilities planning cannot be overemphasized, for it is this emphasis that distinguishes the activities of the facilities planner from the facilities designer and the facilities “locator.”

Dwight D. Eisenhower said, “The plan is nothing, but planning is everything.” As an indication of its importance in facilities planning, consider the process of planning and designing a manufacturing facility, building it, and installing and using the equipment. As shown in Figure 1.7, the costs of design changes increase exponentially as a project moves beyond the planning and designing phases.

The term *strategic planning* appears to have originated in the military. Webster defines strategy as “the science and art of employing the armed strength of a belligerent to secure the objects of a war.” Today, the term is frequently used in politics, sports, investments, and business. Our concern is with the latter usage.

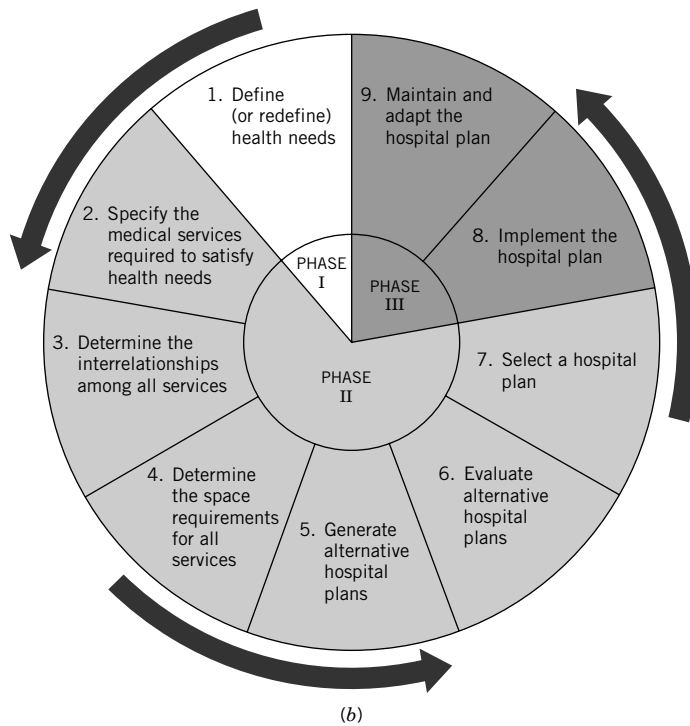
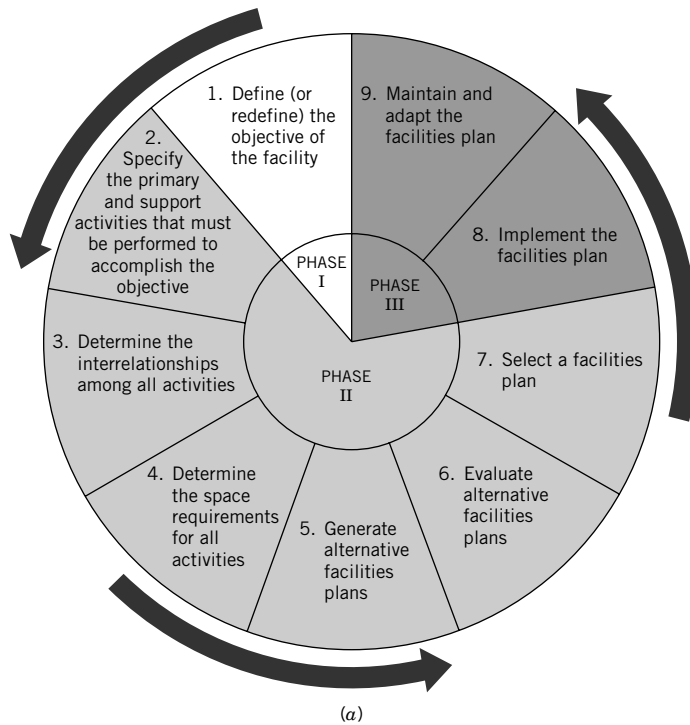


Figure 1.6 The facilities planning process. (a) General and manufacturing facilities. (b) Hospital facilities.

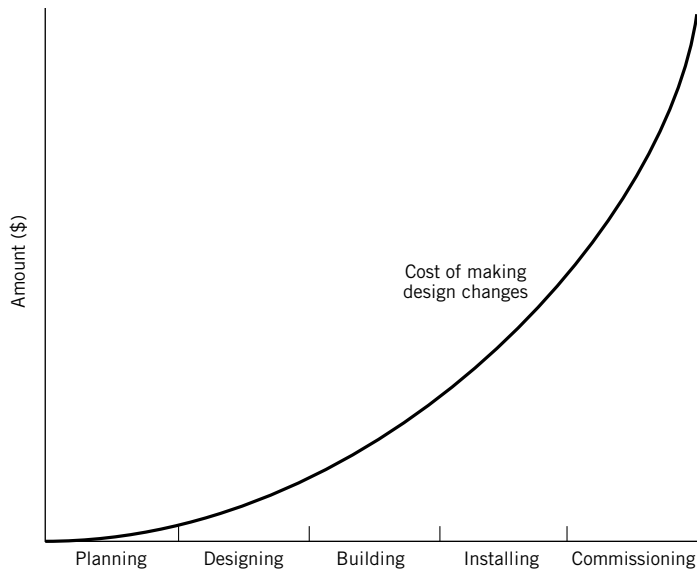


Figure 1.7 Cost of design changes during a project.

Based on Webster's definition of *strategy*, business strategies can be defined as *the art and science of employing the resources of a firm to achieve its business objectives*. Among the resources available are marketing resources, manufacturing resources, distribution resources, and supply chain resources. Hence, marketing strategies, manufacturing strategies, distribution strategies, and supply chain strategies can be developed to support the achievement of the business objectives.

Recall that facilities planning was defined as determining how a firm's resources (tangible fixed assets) best support achieving the business objectives. In a real sense, facilities planning is itself a strategic process and must be an integral part of overall corporate strategy.

Historically, the development of corporate strategies has been restricted to the C-level (CEO, CFO, CIO, etc.) in many companies. Furthermore, business strategies tended to be limited to a consideration of such issues as acquisition, finance, and marketing. Consequently, decisions were often made without a clear understanding of the impact on the supply chain or on such support functions as facilities, material handling, information systems, and purchasing.

As an illustration, suppose an aggressive market plan is approved without the realization that supply chain capacity is inadequate to meet the plan. Furthermore, suppose the lead times required to achieve the required capacity are excessive. As a result, the market plan will fail because the impact of the plan on people, equipment, and space was not adequately comprehended. A winning facilities plan must consider integrating all elements that will impact the plan. An example of the accumulating benefits that can result from integrating operations is shown in Figure 1.8.

Business Week, *Industry Week*, *Time*, *Fortune*, and other business publications have focused on the competitiveness of America. This attention reflects the growing awareness in the business community of the importance of improved supply chains and technology. Wal-Mart, Procter and Gamble, Johnson and Johnson, Dell, and Apple,

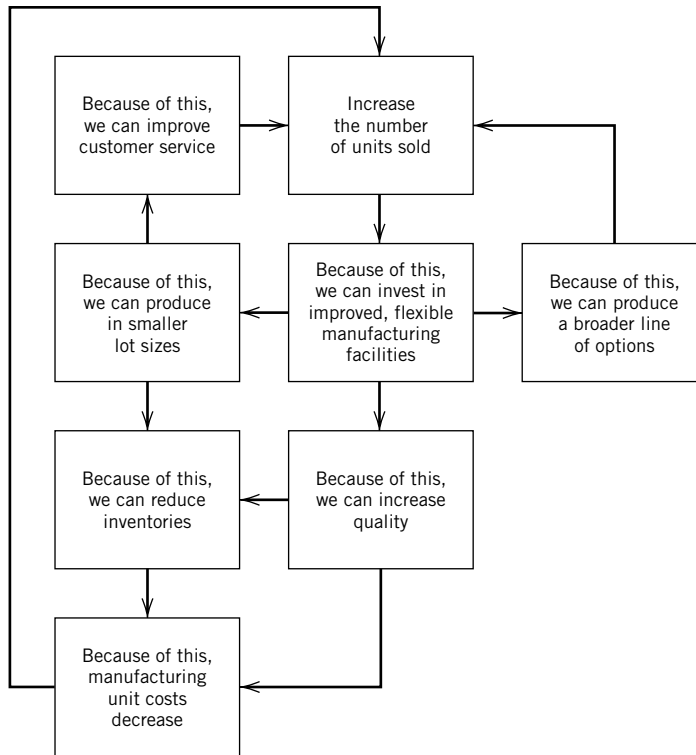


Figure 1.8 Synergistic benefit of winning manufacturing on an integrated manufacturing-marketing team.

among others, have expanded the strategic planning process to include the development of supply chain strategies. It is from these supply chain strategies that facilities strategies must be developed, and from these strategies, facilities plans developed.

1.6 DEVELOPING FACILITIES PLANNING STRATEGIES

The process of effectively translating objectives into actions can take place only if the power of the individuals inside an organization is unleashed. Team-based implementation of company objectives will ensure that all members of the organization are involved in their achievement.

As noted in the previous section, strategies are needed for such functions as supply chain marketing, manufacturing, distribution, purchasing, facilities, material handling, and data processing/information systems, among others. It is important to recognize that each functional strategy is multidimensional. Namely, each must support or contribute to the strategic plan for the entire organization. Furthermore, each must have its own set of objectives, strategies, and tactics.

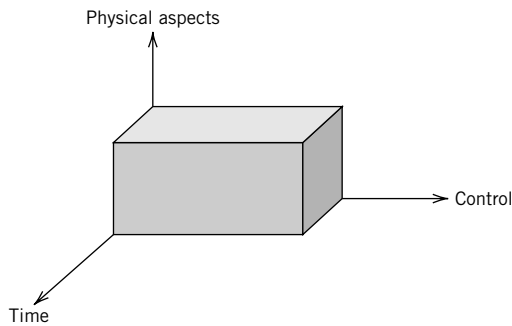


Figure 1.9 Three dimensions for improvement.

As previously stated, one method used to ensure that the objectives are effectively translated into action is the model of success. The model of success is effective because it is lateral rather than hierarchical in its approach. With the traditional top-down approach, only a handful of people are actively involved in ensuring that the objectives are met by driving these goals and plans into action. The lateral structure of the model of success communicates to everyone in an organization where the organization is headed.

The facilities planning process can be improved in a number of ways. Three potential dimensions for improvement are illustrated in Figure 1.9. Suppose the objective is to increase the size of the box shown. One approach is to make it taller by focusing on the physical aspects of facilities planning, for example, buildings, equipment, and people. Another approach is to make the box wider by focusing on control aspects of facilities planning, for example, space standards, materials control, stock locator systems, and productivity measures. While it is possible to make the box taller and wider, we must not overlook the benefits provided by the third dimension: time. To make the box deeper requires time for planning. The old adage, “There’s never time to do it right, but there’s always time to do it over,” has been repeatedly demonstrated with respect to facilities planning. Sufficient lead time is needed to do it right!

Another way to improve this process is to do it in the context of supply chain synthesis, a process that is well defined, integrated, and based on continuous improvement for maximized supply chain performance. It also harnesses the energy of change and has no information delays.

The facilities planning process should also be well defined as to how each function fits, interacts, and integrates. Otherwise, critical information will be lost or an important link will be missing, and all will be lost.

The facilities planning process should be integrated and not allow selfishness. This includes eliminating silos and focusing all functions on customer satisfaction. To eliminate silos, we synthesize the whole supply chain from its origination point to the ultimate customer. The result is a focus on continuous improvement.

In the facilities planning process, everyone involved should understand the energy of change and have a desire to harness this energy for the competitive advantage of the total pipeline. This involves courage and innovation. By harnessing change, we can turn it into an asset. Instead of thinking, “I want to improve my function,” you may have to think, “Tradeoffs might be what are needed to improve the facilities planning process and create the ideal facility.” The facilities planning process

should not accept information delays. It requires true partnerships and an integration of information. To meet today's demands for speed, everyone involved in the process must do the right thing and let everyone else know what they are doing quickly. Communication is critical, robust, and simultaneous.

Facilities planning should be a continuous improvement process focused on achieving total performance excellence with the objectives presented earlier. Because all parties involved in the plan focus on these objectives, facilities planning excellence will be achieved.

A number of internal functional areas tend to have a significant impact on facilities planning, including supply chain marketing, product development, manufacturing, production and inventory control, human resources, and finance. For example, facility location will be impacted by the sourcing decision of materials, and material handling will be affected by decisions related to unit volume, product mix, packaging, service levels for spares, and delivery times.

Product development and design decisions affect processing and materials requirements, which in turn affect layout and material handling. Changes in materials, component shapes, product complexity, number of new part numbers and package sizes introduced (due to a lack of standardization in design), stability of product design, and the number of products introduced will affect the handling, storage, and control of materials. Decisions concerning the global supply chain, the degree of vertical integration, the types and levels of automation, the types and levels of control over tooling and work-in-process, plant sizes, and general-purpose versus special-purpose equipment can affect the location and design of facilities.

Planning and inventory control decisions affect the layout and handling system. Lot size decisions, scheduling, in-process inventory requirements, inventory turnover goals, inventory storage location in the supply chain, and approaches used to deal with seasonal demand affect the facilities plan.

Human resources and finance decisions related to capital availability, labor skills and stability, staffing levels, inventory investment levels, organizational design, and employee services and benefits will impact the size and design of facilities, as well as their number and location. Space and flow requirements will be affected by financial and human resources decisions. In turn, they have an impact on the storage, movement, protection, and control of material.

For the facilities plan to support the overall strategic plan, it is necessary for facilities planners to participate in the development of the plan. Typically, facilities planners tend to *react* to the needs defined by others, rather than participate in the decision making that creates the needs. A proactive rather than a reactive role for facilities planning is recommended. The model of success approach will ensure that facilities planners are on board, focusing on the overall direction of the company.

Close coordination is required in developing facilities plans to support the global supply chain. Manufacturing-facilities planning and distribution-facilities planning interfaces are especially important. As the manufacturing plan addresses automatic load/unload of machines, robotics, group technology, transfer lines, flexible manufacturing systems, numerically controlled machines, just-in-time and computer-integrated manufacturing, alternative storage systems for tooling and work-in-process, real-time inventory control, shop floor control, and waste handling/removal systems, the facilities plan must support changes in manufacturing technology. Likewise, the facilities plan must support a distribution plan that addresses automatic palletizers,

shrinkwrap/stretchwrap, automatic identification, automatic loading and unloading of vehicles and trailers, automated storage and retrieval of unit loads and small parts, and automated guided-vehicle systems.

It is also important for the level of manufacturing/distribution technology in use to be assessed objectively and compared with the state of the art. Five- and 10-year technology targets should be identified and an implementation plan developed to facilitate the required evolution.

Developing contingency plans by asking numerous “what-if” questions is another important element of the process. By asking such questions, an uncertainty envelope can be developed for facility requirements. Also, in translating market projections to requirements for facilities, it is important to consider learning-curve effects, productivity improvements, technological forecasts, and site-capacity limits.

The following 10 issues may have a long-range impact on the strategic facilities plan:

1. Number, location, and sizes of warehouses and/or distribution centers
2. Centralized versus decentralized storage of supplies, raw materials, work-in-process, and finished goods for single- and multibuilding sites, as well as single- and multisite companies
3. Acquisition of existing facilities versus design of modern factories and distribution centers of the future
4. Flexibility required because of market and technological uncertainties
5. Interface between storage and manufacturing
6. Level of vertical integration, including “subcontract versus manufacture” decisions
7. Control systems, including material control and equipment control, as well as level of distributed processing
8. Movement of material between buildings and between sites, both inbound and outbound
9. Changes in customers’ and suppliers’ technology as well as a firm’s own manufacturing technology and material movement, protection, storage, and control technology
10. Design-to-cost goals for facilities

1.7 EXAMPLES OF INADEQUATE PLANNING

Numerous examples exist of situations where inadequate planning was being performed. The following actual situations are presented to illustrate the need for improved planning.

- A large consumer products company decided to allow each of its acquisitions to remain independent, thus requiring the management of many duplicate supply chains. The supply chains consisted of duplicate planning functions, execution systems, and facility locations. After poor performance, the management team soon began to question the rationale of the separate organizations.

- A major manufacturer in the Midwest made a significant investment in storage equipment for a parts distribution center. The selection decision was based on the need for a “quick fix” to a pressing requirement for increased space utilization. The company soon learned that the “solution” would not provide the required throughput and was not compatible with long-term needs.
- An electronics manufacturer was faced with rapid growth. Management received proposals that required approximately equivalent funding for large warehouses at two sites having essentially the same storage and throughput requirements. Management questioned the rationale for one “solution” being a high-rise automated storage/retrieval system (AS/RS) and the other being a low-rise warehouse with computer-controlled industrial trucks.
- Another firm installed miniload systems at two sites. One system was designed for random storage, the other for dedicated storage. The storage and throughput requirements were approximately the same for the two systems; however, different suppliers had provided the equipment and software. Management raised the questions: Why are they different? And which is best?
- A textile firm installed a large high-rise AS/RS for one of its divisions. The amount and size of the product to be stored subsequently changed. Other changes in technology were projected. The system became obsolete before it was operational.
- An engine manufacturer was planning to develop a new site. Decisions had not been made concerning which products would be off-loaded to the new site, nor what effect the off-load would have on requirements for moving, protecting, storing, and controlling material.
- An apparel retailer built a new distribution center on the west coast of the United States for all incoming goods from Asia. A subsequent analysis showed the use of an all-water route from Vietnam through the Panama Canal into the east coast of the United States to provide significant cost savings, thus making the west coast facility obsolete.
- An electronics manufacturer was planning to develop a new site. The facilities planners and architects were designing the first building for the site. No projections of space and throughput had been developed since decisions had not been made concerning the occupant of the building.
- The mission for a major military supply center was changed in order that additional bases could be serviced. The throughput, storage, and control requirements for the new customers were significantly different from those for which the system was originally designed. However, no modifications to the system were funded.
- A manufacturer of automotive equipment acquired the land for a new manufacturing plant. The manufacturing team designed the layout, and the architect began designing the facility before the movement, protection, storage, and control system was designed.
- An aerospace-related manufacturer implemented cellular manufacturing in its process planning and converted to manufacturing cells in a machining department. No analyses had been performed to determine queue or flow requirements. Subsequent analyses showed the manufacturing cells were substantially less efficient as a result of their impact on movement, protection, storage, and control of work-in-process.

- An underwear manufacturer moved its product sourcing from China to Thailand when Thailand became the low-cost country of production and thus shifted distribution flows within the United States from west-to-east to east-to-west due to the utilization of the Suez Canal. The supporting distribution centers required major renovation that was not considered when the shift to Thailand was made.
- An established brick-and-mortar retailer began accepting orders through its Web site. The volume of orders received during the holiday season peak could not be processed by its distribution center. Gift certificates had to be mailed to all of the customers whose orders weren't delivered by Christmas. A study conducted after the new year showed that poor configuration of storage racks, ineffective replenishment processes, lack of proper product slotting, and material handling equipment that could not efficiently process the variety of the products' attributes created a situation that forced the entire fulfillment operation to grind to a halt.

In practically every case, the projects were interrupted and significant delays were incurred because proper facilities planning had not been performed. These examples emphasize once more the importance of providing adequate lead times for planning.

The previous list of examples of inadequate facilities planning could possibly create a false impression that no one is doing an adequate planning job. Such is not the case; several firms have recognized the need for strategic facilities planning and are doing it.

A major U.S. airline developed 10-year and 20-year facilities plans to facilitate decision making regarding fleet size and mix. Maintenance and support facilities requirements were analyzed for wide-body and mid-sized aircraft. The impact of route planning, mergers and acquisitions, and changes in market regions to include international flights were considered in developing the plan.

The airline industry operates in a dynamic environment. Governmental regulations and attitudes toward business are changeable, energy costs and inflationary effects are significant, and long lead times are required for aircraft procurement. For new-generation aircraft, an airline company might negotiate procurement conditions, including options, eight years before taking delivery of the airplane.

1.8 SUMMARY

Facilities planning is a process that is dynamic over time. The methodology continues to change as technology evolves and new approaches are developed. The focus at the current time is on the customer and the view that all components of a supply chain must band together to plan the facilities that will successfully support all of the activities of the supply chain. Facilities planning

- Determines how an activity's tangible fixed assets should contribute to meeting the activity's objectives
- Consists of facilities location and facilities design

- Is part art and part science
- Can be approached using the engineering design process
- Is a continuous process and should be viewed from a life-cycle perspective
- Represents one of the most significant opportunities for cost reduction and productivity improvement

Strategic facilities planning is needed to support competition from a supply chain-versus to supply chain point of view. No longer is the focus of strategic facilities planning only internal. The focus now is on how our facilities planning process supports the entire supply chain from basic raw materials to the final customer. If the facilities planning process does not support the entire supply chain, it is at a disadvantage. Other supply chains may be able to leverage themselves into an advantage by focusing on the customer and on the big picture, rather than simply one location or one company. Moving forward, this focus on the entire supply chain will grow even stronger, and those companies and those supply chains that do not realize this fact will no longer exist.

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PROBLEMS

SECTION 1.1

- 1.1 Describe both the planning and operating activities required to conduct a professional football game from the point of view of the
 - a. visiting team's football coach
 - b. home team quarterback
 - c. manager of refreshment vending
 - d. ground crew manager
 - e. stadium maintenance manager
- 1.2 List 10 components of a football stadium facility.
- 1.3 Describe the activities that would be involved in the (a) facilities location, (b) facilities design, and (c) facilities planning of an athletic stadium. Consider baseball, football, soccer, and track and field.
- 1.4 Assume you are on a job interview and you have listed on your resume a career interest in facilities planning. The firm where you are interviewing is a consulting firm that specializes in problem solving for transportation, communication, and the service industries. React to the following statement directed to you by the firm's personnel director: "Facilities planning is possibly of interest to a firm involved in manufacturing, but it is not clear that our customers have needs in this area sufficient for you to pursue your field of interest."

SECTION 1.3

- 1.5 What criterion should be utilized to determine the optimal facilities plan?
- 1.6 Evaluate the facilities plan for your campus and list potential changes you would consider if you were asked to replan the campus. Why would you consider these?

SECTION 1.4

- 1.7 Chart the facilities planning process for
 - a. a bank
 - b. a university campus
 - c. a distribution center
 - d. a consulting and engineering office
- 1.8 Describe the procedure you would follow to determine the facilities plan for a new library on your campus.

SECTION 1.6

- 1.9 Is facilities planning ever completed for an enterprise? Why or why not?
- 1.10 With the aid of at least three references, write a paper on the industrial engineer and architect's roles in the planning of a facility.
- 1.11 Consider the definition of industrial engineering approved by the Institute of Industrial Engineers. Discuss the extent to which the definition applies to facilities planning.
- 1.12 Read three articles on strategic planning, summarize the material, and relate it to strategic facilities planning.
- 1.13 Develop a list of strategic issues that must be addressed in performing facilities planning for
 - a. an airport
 - b. a community college
 - c. a bank
 - d. a grocery store chain

- e. a soft drink bottler and distributor
 - f. a library
 - g. an automobile dealership
 - h. a shopping center developer
 - i. a logistics service provider
 - j. a professional sports franchise
- 1.14 Develop a set of responses to the following “reasons” for not doing strategic facilities planning:
- a. There are more critical short-term problems to be solved.
 - b. The right people internally are too busy to be involved in the project.
 - c. The future is too hard to predict, and it will probably change anyway.
 - d. Nobody really knows what alternatives are available and which ones might apply.
 - e. Technology is developing very rapidly; any decisions we make will be obsolete before they can be implemented.
 - f. The return on investment in strategic planning is hard to measure.
- 1.15 What is the impact of facilities planning on the competitiveness of manufacturing facilities?
- 1.16 What are the implications of strategic planning on your personal career planning?
- 1.17 What are the impacts of automation on facilities planning?
- 1.18 What are the issues to be addressed in strategic planning for warehousing/distribution? What are the cost and customer services implications?
- 1.19 Explain the impacts of the supply chain on facilities planning.
- 1.20 What are the differences between strategic planning and contingency planning?
- 1.21 How does the issue of time impact the process of facilities planning?