EASTERN MEDITERRANEAN UNIVERSITY
DEPARTMENT OF INDUSTRIAL ENGINEERING
IENG332/MANE332 PRODUCTION PLANNING I
COURSE OUTLINE

COURSE CODE	IENG332/MANE332	COURSE LEVEL	Third Year	
COURSE TITLE	Production Planning I	COURSE TYPE	Area Core	
CREDIT VALUE	(4, 1, 0) 4	ECTS Credit Value	8	
PRE-REQUISITE(S)	IENG212/MANE212, MATH322	CO-REQUISITE(S)		
PREPARED BY	Dr. Faramarz KHOSRAVI	SEMESTER / ACADEMIC YEAR	Spring 2020-21	
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COURSE SCHEDULE	Monday 12:30-14:20 (IE-D203); Tuesday 14:30-15:20 (IE-D203); Wednesday 12:30-14:20 (IE-D201) Office Hour: Wednesday 10:30-12:20			
COURSE WEB LINK	http://staff.emu.edu.tr/faramarzkhosravi/en/teaching/ieng332-mane332			

COURSE DESCRIPTION

Two sequel courses are designed together to provide the basics of production planning and control with the need of modern manufacturing organizations in mind. The topics covered in the first course are production and operations strategy, subjective and objective forecasting (i.e. Delphi method, trend-based methods, and methods for seasonal series), deterministic inventory planning and control (i.e. Economic Order Quantity model and its extensions to several environments), stochastic inventory planning and control, aggregate production planning, and master production scheduling.

COURSE OBJECTIVES

The main objectives of this course are:

1. Significance of production planning and control concepts (history, management theories, competitiveness, flow process, layout arrangements, organizational arrangements, supply chain management, product life cycle, decisions in production systems) (Contributing Student Outcomes 1, 2, 7)
2. Market-driven systems (wheel of competitiveness, integrated production systems, CMS, FMS, CIM, world class manufacturing, lean production, agile manufacturing) (Contributing Student Outcome 1)
3. Problem solving (identification, understanding, developing, solving, interpretation, implementation) (Contributing Student Outcomes 1, 6)
4. Fundamental concepts of Forecasting (judgmental / qualitative, causal, time series) (Contributing Student Outcome 1)
5. Regression method for qualitative forecasting (Contributing Student Outcomes 1, 6)
6. Constant process (LDP, overall average, moving average, Simple Exponential Smoothing) (Contributing Student Outcomes 1, 6)
7. Trend process (Double Exponential Smoothing) (Contributing Student Outcomes 1, 6)
8. Seasonal process (Winter’s method) (Contributing Student Outcomes , 6)
9. Forecast errors, tracking signals (Contributing Student Outcomes 1, 6)
10. Fundamental concepts of Inventory control (terminology, costs, periodic review, continuous review) (Contributing Student Outcomes 1)
11. Lot sizing models (EOQ, EPQ) (Contributing Student Outcomes 1, 6)
12. Quantity discounts (all units, incremental) (Contributing Student Outcomes 1, 6)
13. Inventory control decisions (ABC analysis) (Contributing Student Outcomes 1, 6)
14. Working effectively in multidisciplinary teams, making an independent research for real life cases, and writing a technical report on the results (Contributing Student Outcomes 1, 3, 5, 6)

GRADING CRITERIA

Exams: All examinations will be based on lectures, tutorials, assigned readings, project study or other work. To pass these exams students will need to have studied the material well in advance in order to understand the concepts, procedures and techniques. Exams may be closed book/note type or open book/note type or both types. Exam results will be announced on the notice boards as soon as the exam papers have been evaluated. Descriptions of these examinations are as follows:

Quizzes : There will be 3 quizzes that will be announced in course planning. Instructor will choose two better grades.

Midterm Exam: There will be one midterm examination that covers all the material up to the date of the examination. It will be scheduled for a day in the designated mid-term exams week.

Final Exam: The final exam includes all the material studied after the midterm exam and has the same structure as the midterm exam. Like the midterm exam, the final exam will be scheduled for a day in the designated final exams week.

Term Project: Students should form groups of 5 students (exactly, otherwise you should submit a valid excuse in written form). The topic for the project will be announced to the groups according to the topics by the instructor. Unfortunately, a penalty for late submissions will be applied if the project report is not submitted on the due date.

Make-up Exam: No make-up examination will be given to students who miss quizzes, and whose attendance is below 60%. Make-up examination will only be offered to students who missed the final or midterm exam and provided adequate documentations for the reason for their absence within three working days at the latest after the examination date. A student's illness will only be accepted as a valid excuse if it is supported by a written report of a physician from the Health Center of the EMU.

Resit Exams: The resit examination will cover all the material studied throughout the semester and has the same structure as in the midterm and final examinations. This exam will be scheduled for a day in the designated resit exams week.

TEXTBOOK/S

- Sipper, D., Bulfin, R.L., Production planning, control and integration, McGray-Hill, New York, 1998.
- Heizer, J., Render, B., Operations Management, Prentice Hall, 2004.
- Chase, R.B., Aquilano, N.J., Jacobs, F.R., Operations Management for Competitive Advantage, McGraw Hill, 2001.

INDICATIVE BASIC READING LIST

- Narasimhan, S. L., McLeavey, D. W., Billington, P. J., Production Planning and Inventory Control, Second Edition, Prentice Hall International Inc., America, 1995.
- Pochet, Y., Wolsey, L.A., Production planning by mixed integer programming, Springer, USA. 2006
- Johnson, L. A., Montgomery, D.C., Operations Research in Production Planning, Scheduling and Inventory Control, John Wiley and Sons, 1974.
- Vollman, T.E., Berry, W.L., Whyberk, D.C., Manufacturing Planning and Control Systems, Irwin, 1997.
- Nahmias, S., Production and Operations Analysis, Irwin, 1997
- Pinedo, M., Scheduling: theory, algorithms and systems, Prentice Hall, 1995.

EXTENDED READING LIST

Note that aside from these books, EMU Library has quite a good collection of books on the intermediate and advanced levels in the related fields of industrial engineering discipline.

WEEK	TOPICS
1	Overview of Production Planning and Control Concepts
2	Problem Solving
3	Market Driven Systems
4	Forecasting System and Forecast Control
5	Qualitative Forecasting
6	Causal Forecasting with Regression
7	Time Series Models: Constant Process, Trend Process, Seasonal Process
8	MIDTERM EXAM WEEK
9	Time Series Models: Trend Process, Seasonal Process
10	Forecast Control, Inventory Control: Independent Demand Systems
11	Inventory Control: Quantity Decisions (EOQ, EPQ with backlog)
12	Inventory Control: Quantity Decisions (EOQ, EPQ with extensions)
13	Inventory Control: Quantity Discounts
14	Inventory Control: Control Decisions (ABC Analysis)
15	FINAL EXAM WEEK

Chapter 1: THE PRODUCTION PARADIGM

INTRODUCTION

Production systems are prominent in modern society. These systems form the base for building and improving the economic strength and validity of a country. The task of development and running production systems has become progressively complex. Major changes in produts, processes, management technologies, concepts and culture result in increasing challenges and demands. This chapter identifies and highlights some critical issues related to production systems. We start with a discussion of global production.

1 Global production

spurred by renaissance in 1600s and continued with Britain's initiation of the first industrial revolution, Europe was the the center of economic power in the nineteenth century; the United States, however, became the focus of the second industrial revolution, dominating twentieth century industry. Consequently, management theory and early techniques were the products of western developments. The concepts of the factory production line, division of labor, and functional management structure all matured in Europe and America. The post-world war II emergence of export-oriented southeast Asia, particularly Japan, as a new industrial power has resulted in an open trading system in which we can no longer ignore international competition. The emergence of this global marketplace is the subject of this first section. We first present the evolution of production systems, followed by a discussion of the new competitive environment.

1.1 Evolution of production systems:

We discuss two aspects of the evolution of production systems; its history and the management theories it created.

1.1.1 History:

Four major types of production system have evolved historically: ancient, feodal, european, and american.

We can trace the begining of **Ancient systems** to 5000 B.C when sumerian prisets started to records of inventories, loans, and tax transactions. Around 4000 B.C Egyptians were using the basic management concepts of planning, organizing, and control in their large projects such as the pyramids and similar structures. This period of time continued by Hebrews and Chinese for developing basic concepts on production system such as qualification of workers and initial steps over time and motion study.

During the middle ages, the **Feudal system** evolved, in which the emperor, king, or queen had total power over the country. Nobles were given power over regions in exchange for loyalty to the ruler. The nobles in turn might delegate lands and authority to lesser lords and so on. The production system in existence at this time are best described as domestic. Typically, the family members were the owners as well as the workers, and they did the work at home. Land and labor were the major production factors of the time, which remained the case until the middle of the fifteenth century.

The **European system** started evolving during the Renaissance. Although we normally think of the renaissance for cultural development, much was happening, particularely in Italy, that would affect industrialization and production systems. Double entry bookkeeping and cost accounting were practiced there in the 1300s. After some developments in Italy and England, in 1776 Adam Smith publicized the division of labor in his book, *The Wealth of Nations*. Rather than have one person complete a product, he suggested each be responsible for only one part of the completed job. By this way he increased the number of pins manufactured per person from 20 to 48,000 per day. After 50 years, Charles Babbage worked on specialization of labor that caused increasing market size in all areas.

The beginning of the **American system** can be traced to the development of the modern lathe by Maudslay around 1800. The most important aspect of Maudslay's development was that now some machines were capable of reproducing themselves, which started the machine tool industry and had a great impact on later developments in production systems.

Across the Atlantic Ocean in America, other exciting events were happening. Eli Whitney, inventor of the cotton gin, promoted manufacturing with interchangable parts. Widely credited as the first to use this idea. Whithney used jigs and fixtures to orient and hold the parts, which could be made by less-skilled machinists. This system of manufacture –called *American System* – was adopted by many factories.The convergence of interchangeable parts, specialization of labor, steam power, and machine tools resulted in the emergence of the American system, which was the precursor of mass production as we know it today.

In 1903 Oldsmobile Motors created a stationary assembly line to produce their cars. The Assembly line is the logical outgrowth of specialization of labor and the use of capital to replace labor.

1.1.2 Management theories

Early management theories evolved in this environment bacause operating system were needed to meet increased production demands. As in many historical developments a begining is hard to pinpoint. Many people contributed to the process, but Henry Towne was in the forefront. In 1886 he delivered a paper to the american siciety of Mechanical Engineers and claimed that shop management was so important as engineering management.

Fredrick Taylor is often called the father of scientific management. Starting as a common laborer at Midvale Steel, He held a variety of jobs, working his way through the ranks until he became chief plant engineer. From his work experience, Taylor knew improvement must start with the workers. He felt the solution was not to make them work harder but to manage them better. Management should develope proper work methods, teach them to the workers, and see that they follow them.

As scientific management gained acceptance in the United States, Henry Fayol developed his theories in France. He was an engineer and later he became managing director of a large mining company. He viewed problems from the topdown rather than from the shop floor, as Taylor did. Fayol beleived a firm had six functions: technical (the actual production), commercial (buying and selling), financial (getting and allocating money), security (protection of people and property), accounting (keeping records), and managerial (planning, organizing, command, coordination, and control).

Academia’s contribution to developing management theory came later. Between 1924 and 1927, production levels of a small group of workers at the Hawthorne works of western electric were studied. The idea was to change working conditions one at a time and measure the workers’ output. They first increased the lighting level, and as xpected, production increased. The unexpected happened when production still increased as the lighting level was lowered. The increase continued, even when the available light was only as bright as moon light. At this light, they judged the problem more complicated than originally and called in Elton mayo, a Harvaed professor and the first academic to make major contributions to production system management. The people discussed previously were all practitioners. Mayo concluded that logical factors are far less important than social factors in motivating workers. In essence the attention the workers got made them feel special, and they worked harder. The lesson is that the human factor is critical in production systems.

2 Production systems:

In the broadest sense a production system is anything that produces something. However, we will define it more formally to be anything that takes inputs and transforms them into outputs with inherent value. A good example of a production system is a firm that manufactures simple pencils. Raw materials such as wood, graphite, and paint are the inputs. The transformation consists of cutting the woods in sheets, sanding it, grooving the wood, adding the lead, joining the sheets, cutting the pencil shape, and finally painting the finished pencil. The pencil is the output. We think of large manufacturing operations as production systems, but many other examples are quite different. For example your university is a production system. Freshmen are input, acquisition of knowledge is the transformation, and the output is an educated person. We can break production systems into two classes: manufacturing and service. In manufacturing, the inputs and outputs are usually tangible, and the transformations are often physical. On the other hand, service-oriented production systems may have intangible inputs/outputs, such as information. Transformation may not be physical, as in education. Another difference is that manufacturing goods may be made in anticipation of customer need, which is often not possible for services. Education is a good example of this; students can not be taught before they enroll.

With production systems, we normally think of the portion we can see, usually the transformation processes. However, most moderm production systems are like icebergs- the visible portion is a smll part of the whole system. The study of prosuction systems requires us to consider many of its components, which include the products, customers, raw materials, transformation processes, direct and indirect workers, and formal and informal systems that organize and control the entire process. These components lead to issues and decisions that must be addressed for the production system to operate properly.

We structure our discussion of production systems around four different components: production flow, building blocks of the system, technology, and system size.

2.1 The flow process

The backbone of any production system is the manufacturing process, a flow process with two major components. The physical flow of material can be seen, but information flow is intangible and more difficult to follow. Both types of flow have always existed; however, in the past, information flow was of little importance. As mentioned before, the emerging information technology reshaped production systems, so that information flow is critical.

In figure 1-1 we show a generic model of physical flow in production systems. Material flows from the supplier to the poduction system, to become raw material inventory. It then moves to the production floor, where the material conversion process takes place. The material moves through different conversion processes performed at workstations but does not necessarily traverse the same route each time. Material on the production floor is called work-in-process inventory (WIP). From the production floor the material flows to a location where it becomes finished goods inventory. From there it flows to the customer, sometimes through intermediaries such as distribution centers or warehouses. Note that this discussion of physical production system flow includes both the supplier and customer. We elaborate on this concept in the following chapter.

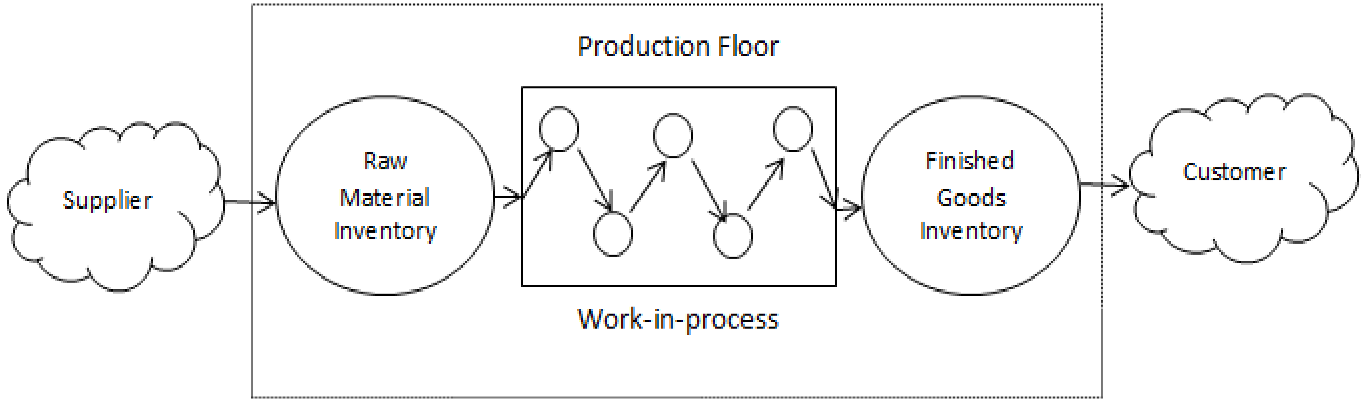

FIGURE 1-1 Generic Physical flow

Figure 1-2 shows a generic production information system common database services all functions and activities of the production system, in whatever location. The leading principle is information integration. The outcome of information flow is seen on terminals throughout the production system.

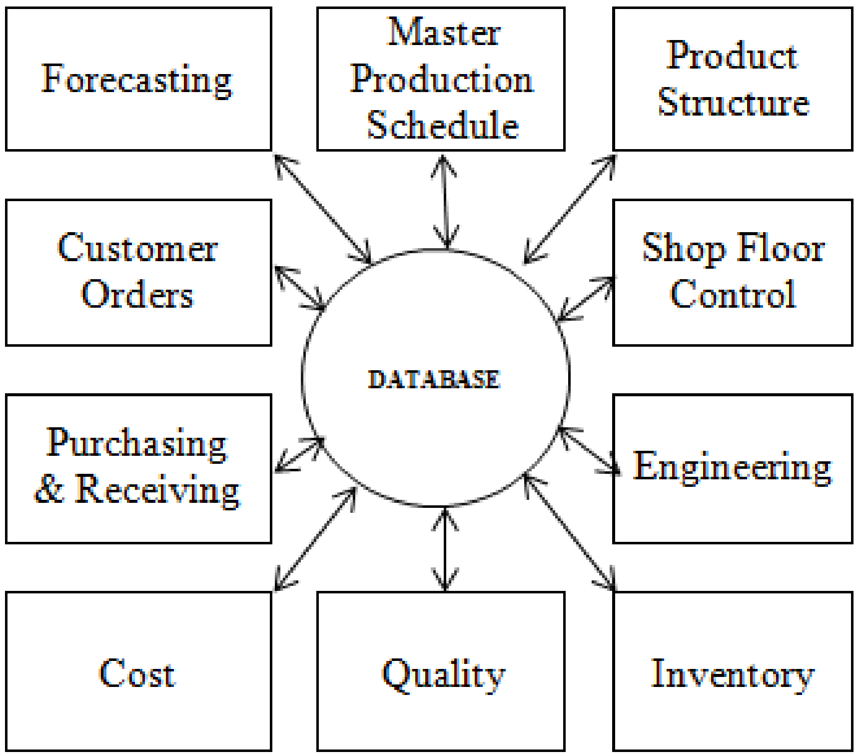

FIGURE 1-2 Generic Production information system

To show the complexity of physical and information flows, we consider a television manufacturer. A TV is no longer just a TV; customer demands include a variety of sizes, styles, and features. Sizes range from the two-inch Watchman to 45-inch and larger projection screens. Styles include portables, table models, and consoles. Different features include picture-in-picture, cable readiness, sleep timer, a built-in VCR, and CD-ROM interactive systems. A plant must be able to make a range of the TVs demanded rather than just one standard model. The manufacturer must decide when and how many of each TV model to make. Once this decision is made the company must procure a variety of inputs, which may be unprocessed raw materials (wood or plastic for the cases) or sophisticated components made separately (picture tubes). They must order the correct quantity and quality of these inputs and arrange for timely delivery and proper storage. People, processes, and materials are coordinated to ensure a quality product completed in a timely, cost-effective manner. Finally, the finished product is packed and shipped to the customer. Although giving a glimpse of system complexity, this simplified description ignores other functions of a production system, such as the choice of technology, maintenance of physical equipment, financial matters, advertising and marketing, and distribution.

2.2 Building blocks

The goal of production systems is to manufacture and deliver products. The principle activity in meeting this goal is the manufacturing process, in which the material conversion of transforming raw material into a product takes place. The manufacturing process can be viewed as a value-adding process. In each phase the conversion performed (at a cost) adds value to the raw material. When this value-adding process is complete, the process is ready to be competitive the goal is that the material conversion has to meet, concurrently, the following objectives.

- **Quality**: the product must have superb quality- equal to or better than its competitors.
- **Cost**: the cost of the product must be lower than the competition.
- **Time**: the production must be delivered to the customer on time, every time.

There are interactions among the three objectives, customers accept higher cost for unique products and low quality for cheap ones.

Although there are many elements that support the achievement of these objectives, we discuss two here: the physical and organizational arrangements.

2.2.1 PHYSICAL ARRANGEMENTS:

The material conversion process takes place on the production floor, which is arranged in a certain way to facilitate conversion. Production volume and production variety determine the type of arrangement, or **layout**. Consider, for example, a chair manufacturer/ intuitively, the manufacturing process to make 50 identical chairs would differ from one to produce 50,000 identical chairs. Also, producing the same number of five different types of chairs would compound the problem. To meet these varying needs, two fundamentally different types of physical layout have evolved: the **job shop** and the **flow shop**.

A Job shop produces low-volume highly customized products. Job shops usually have several elements in common. Workers must be skilled enough to make a variety of products. Similarly, general purpose equipment, which can handle within limits different types of jobs, is normally used. A swing machine , for example, is general purpose equipment for the garment industry. The final characteristic of a job shop is that each job follows its own path or route through the layout.

One typical type of job shop layout of manufacturing equipment is a process layout, in which similar machines are grouped. For example, in a machine shop (a classic job shop), laths are located in one area and milling machines in another area, as shown in figure 1-3. We also show the routing of two different jobs through this layout. Obviously, increasing product variety causing routing to be more complex. Even though managing a job shop can be a difficult task, a large portion of American production is done in a job shop setting.

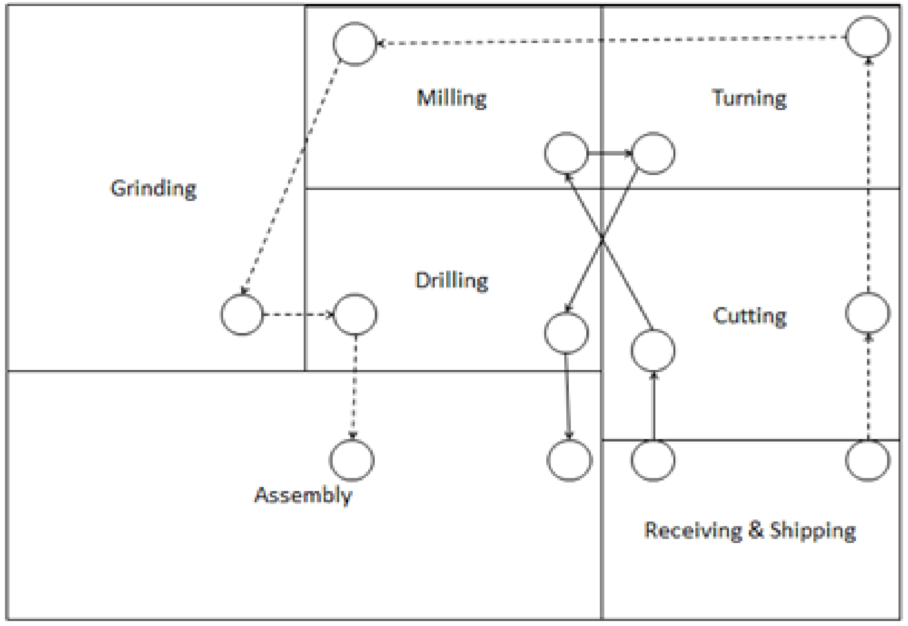

FIGURE 1-3 Process or functional layout

A flow shop produces a high-volume standardized product. The automobile industry is a good example of a flow shop. An assembly line maintains the material flow, hundreds of thousands of a given model of car may be made, and production may last for a year. Workers use special purpose equipment, need little skill, and are able to do fewer tasks than job shop workers.

Each product in a flow shop follows the same sequence of operations. The manufacturing sequence or assembly operations required by the product determine the layout. A flow shop uses a **product layout**. Equipment is arranged so that the product always follows the same routing through the layout (figure 1-4). In addition, to the car industry, manufacturers of home appliances and electronic products use flow shops. Managing a flow shop differs from a job shop. Rather than daily scheduling, the critical problem is setting up and balancing tasks along the assembly line to ensure a smooth operation.

Between the extremes of job shops and flow shops is a hybrid of the two, the **batch shop**.

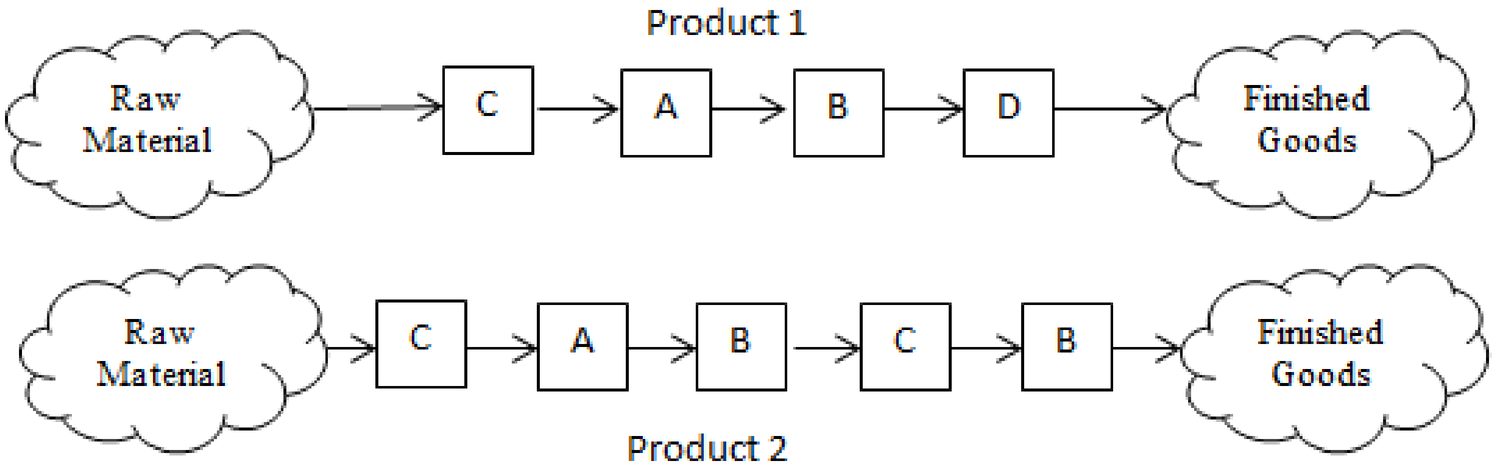

FIGURE 1-4 Product layout

Sometimes, a single, customized product must be made. This production system is a project shop; its output is a one-time-only job. This layout is an extreme case of a job shop making a highly customized, unique product. A project shop uses a **fixed-position** layout. The product (ship, aircraft) stays in one place while the material and equipment are brought to it.

As the project shop is an extreme version of a job shop, the **continuous shop** is a radical extension of the flow shop.the continuous shop is characterized by continuous flow, as in petroleum and chemical industries. Discrete units are not produced, but liquids flowing through pips are chemically transformed into the final products. Because we deal only with discrete production, continuous shops receive no further discussion.

The final physical layouts encountered are the **modern shops**. Modern shops fall into the class of Integrated Production Systems (IPS), and include three major types: Cellular Manufacturing Systems (CMS), Flexible Manufacturing Systems (FMS), and Computer Integrated Manufacturing (CIM). We discuss modern shops in Chapter 2 ().

2.2.2 ORGANIZATIONAL ARRANGEMENT:

The goal of organizations is to subdivide complex tasks into simpler components by division of labor. Designing a structure to do so requires addressing two primary issues: how to divide the labor and how to coordinate the resulting tasks. An industry's organization impacts its production system, so we must understand the organizational environment. There are three major types of organizational structures: **functional, divisional, and matrix.**

Functional and divisional are classic, though opposite, organizational structures. **Functional structure** is built around **inputs** used to achieve the task of an organization. These inputs are grouped according to the especially of the functions performed,e/g/, engineering, production, finance, marketing, human resources, quality, etc. A simplified functional organizational chart in shown in figure 1-5. A more complex chart breaks each function into its dub-functions.

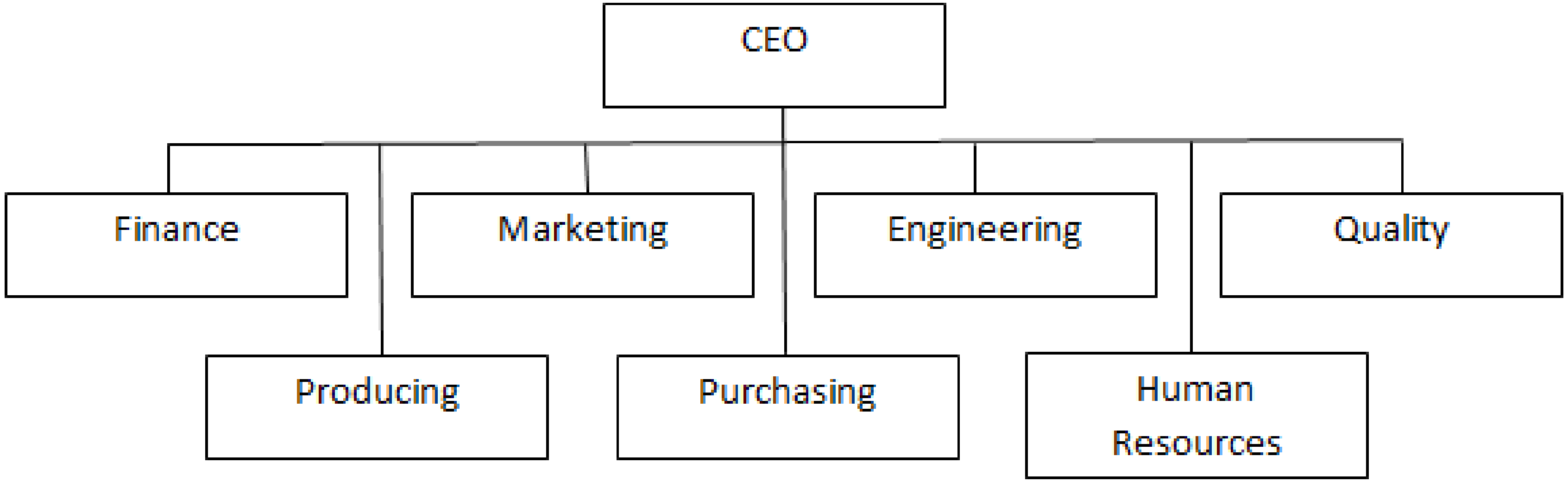

FIGURE 1-5 Functional organization

Divisional structure is built around the **outputs** generated by the organization. The most common is to structure the organization around its products. However it could be built around projects, services, programs, clients, specific markets, or geographical locations. Today, a divisional structure is called the *strategic business unit* (SBU). In figure 1-6 we show a divisional organization by product. Each strategic business unit has separate engineering, marketing, and control functions. The control function is most important to a strategic business unit. Other functions such as production or purchasing may or may not be centralized. Managers in a functional organization have authority commensurate with responsibility. In a SBU structure, they tend to have more responsibility than authority. On the other hand, a SBU organization is more customer oriented, and therefore more popular in market driven systems.

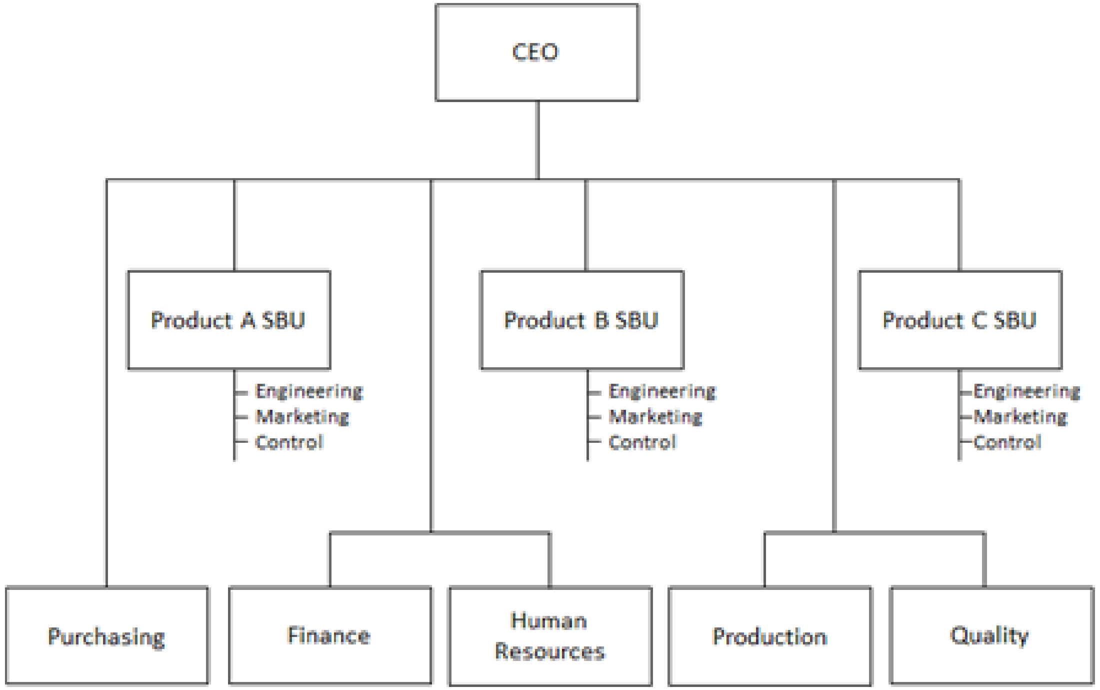

FIGURE 1-6 Product divisional organization

Both functional and divisional structures are designed around a single focus of either inputs or outputs, which maintain a “one person” , “one boss” hierarchy throughout the organization. A **Matrix** organization is structures around two or more central design concepts. One person can have more than a boss, leading to ambiguity within the organization. In a matrix organization, a project or product managers responsible for project completion or for successful development and sales of the product. The project manager does not directly control resources and must contract with other functions in the organization to complete project components. In Figure 1-7 we show a production matrix organization. It illustrate how a two boss situation arises. An employee of a functional department also is responsible to the project manager; in effect, the employee has two bosses. Matrix organization are difficult to manage and are commonly found in research and development (R &D) organization.

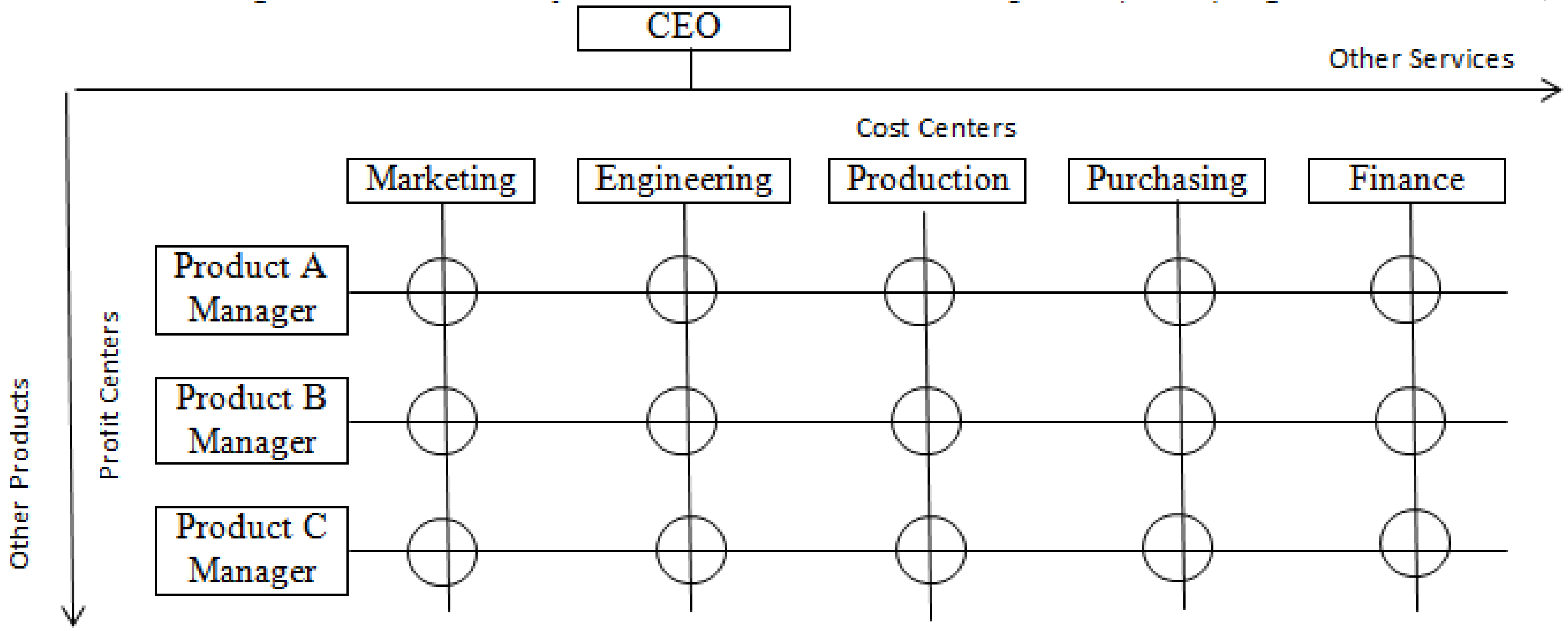

FIGURE 1-7 Matrix organization

2.3 Technology

In section 1-2 we discussed the emergence of market-driven systems also appeared a new production paradigm: the so-called high-tech products or industries. In this section we further explore this paradigm and its impact on production systems.

Although it is difficult to agree on the definition of a high-tech industry, the continuously increasing rate of technological advancement is obvious. Just as clear is that this rate of advancement causes basic changes in products, processes, and managerial techniques. To incorporate and use these technological advances and center the high-tech domain, industry must accept two realities:

- These advances are major and involve a shift in capital and complementary skills.
- These advances inherently involve a commitment to continuous change.

Today certain products or industries are organized as high-tech;e.g., aircraft and space industries, electronics, telecommunications, computers, pharmaceuticals, optics, and composite materials. Further study requires us to be more specific in our definition. Researchers identify three criteria used to classify industries as high-tech.

- Research and development expenditures are above a minimum percentage of sales.
- The proportion of scientific and technological personnel to total employment is above a certain level.
- The product has a certain perceived degree of technological sophistication.

The third criterion is subjective and is the reason for including some industries on our earlier list. Numbers one and two are more objective and do not depend on the product.

2.4 Size of organization

Organizations differ in size and scope, with these differences having an impact on the production systems. We examine three aspects of this impact. The physical process, the management process, and the production management decisions involved.

No matter the size of organizations, the **physical process** in each production system is similar in nature. The generic physical flow (Figure 1-1) and the ensuring layouts how much in common in any size of industrial organization. The difference lies in relative complexity. Small organizations have straight forward material flow, as product volume and variety are limited. Large organizations, usually with a broader product mix, can have many flow routes through the production system. Although the physical locations may differ, each specific flow follows the general pattern that described previously.

Before, we noted that organizational structures vary. the **Management process** is different in large organizations as opposed to that of smaller ones. Each organization has a different managerial process, even though the physical flows are essentially the same. The major dissimilarity arises in the information flow and the related decision-making process. In a functional organization decisions are more centralized but are more decentralized in a strategic business unit. Because of size, decisions in a small organization are more centralized.

The **production management decisions** are another element of interest. In content, these decisions are virtually the same in any type of organization. Generating a forecast for future demand, preparing production plans, and purchasing material are generic decisions made in all size companies. Furthermore, the same types of production management tools are used. Again, the difference lies in complexity and scope. For a small organization a forecast or production plan can be generated by using a PC and simple software. A big organization may need sophisticated software and hardware for the same activities.

The major difference between small and large industrial organizations is not the nature of the physical flow, but the information flow and the decision-making processes used.

3 PRODUCTION MANAGEMENT TECHNOLOGIES

By now we realize that production systems are complex and need managing. Production management technologies have many aspects; behavioral, process technology, quality, and production planning and control (PPC). We concentrate on PPC because it is a significant part of production management technology. We examine the evolution of PPC technology, define the vast area it represents, introduce the concept of product life cycle, and discuss appropriate technologies.

3.1 Evolution

Previously, we discussed the contribution of management pioneers such as Taylor and Fayol. Taylor laid the groundwork for operations-oriented analysis. Gantt, a contemporary and associate, added another dimension to taylor's work by recognizing that a process is a combination of operations. He developed a rudimentary method of scheduling operations, the Gantt Chart. These charts are used today and deal with scheduling problems and project environments.

About the same time, Frank and Lillian Gilbert led a team that further developed the field of operation analysis. They originated the idea that operations are broken down into independent components, such as grasp, search, and release. Putting these components together in different ways create different operations. Their work is a basis for predetermined time standards used to estimate operation time, important data for a production planning and control.

Shewhart proposed one of the first quantitative approaches to PPC. In the 1920s he developed an organized theory of statistical quality control as applied to manufacturing operations. His rationale for dealing with variation was a breakthrough, replacing the deterministic approaches previously used.

3.2 Production planning and control

Production planning and control technology combine the physical and information flows to manage the production system. PPC has several distinct elements. In figure 1-8 we super impose these elements on the physical flow of a production system.

We position these elements at different places along the physical flow route and interaction between the elements is not shown. The PPC function integrates material flow using the information system. Integration is achieved through a common data base (Figure 1-2).

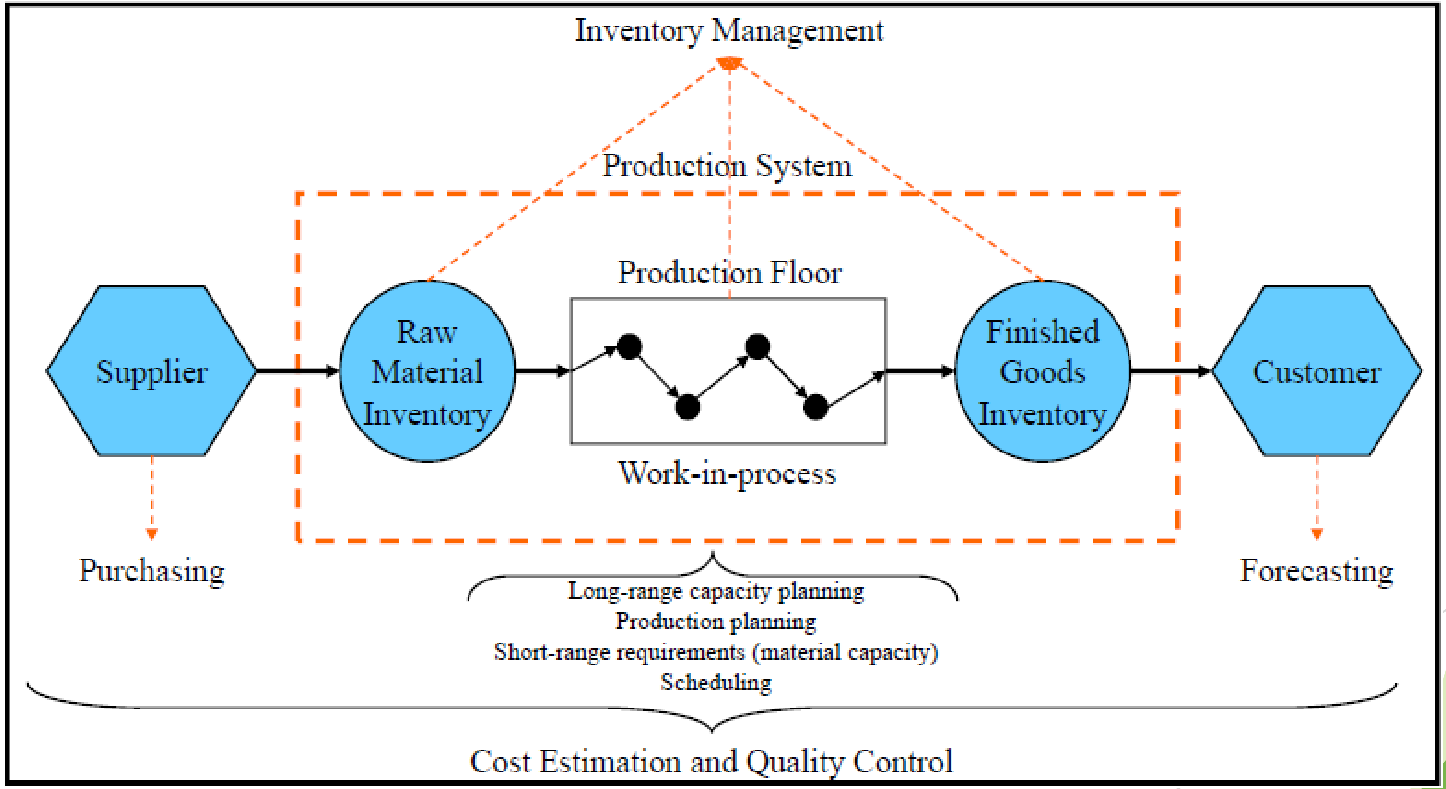

FIGURE 1-8 Elements of production planning and control

Interaction with the external environment is accomplished by forecasting and purchasing. Forecasting customer demand starts the production planning and control activity. Purchasing connects the production system with its inputs provided by the external suppliers. Extending production planning and control to suppliers and customers is known as **supply chain management**.

Some elements are associated with the production floor itself. Long-range capacity planning guarantees that future capacity will be adequate to meet future demand, and it may include equipment, people, and even material. This decision is aided by a technique known as **aggregate planning**. Production planning transforms the demand forecasts into a master production plan, which considers overall availability of capacity and material. Detailed planning generates short-range requirements for material and capacity and performs short-term production scheduling. Additionally, inventory management maintains and controls raw material, work in process, and finished goods. Cost estimation and control and quality follow-up involve all parts of the production system.

Many of these elements relate to avtivities performed by other functions, e.g., the purchasing department or the production function. PPC does exactly what the name implies; planning and control of production.

3.3 Product life cycle

A product life cycle describes the evolution of the product as measured by sales over time. The five stages of a product life cycle are product planning, introduction, growth, maturity, and decline. Figure 1-9 shows sales in each of these stages.

Product planning is the development stage, in which both product design and production process are determined. There are no sales during this stage.

Introduction represents a period of low-volume sales. The product is refined, and marketing efforts are beginning.

The **growth** stage has rapid product growth and a fast increase in sales. This period is difficult for the manufacturing organization, which has to keep up with the increasing sales volume.

At **maturity**, we see a tapering off in the growth rate as the market becomes saturated. Demand is stable and may decline slowly. A wise producer in this stage, must think about designing and planning for the next product.

A drop in product demand is seen in the **decline** phase. The product has been replaced by new products. Sales and profits decrease, and at same point, production is halted.

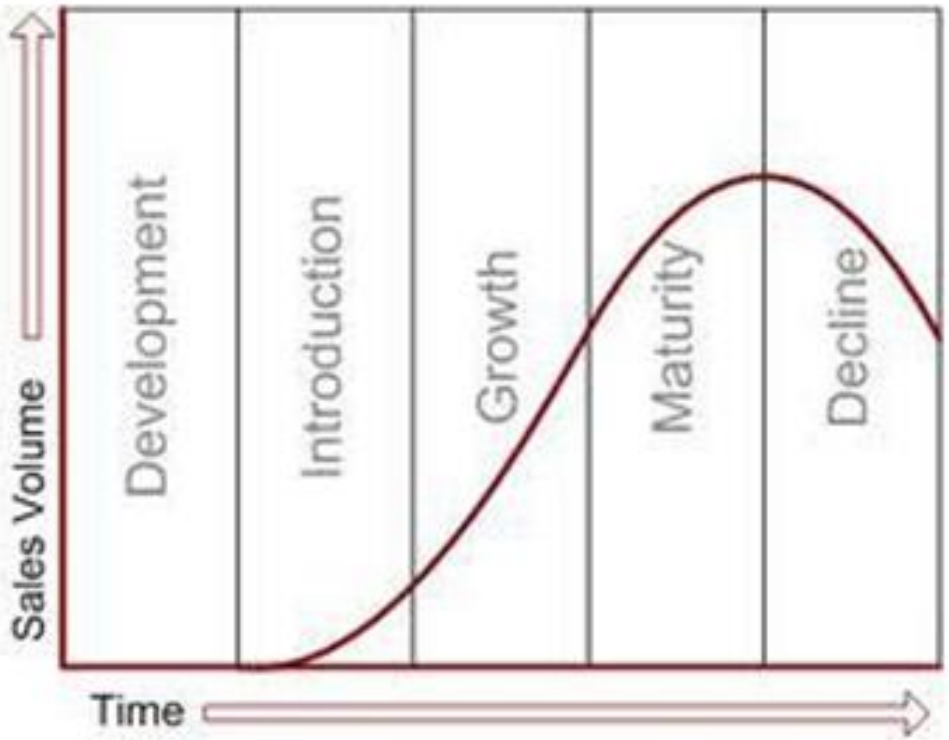

FIGURE 1-9 Product life cycle

Neither life cycles nor the length of the individual stages are the same for all products. For some products the life cycle may be short-several years for high-tech products or a season for fashion goods. Other products may be survive for years. By modifying a product, its life cycle may be extended.

4 DECISIONS IN PRODUCTION SYSTEMS

By now production systems, their evolution, organization, technology, and the tools required to manage them should be familiar. However, neither management tools for computers run an organization. Organizations are run by people who make decisions that keep the organization moving toward its objectives. İn the following section we address decision making in production systems. We discuss the notion of a planning horizon, present types of decisions, and introduce the implementation cycle.

4.1 Planning Horizon:

The types of decision in a production system depend on the planning horizon, which is no different from everyday life. A decision to buy a house has long-term impact and takes a long time to prepare. On the other hand, deciding what to buy in the grocery store can be spontaneous , and its implications are short lived. For planning purposes, business and industry usually identify three types of planning horizons: long, medium, and short.

A **Long planning horizon,** sometimes called strategic planning, covers a horizon of one to several years into the future. The decisions made for this horizon are called strategic decisions. They have a long-range impact on the direction of production systems and should be consistent with long-term organizational goals.

A medium planning horizon covers any period from one month to one year and is called tactical planning. Decisions made for this time frame, known as tactical decisions, are oriented towards achieving the annual goals set for the production system.

A time frame ranging from days (sometimes hours) to weeks or one month is the **short planning horizon**, also known as operational planning. Operational decisions are concerned with meeting the targets of the monthly production plan. In figure 1-10 we show the three planning horizons on a time scale

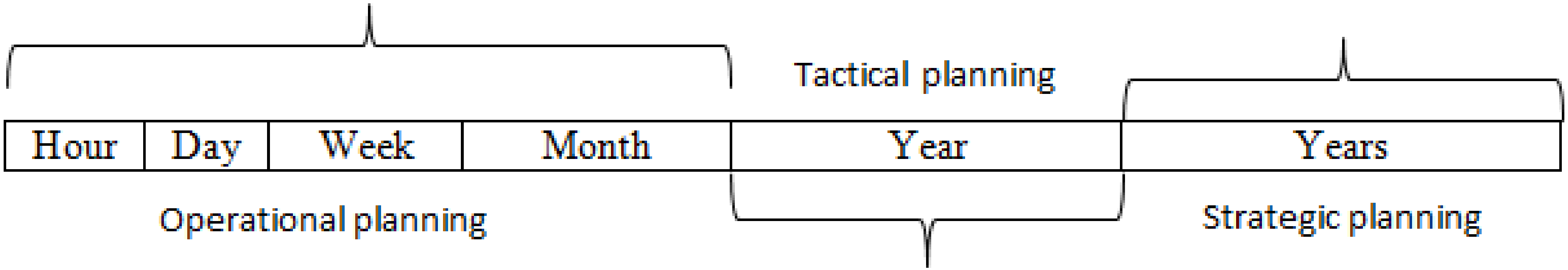

FIGURE 1-10 Planning horizons

4.2 Types of decisions:

Even in the middle-sized industrial organization, there are hundreds of decisions made every day and at all management levels. The production system is part of this decision-making process, and some foundation is required to understand its decision-making environment. We identify three criteria for classifying production system decisions: organizational hierarchy, time, and topic.

Obviously the nature of decisions made by top management is different from those made by production line managers. Typically, strategic decisions are made by top management, tactical decisions are made by middle management, and operational decisions are made by operations managers. A strategic decision might involve capacity expansion. Its derived tactical decision would be the choice of equipment to increase capacity. How to install the equipment would be an operational decision.

Classification by time was covered in the discussion of planning horizons. A definite relationship exists between time and hierarchical classifications. Typical top management decisions are long term, whereas operational decisions are short term by nature.

Lastly, we include the topical content of different discussions. A decision might deal with production issues, a financial aspect, quality, or material. Some decisions will relate to more than one topical area.

In table 1-1 we illustrate these decisions relative to production planning. As seen in the table the units used inj defining production decisions may vary along the time/hierarchy axis.

TABLE 1-1 Production planning decisions

	Long (strategic) Top management	Intermediate (tactical) Middle management	Short (operational) Operational management
Time	Three to ten years	Six months to three years	One week to six months
Unit	Dollars; hours	Dollars; hours; product line; family	Indididual products; product family
Inputs	Aggregate forecast; plant capacity	Intermediate forecast; capacity and production levels taken from long range plan	Short range forecast; capacity and production levels, processes; inventory levels
Decisions	Capacity; product; supplier needs; quality policy	Work force levels; processes; production rates. Inventory levels; contracts with suppliers;quality levels; quality costs	Allocation of jobs to machines; overtime; undertime; suncontracting; delivery dates for suppliers; product quality