2002

Operations Management

Politis, John D.

Biography

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Dr. John Politis is Pioneering Faculty and Subject Coordinator of the Bachelors of Business and Engineering Management Programs, Faculty of Business and Engineering, Higher Colleges of Technology, Ministry of Higher Education, Dubai, United Arab Emirates. He is also the Chair for the Bachelor of Engineering Management Quality Assurance Program.

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ACKNOWLEDGEMENTS

I am grateful to the Higher Colleges of Technology for providing me the opportunity of conducting this work. I am especially grateful to the reviewers – Dorothy Sharp, Adrian Waygood, and Bob Hunt – for their many helpful comments and suggestions for improving the book. These views have been incorporated wherever practicable. I am indebted to Fred Partick, Mahmoud Taha and Jonathan Wilde for their encouragement and support throughout the various stages of the book production.

Finally, my wife, Stergiani Melidoniotis, understood my ideas and watched me with patience. For this I am grateful and I owe her a great debt of thanks. My children Denis and Nicholas can't quite figure out what I do, but think it is interesting anyway. Hopefully, they were able to share the tacit knowledge that will benefit them in the future. That's my way of saying "Thanks" to Denis and Nicholas.

PREFACE

This book provides a fundamental, yet comprehensive, coverage of Operations Management. It will serve the instructional needs of business, engineering and technology students. The book not only covers the principles and practices, but also some of the tools and techniques. Sufficient theory is presented to ensure the reader has a sound understanding of the basic concepts. Questions and exercises in the book have been designed to reinforce learning and tests the understanding once the reader have read the corresponding chapter in the text. It is not necessary that all questions and exercises are completed sequentially.

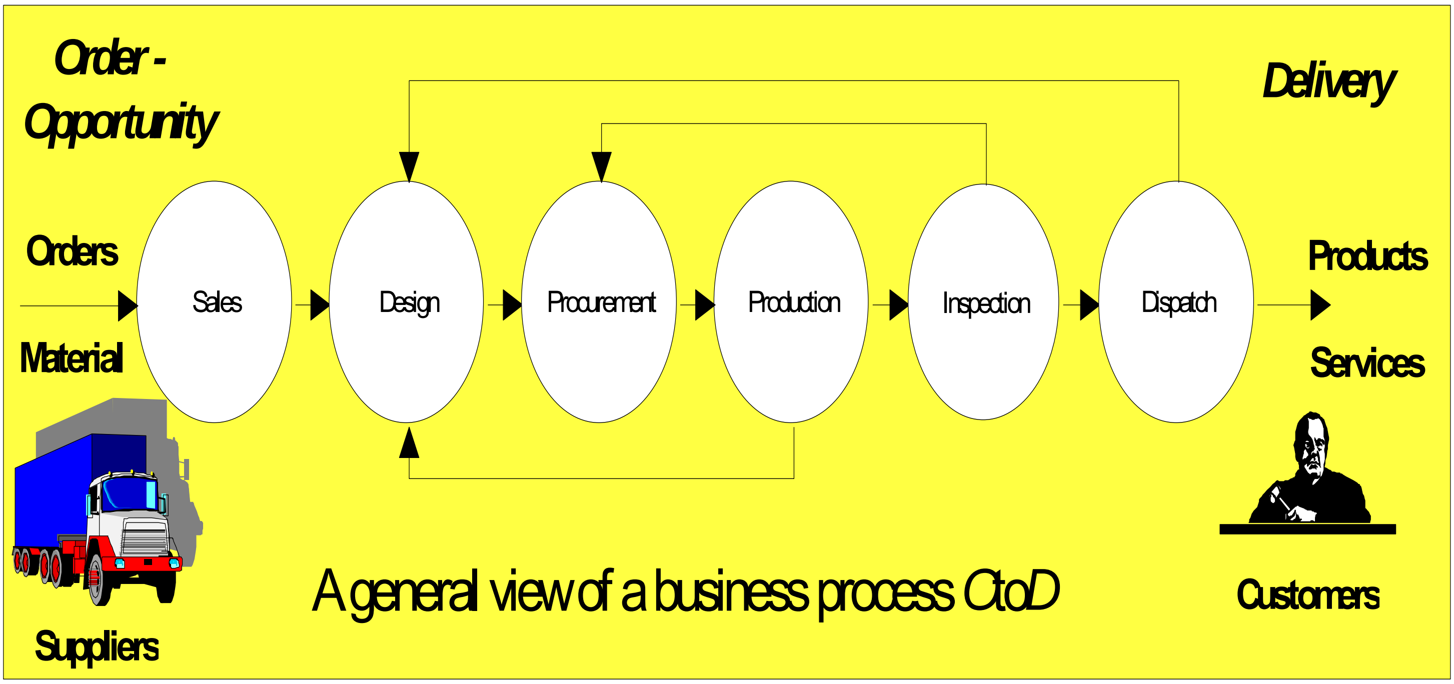
The book is divided into twelve chapters in accordance with the following table.

Topic Structure

	The strategic role and objectives of operations management This chapter introduces the role and objectives of operations management and

Chapter 1	relates them to the organization's strategic plan. Topics covered will include: the role of the operations in the organization's strategic plans; how the contribution of operations to the organization's competitiveness can be assessed; the meaning of the five performance objectives for operations – quality, speed, dependability, flexibility and cost; the internal and external benefits which an operation can derive from excelling in each of its objectives.
Chapter 2	Operations strategy This chapter looks ahead to formulate the operation strategy within the overall strategic decision making in the organization. The chapter looks at the types of decisions, which an operation will have to take in order to establish the content of operations strategy. It will examine the strategy hierarchy of which operations strategy is a part and will demonstrate how performance objectives will have different priorities depending upon the organization's customers, competitors and the position of its products and services on their life cycle.
Chapter 3	Design in operations management This chapter covers the basic principles of *both* the design of products and services and the design of the processes, which create them. The design principles will be related to an organisation's customers, as well as its competitors. Topics covered will include: the nature and purpose of the design activity in operations; the way in which the purpose of the design activity must always be to satisfy customers and the way in which products, services and processes are designed; how design can be considered to be a decision-making process.
Chapter 4	Design of the operations network This chapter helps managers to understand the nature of operations networks and the concept of the 'supply-side' and the 'demand-side' parts of the network. It will examine the advantages of taking a network perspective in making strategic design decisions. It will also help to determine the extent to which an operation chooses to be 'vertically integrated' into the network, the location of each operation within the network, and the capacity of each part of the network.
Chapter 5	The nature of planning and control This chapter introduces the nature of demand and supply and provides an overview of the principles and methods of planning and control and examines the influence of volume and variety on planning and control. It also provides specialist tools to planning and control in project environments.
Chapter 6	Supply chain planning and control This chapter goes beyond the strategic and structural issues of designing supply networks presented in Topic 4 and considers the more 'infrastructural' issues of planning and controlling the 'strands' in the supply network. Topics covered will include: definitions of purchasing, physical distribution management, logistics, materials management and supply chain management; purchasing and supplier development; integration of the organization's functions through logistics and materials management; integration of organizations through supply chain management.
Chapter 7	E-commerce and operations management This chapter continues from Chapter 6 and features on e-commerce and the Internet purchasing (e-procurement). In particular, it looks at how operations managers can use e-commerce and Internet purchasing to improve their operations. Topics covered will include: Economics of e-commerce, security in the e-commerce environment, e-procurement, technologies in services, information sciences in operations (transaction processing, management information systems and artificial intelligence), and scheduling and logistics improvement. A wide variety of examples of business-to-business electronic commerce illustrate the importance of this topic.
	Operations improvement This chapter looks at how managers can make their operation perform better,

Chapter 8	how they can stop it failing, and how they can bring their improvement activities together. Topics covered will include: how operations can measure their performance in terms of the five performance objectives – quality, speed, dependability, flexibility and cost; the principles and stages of benchmarking; the way in which operations managers can quantify the importance of their significant competitive factors and their achieved performance using the importance-performance matrix; the business process re-engineering (BPR) approach to improvement; and the two contrasting improvement strategies of continuous and breakthrough improvement.
Chapter 9	**Waiting line models for service improvement** This chapter focuses on operating systems of service organizations. The chapter looks at how managers can reduce waiting time since waiting takes place in virtually every productive process or service. Topics covered will include: elements of a waiting line, the calling population, the arrival rate, service times, queue disciple and length, waiting line analysis and quality, and the single-channel, single-phase and multiple-channel, single-phase models.
Chapter 10	**Project based management today** This chapter covers the basics of project management and relates it to the broader operations management concepts covered in other chapters. Topics covered will include: project life cycle; project management bodies of knowledge and competencies; five functions of project management (scope, organization, time, cost, quality); project teams; project planning and control; work breakdown structures, Gannt, CPM and PERT charts; project management information systems.
Chapter 11	**Project based management futures** This chapter looks ahead to examine the implications of the evolution from hierarchical to flat projectised organizations. It will also examine the new paradigms of 'critical chain' versus the traditional 'critical path' approach to project scheduling. It finally examines how service organisations can benefit from the ‘traditional’ project management techniques.
Chapter 12	**The operations challenge** The last chapter in operations management looks into the challenges of operations strategy formulation from an international perspective and how the decisions resulting from operations strategies have an ethical dimension. It also examines the need for creativity in devising operations strategies and finally the challenge of implementing the chosen strategies are discussed.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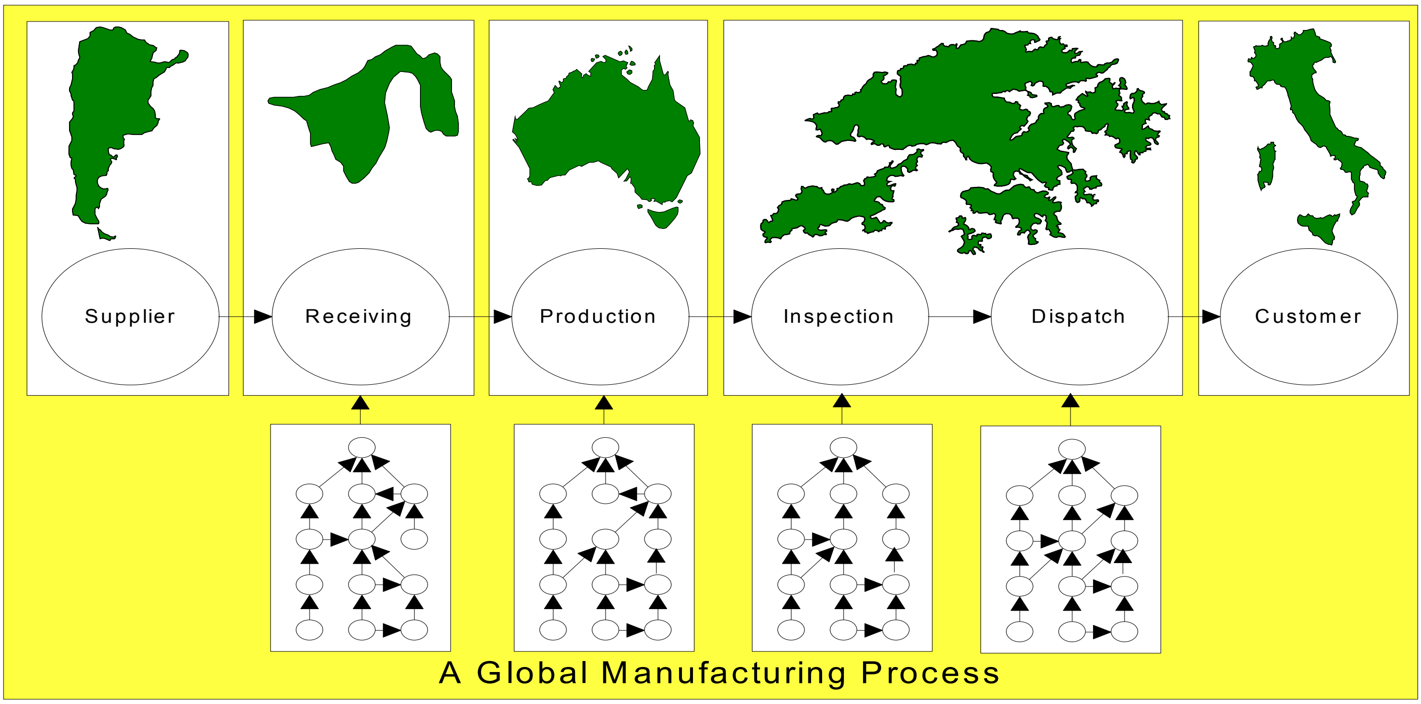
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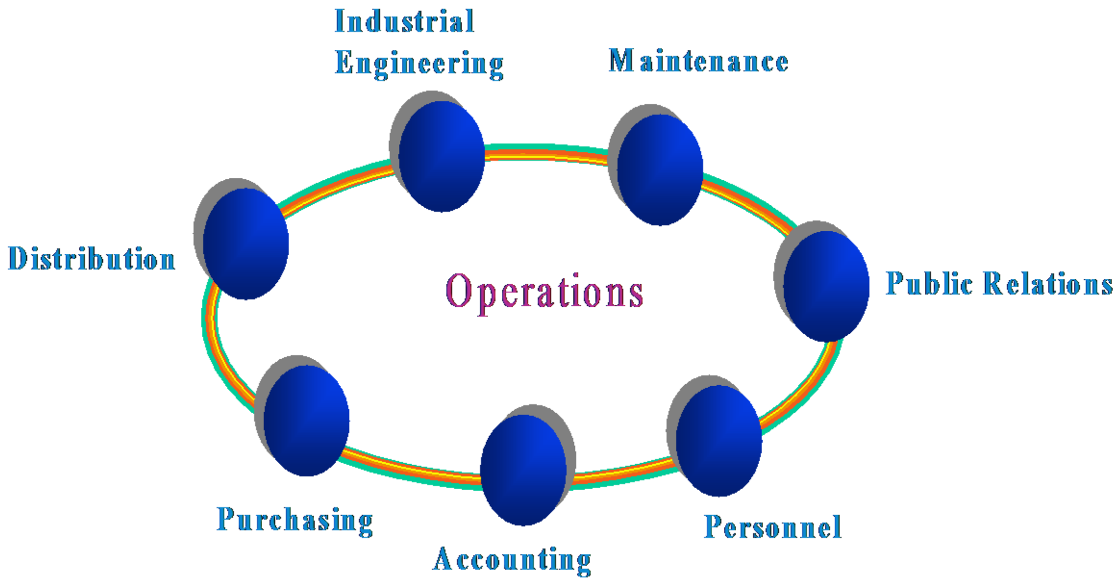
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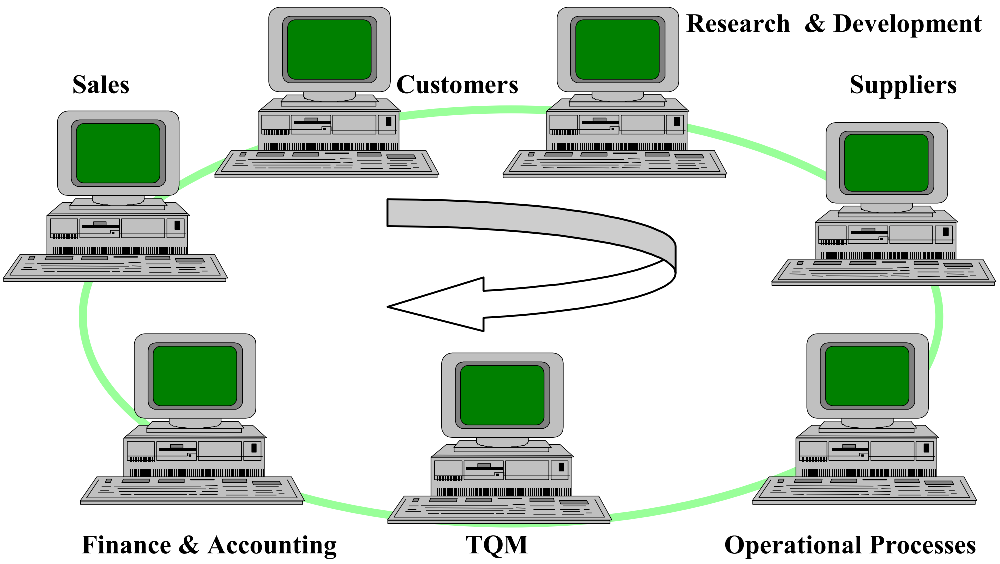
Research & Development
Sales
Customers
Suppliers
Finance & Accounting
TQM
Operational Processes

Operations Management

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for

Higher Colleges of Technology, United Arab Emirates

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Chapter 1

The strategic role and objectives of Operations Management

Contents .... Page

The strategic role and objectives of operations management

Learning outcome

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- develop an understanding of the strategic importance of operations and how operations can provide a competitive advantage in the marketplace.

- appreciate the role of operations management and the people who manage the operation within the business.

- define the relationship between operations and other business functions, such as Marketing, Finance, Accounting, Engineering/Technical, Purchasing, and Human Resources.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Identify the strategic role of operations management in the running of organisations
- Understand operations as a Transformation Process
- Be familiar with the "characteristics" used to distinguish different operations
- Recognise the activities of operations management
- Understand the nature of the five performance objectives – quality, speed, dependability, flexibility and cost; and the internal and external benefits which an operation can derive from excelling in each of its objectives
- Appreciate the role the operations play in achieving strategic success

What you will need

Suggested study time	Text Book	5 hours
	Activities and exercises	2 hours
	Total	7 hours
Other resources:	Suggested readings	4 hours

Introduction

Operating a large amusement park, such as Disney's Epcot Center, is every bit as complicated as manufacturing an aircraft carrier. Thousands of activities must be co-ordinated on a daily basis. Equipment must be well-maintained, workers well-trained, and shelves well-stocked, while keeping costs down. On top of this, services typically deal with more customers (each with their own service expectations) more frequently than manufacturers, and handle more unexpected occurrences. Maybe that's why General Motors (GM), Xerox, IBM and other organisations routinely benchmark *Disney* operations.

Welcome to the study of operations management. Around the world and in the United Arab Emirates (UAE) in particular traditionally operations managers are "trained" rather than "educated". Service and manufacturing organisations prefer that their staff are given "on the job" training in preference to other forms of training or education. The end result is that management has a number of deficiencies, and operations management is one of the most serious. While other areas are important, there seems to be an overwhelming emphasis on the financial, marketing and human resource management areas. A poll I carried out over the last five years with students in three Australian Universities and in the Higher Colleges of Technology, UAE showed that students have a greater familiarity with these areas, knowing what is studied in the relevant courses, and knowing fairly accurately the role of the manager in each of these areas. However, when we consider the operations management area the results showed that an operations manager is one who deals only with engineering or design and development or managing blue-collar workers, and has been trained "on the job" to take on the role of manager.

While it appears that the student does not know the role of operations manager fairly accurately, over the last decade organisations realised the importance of "educated" operations managers. Companies in the UAE: Etisalat, Dubal , DEWA, Dubai Ports, Emirates Airlines, Department of Civil Aviation, Airforce, and Emirates Internet & Multimedia, and in Australia: Abbott Australasia, Arnott's Biscuits, Coca-Cola Amatil, Kodak Australia, Boeing Australia, Hawker de Havilland, Hewlett-Packard, Pacific Power, and Qantas are sending their managers to business colleges to major of what college course catalogues call operations management. It is now not uncommon for operations management to be a compulsory unit in graduate management courses. Wickham Skinner, of the Harvard Business School, believes that the skills and knowledge of operations managers in industry must be improved. He urges CEO's to upgrade their operations managers and give them latitude to handle the entirely new set of challenges arising from global competition and new technologies (Skinner, 1988).

In the twenty-first century, the effective management of operations - using concepts such as the extended value chain, total quality management, quality function deployment, process reengineering, concurrent engineering, benchmarking and business process problem solving, flexibility and economies of scope – will be the key source of competitive advantage. If this course results in you becoming a better-educated operations manager or a better-informed non-operations manager we will have achieved our objective. To understand better the role of operations and the operations manager it is important to be aware of some historical events in operations management.

A brief history

The history of production and hence operations systems goes back to the ancient times of the Great Wall of Chine, the Egyptian pyramids, the Athenian Parthenon, and the roads and aqueducts of Rome. In the modern sense, however, operations management has its roots in the Industrial Revolution. From the Industrial Revolution of the 1960s through to Globalisation and the Internet of the 1990s the field of operations is rapidly changing and growing in importance. The manager of operations is confronted with intense competition, global markets, global sourcing, product and service variety, mass customisation, advances in technology, worker involvement, and environment and ethical concerns. These are some of the reasons why operations management is such an exciting disciple. For the benefit of the future operations managers, and better informed non-operations managers, the players and events in operations management are summarised in Table 1.1 below.

Table 1.1 Some Historical Events in Operations Management

Era	Events/Concepts	Dates	Originator
Industrial Revolution	Steam engine Division of labour Interchangeable parts	1769 1776 1790	James Watt Adam Smith Ali Whitney
Scientific Management	Principles of scientific management Time and motion studies Activity scheduling chart Moving assembly line	1911 1911 1912 1913	Fred Taylor Frank & Lillian Gilbreth Henry Gantt Henry Ford
Human Relations	Hawthorne studies Motivation theories	1930 1940s 1950s 1960s	Elton Mayo Abraham Maslow Fred Herzberg Douglas McGregor
Management Science	Linear programming Digital computer Simulation, waiting line theory, decision theory, PERT/CPM MRP	1947 1951 1950s 1960s	George Dantzig Remington Rand Operations research groups Joseph Orlicky, IBM
Quality Revolution	JIT (just-in-time) TQM (total quality management) Strategy and operations Business process reengineering	1970s 1980s 1990s	Tsiichi Ohno, Toyota Edward Deming, Joseph Juran Wickham Skinner, Robert Hayes Michael Hammer, James Champy
Information Age	EDI, EFT CIM (computer-integrated manufacturing), PC's Internet, World Wide Web	1970s 1980s 1990s	Numerous individuals & companies Tim Berners-Lee
Globalisation	Worldwide markets and operations	1990s	Numerous companies & nations

	Supply chain management Electronic commerce Mass customisation		

Adapted from Russell and Taylor III (2000: 9).

The nature of activities of operations management can be found in the definitions that follow.

Definitions of Operations Management

A review of the literature revealed that the definitions of operations management closely reflect the diverse nature of activities to which its concepts and techniques are applied.

Wild (1995: 7) defines operations management in the following terms:

> "Operations Management is concerned with the design and the operation of systems for manufacture, transport, supply or service".

Gaither (1996: 4) includes in the term of 'production' into his definition. For Gaither production and operations management (POM) is:

> "the management of an organisations production system, which converts inputs into the organisation's products and services".

Stevenson (1999: 4) defines operations management as:

> "the management of systems or processes that create goods and/or provide services".

Krajewski and Ritzman (1999: 3) refers to operations management as:

> "the direction and control of the processes that transform inputs into finished goods and services". Similarly,

Heizer and **Render** (1999: 4) define operations management as transformation process.

> "Operations Management is the set of activities that creates goods and services through the transformation of inputs into outputs".

Slack et al. (1998: 6) distinguishes operations management from operations function. For Slack et al. **operations function** of the organisation is:

> "the arrangement of resources which is devoted to the production of its goods and services".

Operations management is the term which is used for the activities, decisions and responsibilities of operations managers who manage the arrangement of resources which, are devoted to the production of goods and services within an organisation.

Russell and Taylor (2000: 5) emphases that "operations management designs and operates productive systems – systems for getting work done" and distinguish the term operations as:

> "a function or *system that* transforms inputs into outputs of greater value".

The process of transformation of inputs into outputs can be illustrated using a service operation industry example. W.I. Carr Malaysia is the Malaysian operation of a specialist South East Asian stock-broking business head quartered in Hong Kong (Russell, 2000) The Malaysian operation is an equity research operation, which is to say that its principal function is to undertake and produce high quality corporate, industry and economic research on Malaysian listed companies, the Malaysian stock-market and the Malaysian economy.

Description of the business / service process of W.I. Carr Malaysia

The research product consisted of a weekly investment newsletter (the Weekly), in-depth but irregular research pieces on companies or industries of topical interest and frequent corporate research updates in response to company visits, company announcements and bi-annual earnings statements. Regular commentary and analysis of economic and political developments was also provided. Although the KL Stock Exchange has some 600 listed companies, the research department's efforts were more or less restricted to coverage of the top 100 companies by market capitalisation.

The brokerage business is highly competitive, with approximately 40 local firms and 20 international firms competing for business. The business has relatively high fixed costs – about 70 percent of costs are staff costs. The market is highly regulated, with nominally fixed commissions and onerous licensing requirements making it difficult but not impossible to compete on price. However, variable costs are negligible and once fixed costs are met by revenue, profitability increases exponentially. Therefore, the business can be extremely lucrative for successful firms and the emphasis in business management tends to be top-line revenue growth and market share, rather than cost control.

Essentially the service process is one of collating, processing, analysing, re-packaging and delivering information to a client base of professional, institutional investors – fund managers. Listing order winners is a subjective exercise, but most lists would include accuracy or forecasts, value-addition in research analysis, track record of stock recommendations, access to top management and speed and quality of research delivery. Similarly, order qualifiers would include breadth of coverage, regularity of research output, consistency of contact (sales and research) with customers and the basic readability (style and grammar) of the research product. The actual transformation process is shown in the flow diagram of Figure 1.1.

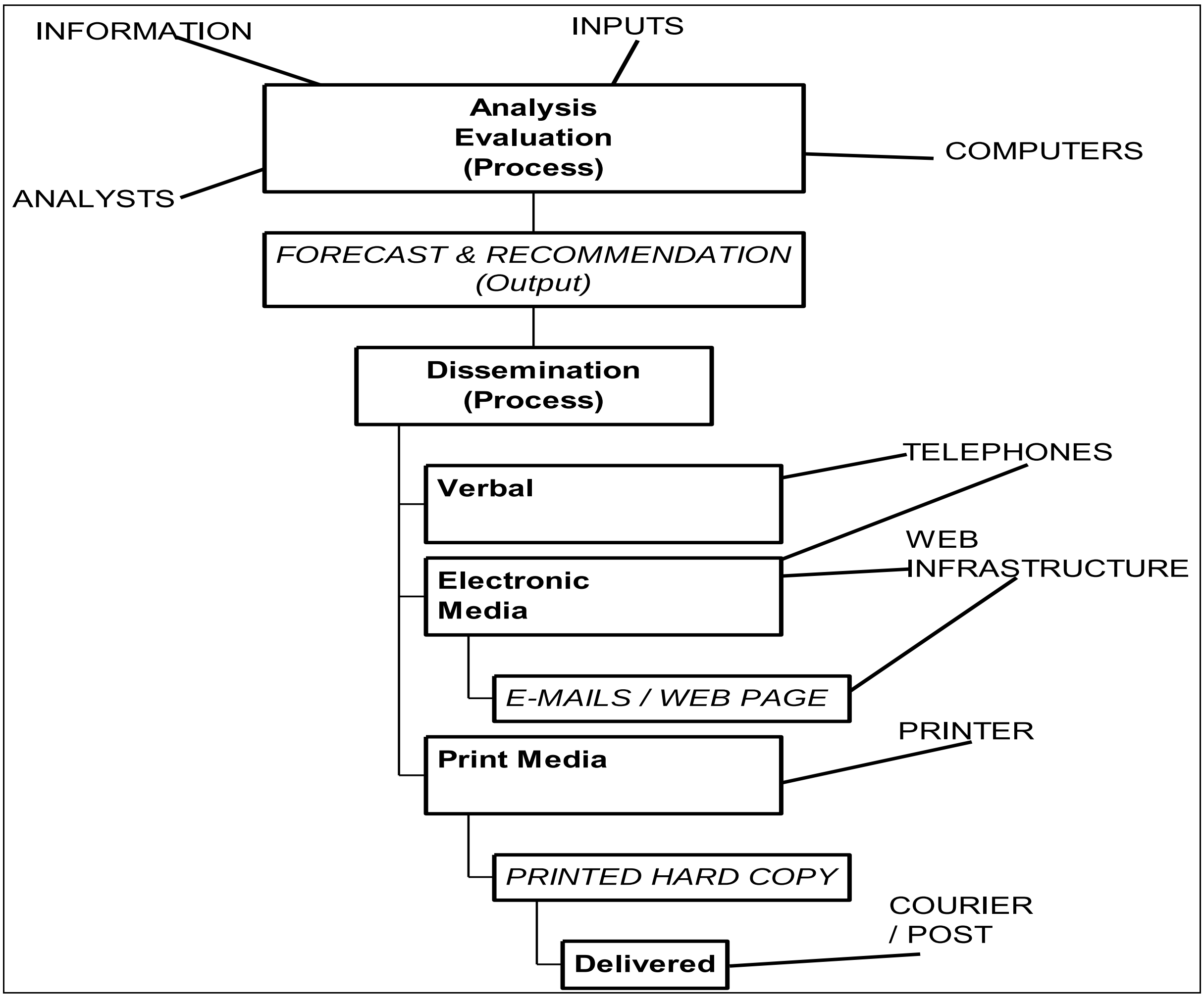


Figure 1.1 Simplified Process flow for Research Production and Dissemination

Figure 1.1 represents a simplified process flow chart for research production. The process flows down the chart from top (input) to bottom. Equity research is an information business and information represents the main raw material, or input. Other main inputs are the analyst's knowledge and experience, data processing equipment (PC's) and communications equipment. Once the information is processed (analysed and evaluated), the analyst will have to come up with an analysis including, in particular, a profit forecast and a recommendation as to whether the stock is attractive or not. These are the key outputs of the process. These outputs then have to be further processed for delivery to the firm's clients. There are three main forms of delivery – verbal (mainly by telephone), electronic (via e-mail, web-site and fax) and by printed hard copy (usually delivered by courier).

Activity 1.1

Provide workplace examples for each of the above definitions of operations management. Which of the above definitions would you expect to be the most suitable for your organisation? Explain.

What is Operations Management?

Operations management deals with the production of goods and services that we buy and use every day. Generally, it is the process that enables organisations to achieve their goals through efficient acquisition and utilisation of resources. Every organisation, whether public or private, manufacturing or service, has an operations function. The management of operations is the focus of this course.

Operations managers organise the production and delivery of the goods and service we all use. To understand operations management we need to understand:

- that operations is 'the arrangement of resources which are devoted to the production of goods and services';
- that an operations manager is 'a member of the organisation who has the responsibility for managing some, or all, of the resources that comprise the operations function';
- that operations management is 'the term used to describe the activities, decisions and responsibilities of an operations manager'.

Operations managers have to ensure that the resources are used efficiently so that **today's** customers can be satisfied and **today's** competitors can be beaten. He or she also has to find ways of using resources more efficiently so that **tomorrow's** customers can be satisfied and **tomorrow's** competitors can be beaten.

The Position of Operations in the Organisation

Most organisations consist of two types of functions. 1) Major functions such as operations, marketing, accounting and finance, product and/or service development; and 2) Support functions such as human resources, purchasing, maintenance, engineering, etc. The basic (major) functions of business organisations are shown in Figure 1.2, while the operations intefaces with a number of supporting functions are shown in Figure 1.3.

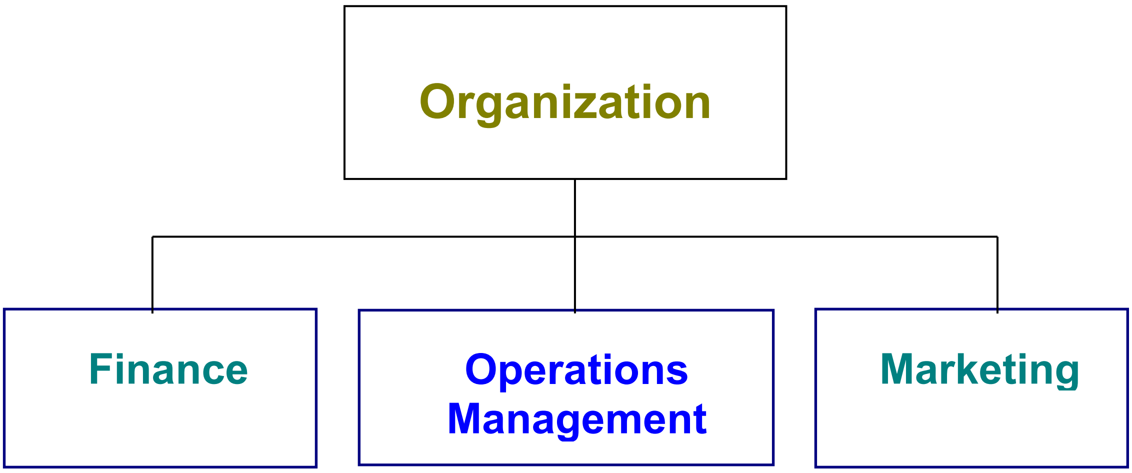


Figure 1.2 Major Functions of Business Organisations

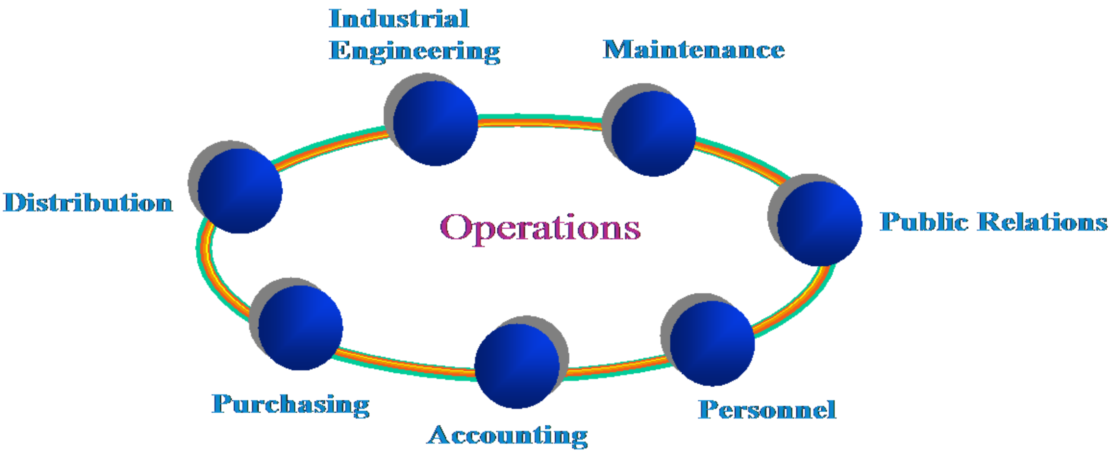


Figure 1.3 Support Functions Interfacing with Operations

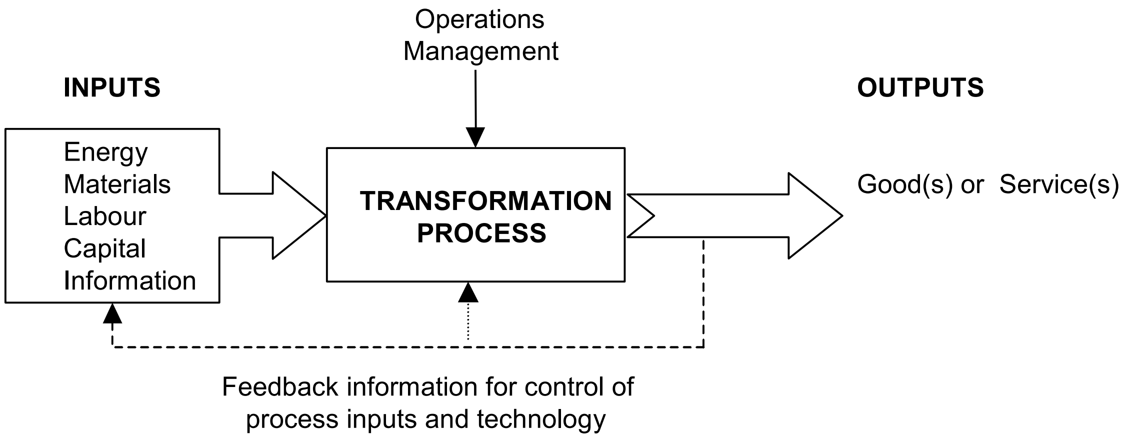
Although operations is the central function or the 'hub' of the organisation in contact with every functional area, the degree of overlap (the boundaries) between these functions vary from organisation to organisation. Depending on the organisation, operations might be responsible for developing products and/or services, choosing process technologies, devising delivery schedules, buying in materials, buying in services, originating budgets, recruiting and training staff.

The functional structure of organisations is a human creation. An alternative way however is to look at processes and examine the organisation in terms of the flows of information and materials within it, or the configuration of resources combined for the provision of good and services.

The Input-Transformation-Output Process Model

The essence of the operations is to *add-value* during the transformation process. Value-added is the term used to describe the difference between the cost of inputs and the value or price of outputs. In the general input-transformation-output model shown in Figure 1.4, inputs (such as capital, materials, machines, labour, data) are transformed into outputs (goods, services, profit, losses).

The output of an operation can usually be classified on a spectrum ranging from pure goods to pure services. Most operations produce either goods, which are accompanied by facilitating services, or services, which are accompanied by facilitating goods. Operations take inputs, transform them, or use them to transform something else, thereby producing outputs, which are of a higher value than the inputs (see Figure 1.4). Requirements and feedback from customers are used to adjust factors in the transformation process, which may in turn alter inputs. The challenge for operations management is to ensure that the transformation process is performed efficiently and that the output is of greater *value* than the sum of the inputs. The role of the operations is to create value. The transformation process itself can be viewed as a series of activities along a *value chain* extending from supplier to customer. Any activities that do not add value are superfluous and should be eliminated.



can be either transforming or transformed resources. Transforming resources include facilities and staff. Transformed resources include materials, information and customers.

The transformation process varies depending on the transformed resources. If the transformed resource is materials then the transformation process might be concerned with physical properties, location (parcel delivery), or possession (retail store). If the transformed resource is information then the transformation process might be concerned with information properties (accounting), possession (marker research), store (library), or location (telecommunications). If the transformed resource is a customer then the transformation process might be concerned with physical properties (cosmetic surgeon), store (hotel), location (airline), physiological state (hospital), or psychological state (theatre).

The output of operations also differ in terms of their:

- **Tangibility** – can you physically touch the product or service? Goods are usually tangible; services are not.
- **Storability** – can you store the product or service? Good are usually stored; services cannot.
- **Transportability** – can you transport the product or service from one location to another? Goods can usually be transported; services cannot.
- **Simultaneity** – when are the products and/or services produced? Goods are usually produced prior to customer receiving them. Services are often produced simultaneously to their consumption.
- **Customer contact** – customers usually have low contact with organisations producing goods and high contact with organisations providing services.
- **Quality** – how do customers judge the quality of the goods or services they received? As customers do not normally see goods being produced, they will tend to judge the quality of an operation producing goods by the quality of the goods themselves. As customers are intimately involved in the provision of services, they will tend to judge the quality of an operation providing services by looking at both the actual service and the way in which it is delivered.

Activity 1.2 - CASE PROBLEM

Value-Added Operations at Lands' End

Lands' End, headquartered in Dodgeville, Wisconsin, is the largest speciality catalogue company in the United States. The company's products include casual and tailored clothing for men, women, and children, shoes and accessories, soft luggage, and items for bedrooms and bathrooms. Fast, efficient operations allow Lands' End to offer convenient at-home shopping of quality merchandise at competitive prices.

Lands' End catalogues are known for descriptive product narratives that tell customers everything they could want to know about a garment and its construction. The company's toll-free phone lines for sales and customer service are open twenty-four hours a day, 364 days a year. More than 1,000 phone lines handle about 50,000 calls each day--almost 100,000 calls daily in the weeks prior to Christmas. Eighty-five percent of all orders are placed by phone.

In-stock orders leave Lands' End's Dodgeville distribution Center (a structure the size of sixteen football fields) the day after they are received. Standard delivery is two business days anywhere within the continental United States. Lands' End works directly with some of the best fabric mills and manufacturers in the world. Garments are produced to Lands' End's own quality specifications, not to less stringent industry-wide specifications. In addition to its booming U.S. business, the company now does business in 75 countries, with facilities or special licensing agreements in Canada, the United Kingdom, Japan, and Germany. The Land's End philosophy is outlined in its eight "Principles of Doing Business."

Principle 1: We do everything we can to make our products better. We improve material, and add back features and construction details that others have taken out over the years. We never reduce the quality of a product to make it cheaper.

Principle 2: We price our products fairly and honestly. We do not, have not, and will not participate in the common retailing practice of inflating mark-ups to set up a future phoney "sale."

Principle 3: We accept any return, for any reason, at any time. Our products are guaranteed. No fine print. No arguments. We mean exactly what we say: GUARANTEED, PERIOD.

Principle 4: We ship items in stock the day after we receive the order. At the height of the last Christmas season, the longest time an order was in the house was 36 hours, excepting monograms, which took another 12 hours.

Principle 5: We believe that what is best for our customer is best for all of us. Everyone here understands that concept. Our sales and service people are trained to know our products and to be friendly and helpful. They are urged to take all the time necessary to take care of you. We even pay for your call, for whatever reason you call.

Principle 6: We are able to sell at lower prices because we have eliminated middlemen; because we don't buy branded merchandise with high protected mark-ups; and because we have placed our contracts with manufacturers who have proved that they are cost conscious and efficient.

Principle 7: We are able to sell at lower prices because we operate efficiently. Our people are hard-working, intelligent, and share in the success of the company.

Principle 8: We are able to sell at lower prices because we support no fancy emporiums with their high overhead. Our main location is in the middle of a 40-acre cornfield in rural Wisconsin.

Activity 1.2

In groups of three attempt to answer the following questions:

Think about the operations function at Lands' End. What is involved in the transformation process? How does the company "add value" for its customers?

Examine Lands' End's eight principles for doing business. What image is the company trying to portray? What specific activities support the image?

Gather information on Lands' End's competitors, L. L. Bean and Eddie Bauer. Are there any obvious differences in their competitive strategies? Describe the global activities of each company.

Source: Prentice-Hall. "A Brief History of Lands' End." On Location at Lands' End Video Series. Video 4.1– CD in Operations Management (Russell & Taylor, 2000); ISBN 0-13-086959-7.

Macro and Micro Operations

The input-transformation-output model can be used to describe macro and micro operations. All operations consist of micro operations, each of, which produces outputs by taking inputs and transforming them, or using them to transform something else. An example of macro operations that are made up of many micro operations is shown in model of Figure 1.5. This input-transformation-output model can be extended to the level of the individual.

There are two important implications of this model. *First*, the input-transformation-output model makes explicit the fact that other parts of the organisation can be viewed as 'operations' and hence some tools and techniques of operations management might be applied elsewhere in the organisation. *Second,* the input-transformation-output model underpins the concept of the internal customer-supplier. Each micro operation is a customer of, and a supplier to, another micro operation. Therefore, the organisation as a whole is made up of a network of internal customers and suppliers. (Note: internal customers and suppliers do not operate in a free market.)

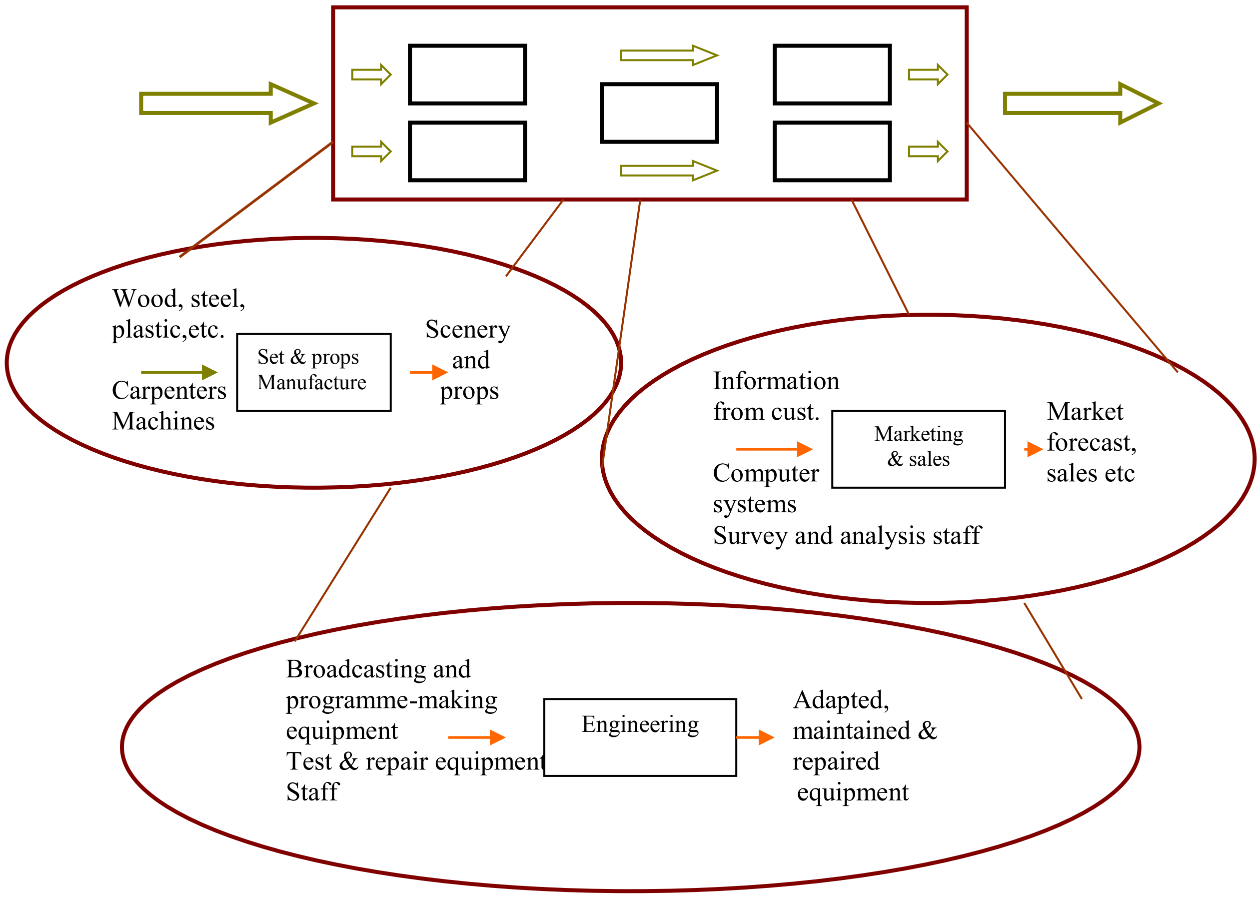


Figure 1.5 **Macro/Micro Operations Model**

Adopted from Slack et al. (2000: 17)

Buffering the Operation against Environmental Uncertainty

Often operations exist in turbulent environment. So for operations to be efficient and stable buffering is required against environment uncertainty. This can be achieved through;

- Physical buffering – keeping an inventory or safety stock of resources either at the input or the output side of the transformation process (see Figure 1.6).
- Organisational buffering – allocating responsibility so that the operations function is protected from the external environment by the other functions.

Figure 1.6 **Physical Buffering**

Is buffering an appropriate practice for operations management?

Although till recently, maintaining buffering was the way of running operations, in today's environment buffering is being criticised for the following reasons:

- Operations never develop an understanding of the environment which would help it exploit new development.
- An operation is never required to take responsibility for its action. Always there is another function to blame resulting in conflict between functions.
- Physical buffering often requires large stocks of input or output resources, which are both expensive (think of the opportunity cost) and prevent operations of achieving continuous improvement (think of the KAIZEN and Just-in-Time philosophies).
- Physical buffering in customer processing operations means making the customer waits for the service, which could lead to customer dissatisfaction.

The above reasons have encouraged successful organisations to move towards exposing the operations function to environmental turbulence through the reduction or even elimination of safety stock.

The Many Different Types of Operations

Although all goods and services are produced via the transformation process (input-transformation-output mode), and operation can be categorised using four dimensions, namely, output volume; output variety, variation in demand and degree of customer contact.

High output volumes result in operations which:
- involve highly repetitive tasks;
- are easy to specialise;
- are easy to systemise
- are highly capital intensive;
- have low unit costs.

High output variety results in operations which:
- need to be flexible;
- are complex;
- provide a service which has to be closely matched to customer needs;
- have high unit costs.

High variation in demand results in operation which:
- need to be flexible;
- have to anticipate future demand;
- have to be able to change their capacity.

High customer contact results in operation which:
- need to be able t offer fast service as waiting tolerance is likely to be low;
- use customer perception to measure performance;
- need skilled staff.

Often operations with high customer contact have *back-office* as well as *front-office* jobs. Back-office activities are those that are done behind the scenes and they involve little direct customer contact. For example, in an airport the *back-office* activities are those of baggage handling; overnight freight delivery; ground crew putting meals on board and refreshing the aircraft; cooking and administration. On the other hand, *front-office* activities are those of catering (meals and drinks) on board; answering people's questions; passport control; checking documentation and baggage; and ticketing travellers.

The Activities of Operations Managers

The operations manager is the key figure in the operations system: he or she has the responsibility for the creation of goods and the provision of services. The kinds of jobs that operations managers oversee vary tremendous from organisation to organisation due to the different products or services involved. Thus managing an insurance company operation requires different skills and experience than managing an aircraft manufacturing operation. However, in a very important respect, the jobs are essentially *managerial* and generally the activities of operations managers fall into two categories. These are those the operations manager has indirect responsibility for and those the operations manager has direct responsibility for.

Activities which operations managers have indirect responsibility for include:

- informing other functions of the opportunities and constraints provided by the operation's capabilities;
- discussing with other functions how operations plans and their own plans might be modified to the benefit of both functions;
- encouraging other functions to suggest ways in which the operations function can improve the service it provides to the rest of the organisation;

Activities which operations managers have direct responsibility for include:

Understanding operations strategic objectives which involves:

- developing a clear vision which explains how the operations function can help the organisation achieve its long-term goals;
- translating these goals into explicit performance objectives for operations.

In order for operations managers to manage all the activities of an operations system, which converts inputs into the organisation's products and services, they should be able to make decisions for all the activities that involve in the operation system. Classifying operations management decisions is difficult, but in my experience as an operations manager for 20 years and the experiences of others, decisions tended to fall into three general catagories, namely, *strategic*; *operating*; and *control*; decisions.

Strategic decisions concern operations strategies and the long-range game plan for the organisation. These decisions are so important that typically people from the major functions (i.e., operations, marketing, accounting and finance, product and/or service development) and the support functions (i.e., human resources, purchasing, maintenance, engineering) get together to study the business opportunities carefully and arrive at a decision that puts the organisation in the best position for achieving its long-term goals. Examples of these decisions are:

- deciding whether to launch a new-product development project;
- deciding on the organisation's products, processes and services;
- deciding how to allocate scarce raw material, utilities, production/service capacity, and personnel among new and existing business opportunities (deciding for the optimal distribution of scarce resources among product line or business units);
- deciding on the new facilities (factories, offices, etc) that are needed, and
- deciding where to locate them.

Operating decisions must resolve all the planning issues related to the delivery of products and services to meet customer's demands. The principal responsibility of operations is to take the orders for products and services from customers, which the marketing function has generated, and deliver products and services in such a way that there are *satisfied customers* at reasonable costs. Carrying out this responsibility, a number of decisions should be made, such as:

- deciding on the amount of inventory that has to be carried; (Note: there is a minimum inventory necessary to keep a perfect system running.)
- deciding on the amount of overtime (extra capacity) required to meet customer's demand, or whether to subcontract some products or services;
- deciding about planning and controlling the production of services;
- deciding on the materials management techniques to be used and designing a detail plan for purchasing raw materials to support next month's products and services.

Control decisions are concerned with a variety of problems in operations. The facts of life for operations managers are that their workers do not always perform as expected, product and service quality can vary, and equipment can break down and usually does when it is least expected. Operations managers engage in planning, analysing, and controlling activities so that poor workers performance, inferior product/service quality, and excessive equipment (machine, systems, etc) breakdowns do not interfere with the profitable operation of the organisation. Examples of this type of decision are:

- deciding what to do about a department's failure to meet the planned labour cost target;
- developing labour cost standards for a revised product or service design that is about to go ahead;
- deciding what the new quality acceptance criteria should be for a product or service that has had a change in design;
- deciding how often to perform preventive maintenance on the facilities and resources (key machines/systems/equipment) for the delivery of products or services.

The Strategic Role and Objectives of Operations

The principal role of operations is to produce the goods and services demanded by the organisation's customers. But this is not all an operations function does.

Operations must **help implement** the business strategy, a strategy that starts as a statement of intend and only comes into being as decisions are made and actions are taken. Because operations are usually accountable for the majority of an organisation's resources, for a strategy to be implemented requires the operation's resources to be deployed in a consistent matter over an extended period of time.

Operations **must support** the business strategy by ensuring that its technology, people, systems, procedures, etc are capable and available when needed to achieve its strategic objectives.

Operations **should drive** the business strategy by giving it a long-term competitive advantage via listening to the 'voice' of the customers, thereby delivering high quality products and services, and achieving on time delivery.

In summary, Slack et al. (1988) suggested that operations have three distinct roles that are associated with business strategy:

(a) 'implementer' of strategy (operations as effector);

(b) 'support'of strategy (operations as follower);

(c) 'driver' of strategy (operations as leader).

How the Contribution of Operations Can Be Assessed

Professor's Hayes and Wheelwright, of Harvard Business School, provide a useful model made up of four stages for assessing the contribution of the operations in organisations. The model can be used in two ways. *Firstly*, members of the operations can be asked what are their aspirations; and *secondly*, members of other major functions can be asked how they see operations. With these inputs, the model can trace the progression of operations in a continuum from the very poor level of contribution (Stage 1) to the one which is creative and proactive and is becoming central to strategic thinking (Stage 4). Scholars and operations managers to describe the operation's strategic development use the four stages of Hayes and Wheelwright's (1984) model.

For stage 1 organisations, the objective is to minimise any negative impact of operations. In stage 1 organisations:

- external 'experts' will be used to make decisions of strategic importance to operations;
- internal management control systems will be used to monitor operational performance;
- operations will be encouraged to be flexible and reactive.

For stage 2 organisations, the objective is for operations to help the business maintain parity with its competitors. In stage 2 organisations:

- industry practice will be followed;
- the planning horizon for operations investment will be extended so that it incorporates a single business cycle;
- capital investment will be seen primarily as a way of catching up with the competition.

For stage 3 organisations, the objective is for operations to provide credible support for the business strategy. In stage 3 organisations:

- operations investments will be screened for consistency with the business strategy;
- the implications for operations of changes in business strategy will be considered;
- a systematic approach to the long-term development of the operations function will be adopted.

For stage 4 organisations, the objective is for operations to provide a source of competitive advantage. In stage 4 organisations:

- efforts will be made to anticipate the potential of new operations practices and technologies;
- operations will involved in major marketing and engineering decisions;
- long-range programs will be pursued in order to acquire capabilities in advance of needs.

Finally, Hayes and Wheelwright's four stages model for assessing the contribution of the operations in an organisation can be depicted in the matrix of Table 1.2 below.

Table 1.2 Matrix Assessing the Contribution of the 'Operations'

	Neutral	**Supportive**
Internally	**Stage 1** Objective is to minimise any negative impact of 'operations'	**Stage 3** Objective is for 'operations' to provide credible support for the business strategy
Externally	**Stage 2** Objective is for 'operations' to help the business maintain parity with its competitors	**Stage 4** Objective is for 'operations' to provide a source of competitive advantage

The Meaning of the Five Performance Objectives – The Benefits of Excelling at the Performance Objectives

According to Slack et al. (1998: 51) an operation in an organisation “contributes to achieving an operations-based advantage through five ‘performance objectives’”, namely, quality; speed; dependability; flexibility; and cost.
Quality – doing things right: That is providing error-free goods and services, which are fit, for their purposes. In many operations quality is the most visible performance objective as it is relatively easy for customers to judge.

In terms of the external benefit, by providing ‘error-free’ products and services enhances customer satisfaction. Internally, quality reduces costs and increases dependability. In other words, an organisation does not have to spend money to rectify mistakes.

Speed – doing things fast: By doing things fast an operation minimises the time between the customer asking for and receiving the goods and/or services. The faster an organisation can deliver a particular product or service the less likely a customer is to go to the competitor.

In terms of the external benefit, speed means delivering products and services fast, and hence increasing their availability. Internally, doing things fast reduces inventories, eliminates queues and reduces risk of obsolescence.

Dependability – doing things on time: Doing things on time involves delivering promises. To be dependable organisations must be able to estimate delivery dates accurately, communicate them to the customer, and deliver when promised.

By delivering products and services on time an organisation meets its commitment to customers and hence enhancing customer satisfaction (external benefit). Internally, delivering products and services on time minimises disruptions, which often cost money and waste time. Thus, dependability saves money, time and provides stability.

Flexibility – being able to change what you do: That is adapting the operation’s activities to change. The advantage of flexibility is that it helps the organisation to cope with unexpected circumstances. This performance objective could mean two things. a) being able to change fast enough and b) being able to change far enough. Flexibility could also be viewed as:

- product/service flexibility – being able to offer a wide range of products and services;
- mix flexibility – being able to change the mix of products and services offered;
- volume flexibility – being able to change the volume of products made;
- delivery flexibility – being able to cope with changing customer demands in terms of due dates.

Being able to change fast enough and far enough means that an organisation can cope with changing customer demands, hence the benefit comes from enhanced customer satisfaction (external benefit). As known, changing demands always causes problems, and being flexible means that an organisation is able to absorb some of these easily and early. By being flexible than an organisation can benefit internally through a quick response to change and by saving money.

Cost – doing things at low cost: By definition every customer wants products and services at low cost. In many ways cost is the most important performance objective. Achieving low costs involves the correct mix of staff, facilities, materials, technology and processes.

By being able to create products and services at low cost means that an organisation can offer these to the market at a price it will bear, while still achieving a return on investment that would satisfy shareholders (external benefit).

Internally, quality operations do not waste time or effort having to re-do things nor are their internal customers inconvenienced by flawed services. Hence high quality could result in low costs. Fast operations reduce the level of work-in-process (inventory) between the micro operations as well as reducing the administrative overheads. Both effects can reduce the overall operating cost. Dependable operations do not spring any unwelcome surprises an their internal customers. This eliminates wasteful disruption and allows the other micro operations to operate efficiently. Flexible operation adapts to changing circumstances quickly and without disrupting the rest of the operation. Also flexible operations can change over between tasks quickly and without wasting time and capacity resulting in low costs.

Complete the following questions:

TRUE/FALSE QUESTIONS

1. An example of inputs in a transformation process is goods and services. **False**

2. Since service organisations such as barber shops and hospitals do not produce a product, the principles of operations management do not apply. **False**

3. The three primary functions of a firm are production, finance, and accounting. **False**

4. Of the three primary functions of a firm, operations typically has the largest investment in assets. **True**

5. In operations management, we try to ensure that the transformation process is performed efficiently. **True**

6. In operations management, we try to ensure that the transformation process' output is of greater value than the sum of the input. **True**

7. Any activities that do not add value during the transformation process are needed. **False**

8. Any activities that do not add value during the transformation process should be eliminated. **True**

9. The process chosen to provide the product or service need not be consistent with the product or service characteristics. **False**

10. Compete on speed, companies must expect radical change. **True**

11. Operating systems execute strategic decisions on a day-to-day basis.

True

MULTIPLE CHOICE QUESTIONS

1. Activities in operations management include all of the following except

a) arranging work

b) controlling quality

c) establishing demand

d) managing inventory

2. In operations, the transformation process can be

a) physical

b) locational

c) psychological

d) all of the above

3. Which activity is not part of operations?

a) location of facilities

b) financial control

c) inventory control

d) arrangement of plant layout

4. Which of the following is not an input to the transformation process?

a) material

b) machines

c) services

d) labour

5. The transformation process in the communications industry is typically __________.

a) physical

b) physiological

c) psychological

d) informational

6. Operations management can
   a) reduce cost
   b) increase sales
   c) gain market share
   d) all of the above

7. Strategic decisions in operations can involve
   a) products and services
   b) capacity and facilities
   c) quality
   d) all of the above

8. Forming alliances is one of the most effective ways of competing on
   a) cost
   b) quality
   c) speed
   d) flexibility

9. Competing on quality requires
   a) a commitment from everyone in the company
   b) defining quality as a comparison with the competition
   c) the marketing strategy identify the product as "quality"
   d) all of the above

10. A positioning strategy should consider
   a) the strengths of the organisation
   b) the needs of the marketplace
   c) the position of the competition
   d) all of the above

SHORT-ANSWER QUESTIONS

1. What constitutes "operations" at (a) a bank, (b) a retail store, (c) a hospital, (d) a cable TV company, (e) an internet provider firm?

2. Fully describe how operations have been affected as we have moved from the Industrial Revolution to the current era of globalisation.

3. Discuss the requirements from an operations perspective of competing on (a) quality, (b) speed, (c) dependability, (d) flexibility, and (e) cost. Give examples of manufacturing or service firms that successfully compete on each of the criteria listed.

4. What role should operations play in corporate strategy?

5. Name several strategic decisions that involve the operations management.

6. Many organisations see the role of operations as getting on with the job of making products or serving customers. Discuss the implications of this view of the operations function.

Summary

This topic provided an introduction to operations management. In particular it focussed on the strategic importance of operations management and how operations management can provide a competitive advantage in the market place.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic establishes the context for the rest of the module?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your understanding. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember if you need assistance in your study, the faculty is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Introduction to operations management

- ☐ Definitions
- ☐ Historical foundations

Strategy and role of operations management

- ☐ The role of operations manager
- ☐ Position of operations in organisations
- ☐ The input-transformation-output process model
- ☐ Macro and micro operations
- ☐ Types of operations
- ☐ The strategic role of operations
- ☐ Contribution of operations and its assessment
- ☐ The meaning of five performance objectives
- ☐ The benefits of excelling all the performance objectives

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this topic with the lecturer or another student.

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Operations Management

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Operations Management

Text Book & Participant Workbook

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Table of contents

Chapter 1

Chapter 1

The strategic role and objectives of Operations Management

Learning outcomes

By successfully achieving the stated ‘enabling objectives’ for this topic, you should be able to:

- develop an understanding of the strategic importance of operations and how operations can provide a competitive advantage in the marketplace.

- understand the relationship between operations and other business functions, such as Marketing, Finance, Accounting, Engineering/Technical, Purchasing, and Human Resources.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcomes stated above.

- Identify the strategic role of operations management in the running of organisations
- Understand operations as a Transformation Process
- Be familiar with the “characteristics” used to distinguish different operations
- Recognise the activities of operations management
- Understand the nature of the five performance objectives – quality, speed, dependability, flexibility and cost; and the internal and external benefits which an operation can derive from excelling in each of its objectives
- Appreciate the role the operations play in achieving strategic success

What you will need

Suggested study time	Study Guide	3 hours
	Activities and exercises	2 hours
	Text Book	2 hours
	Total	7 hours

Other resources:	Suggested readings

Introduction

Operating a large amusement park, such as Disney's Epcot Center, is every bit as complicated as manufacturing an aircraft carrier. Thousands of activities must be co-ordinated on a daily basis. Equipment must be well-maintained, workers well-trained, and shelves well-stocked, while keeping costs down. On top of this, services typically deal with more customers (each with their own service expectations) more frequently than manufacturers, and handle more unexpected occurrences. Maybe that's why GM, Xerox, IBM and other organisations routinely benchmark Disney operations.

Welcome to the study of operations management. Around the world and in the UAE in particular traditionally operations managers are "trained" rather than "educated". Service and manufacturing organisations prefer that their staff are given "on the job" training in preference to other forms of training or education. The end result is that UAE management has a number of deficiencies, and operations management is one of the most serious. While other areas are important, there seems to be an overwhelming emphasis on the financial, marketing and human resource management areas. A poll I carried out over the last year with students from Dubai Men's college showed that students have a greater familiarity with these areas, knowing what is studied in the relevant courses, and knowing fairly accurately the role of the manager in each of these areas. However, when we consider the operations management area the results showed that an operations manager is one who deals only with engineering or design and development or managing blue-collar workers, and has been trained "on the job" to take on the role of manager.

While it appears that the UAE student does not know the role of operations manager fairly accurately, over the last five years organisations realised the importance of "educated" operations managers. Companies such as Etisalat, Dubal , DEWA, Dubai Ports, Emirates Airlines, Department of Civil Aviation, Airforce, and Emirates Internet & Multimedia are sending their managers to business colleges to study in what college course catalogues call operations management. It is now not uncommon for operations management to be a compulsory unit in undergraduate management courses. Wickham Skinner, of the Harvard Business School, believes that the skills and knowledge of operations managers in industry must be improved. He urges CEO's to upgrade their operations managers and give them latitude to handle the entirely new set of challenges arising from global competition and new technologies (Skinner, 1988).

In the 21st century, the effective management of operations - using concepts such as the extended value chain, total quality management, quality function deployment, process reengineering, concurrent engineering, benchmarking and business process problem solving, flexibility and economies of scope – will be the key source of competitive advantage. If this course results in you becoming a better-educated operations manager or a better-informed non-operations manager we will have achieved our objective. To understand better the role of operations and the operations manager it is important to be aware of some historical events in operations management.

A brief history

The history of production and hence operations systems goes back to the ancient times of the Great Wall of China, the Egyptian pyramids, the Athenian Parthenon, and the roads and aqueducts of Rome. In the modern sense, however, operations management has its roots in the Industrial Revolution. From the Industrial Revolution of the 1760s through to Globalisation and the Internet of the 1990s the field of operations is rapidly changing and growing in importance. The manager of operations is confronted with intense competition, global markets, global sourcing, product and service variety, mass customisation, advances in technology, worker involvement, and environment and ethical concerns. These are some of the reasons why operations management is such an exciting discipline. For the benefit of the future operations managers and better informed non-operations managers the players and events in operations management are summarised in Table 1.1 below.

Table 1.1 Some Historical Events in Operations Management

Era	Events/Concepts	Dates	Originator
Industrial Revolution	Steam engine	1769	James Watt
	Division of labour	1776	Adam Smith
	Interchangeable parts	1790	Ali Whitney
Scientific Management	Principles of scientific management	1911	Fred Taylor
	Time and motion studies	1911	Frank & Lillian Gilbreth
	Activity scheduling chart	1912	Henry Gantt
	Moving assembly line	1913	Henry Ford
Human Relations	Hawthorne studies	1930	Elton Mayo
	Motivation theories	1940s	Abraham Maslow
		1950s	Fred Herzberg
		1960s	Douglas McGregor
Management Science	Linear programming	1947	George Dantzig
	Digital computer	1951	Remington Rand
	Simulation, waiting line theory, decision theory, PERT/CPM	1950s	Operations research groups
	MRP	1960s	Joseph Orlicky, IBM
Quality Revolution	JIT (just-in-time)	1970s	Tsiichi Ohno, Toyota
	TQM (total quality management)	1980s	Edward Deming, Joseph Juran
	Strategy and operations		Wickham Skinner, Robert Hayes
	Business process reengineering	1990s	Michael Hammer, James Champy

Adopted from Russell and Taylor III (2000: 9).

Let’s examine some definitions of operations management.

Definitions of Operations Management

A review of the literature revealed that the definitions of operations management closely reflect the diverse nature of activities to which its concepts and techniques are applied.

Wild (1995: 7) defines operations management in the following terms:

“Operations Management is concerned with the design and the operation of systems for manufacture, transport, supply or service”.

Gaither (1996: 4) includes the term of ‘production’ in his definition. For Gaither production and operations management (POM) is:

“the management of an organisation's production system, which converts inputs into the organisation’s products and services”.

Stevenson (1999: 4) defines operations management as:

“the management of systems or processes that create goods and/or provide services”.

Heizer and **Render** (1999: 4) define operations management as transformation process.

“Operations Management is the set of activities that creates goods and services through the transformation of inputs into outputs”.

Slack et al. (2000: 6) distinguishes operations management from operations function. For Slack et al. **operations function** of the organisation is:

"the arrangement of those resources which are devoted to the production and delivery of its products and services".

Operations management is the term which, is used for the activities, decisions and responsibilities of operations managers who manage the arrangement of resources which, are devoted to the production of goods and services within an organisation.

Russell and Taylor (2000: 5) emphases that "operations management designs and operates productive systems – systems for getting work done" and distinguish the term operations as:

"a function or system that transforms inputs into outputs of greater value".

Activity1.1

Provide workplace examples for each of the above definitions of operations management. Which of the above definitions would you expect to be the most suitable for your organisation? Explain.

What is Operations Management?

Operations management deals with the production of goods and services that we buy and use every day. Generally, it is the process that enables organisations to achieve their goals through efficient acquisition and utilisation of resources. Every organisation, whether public or private, manufacturing or service, has an operations function. The management of operations is the focus of this course.

Operations managers organise the production and delivery of the goods and services we all use. To understand operations management we need to understand:

- that operations is 'the arrangement of resources which are devoted to the production of goods and services';
- that an operations manager is 'a member of the organisation who has the responsibility for managing some, or all, of the resources that comprise the operations function';
- that operations management is 'the term used to describe the activities, decisions and responsibilities of an operations manager'.

Operations managers have to ensure that the resources are used efficiently so that **today's** customers can be satisfied and **today's** competitors can be beaten. He or she also has to find ways of using resources more efficiently so that **tomorrow's** customers can be satisfied and **tomorrow's** competitors can be beaten.

The Position of Operations in the Organisation

Most organisations consist of two types of functions. 1) Major functions such as operations, marketing, accounting and finance, product and/or service development; and 2) Support functions such as human resources, purchasing, maintenance, engineering, etc. The basic (major) functions of business organisations are shown in Figure 1.1, while the operations interfaces with a number of supporting functions are shown in Figure 1.2.

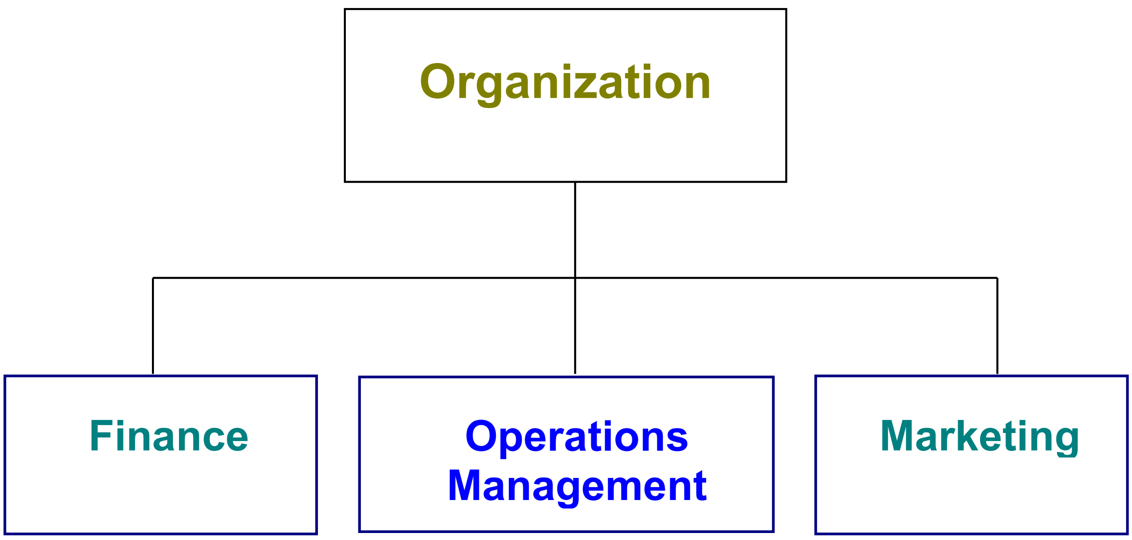

Figure 1.1

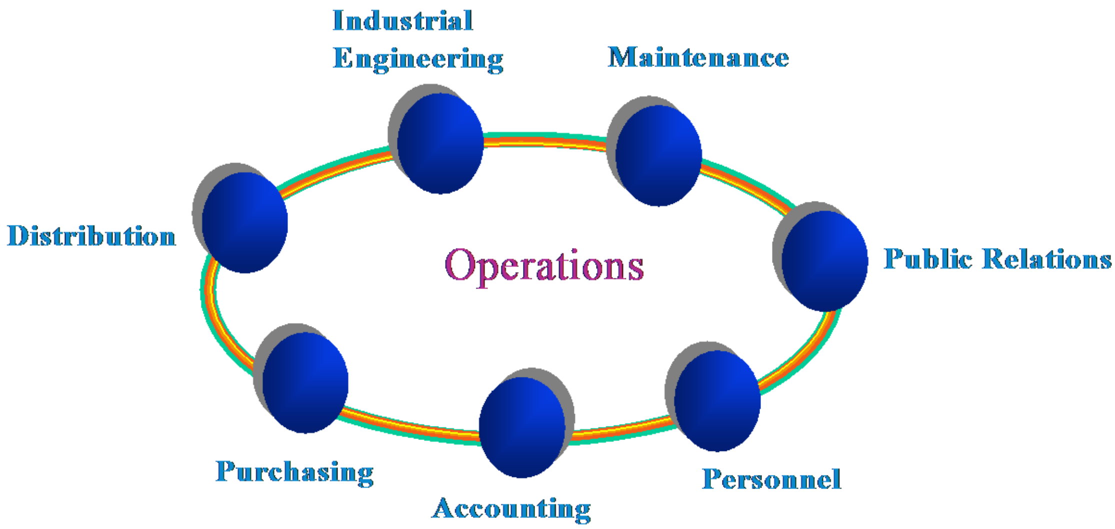

Figure 1.2

Although operations is the central function or the 'hub' of the organisation in contact with every functional area, the degree of overlap (the boundaries) between these functions vary from organisation to organisation. Depending on the organisation, operations might be responsible for developing products and/or services, choosing process technologies, devising delivery schedules, buying in materials, buying in services, originating budgets, recruiting and training staff.

The functional structure of organisations is a human creation. An alternative way however is to look at processes and examine the organisation in terms of the flows of information and materials within it, or the configuration of resources combined for the provision of good and services.

The Input-Transformation-Output Process Model

The essence of the operations is to *add-value* during the transformation process. Value-added is the term used to describe the difference between the cost of inputs and the value or price of outputs. In the general input-transformation-output model shown in Figure 1.3, inputs (such as capital, materials, machines, labour, data) are transformed into outputs (goods, services, profit, losses).

The output of an operation can usually be classified on a spectrum ranging from pure goods to pure services. Most operations produce either goods, which are accompanied by facilitating services, or services, which are accompanied by facilitating goods. Operations take inputs, transform them, or use them to transform something else, thereby producing outputs, which are of a higher value than the inputs. Requirements and feedback from customers are used to adjust factors in the transformation process, which may in turn alter inputs. The challenge for operations management is to ensure that the transformation process is performed efficiently and that the output is of greater *value* than the sum of the inputs. The role of the operations is to create value. The transformation process itself can be viewed as a series of activities along a *value chain* extending from supplier to customer. Any activities that do not add value are superfluous and should be eliminated.

At a *macro* level all operations conform to the input-transformation-output model described above. At the *micro* level differences can be observed. Depending on the operation the inputs can be either transforming or transformed resources. Transforming resources include facilities and staff. Transformed resources include materials, information and customers.

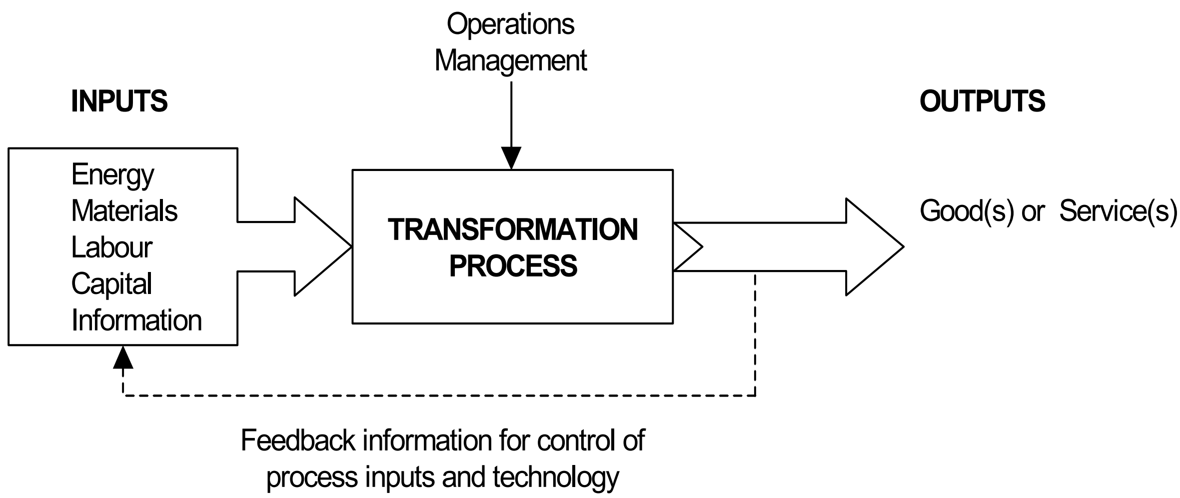

Figure 1.3

The transformation process varies depending on the transformed resources. If the transformed resource is materials then the transformation process might be concerned with physical properties, location (parcel delivery), or possession (retail store). If the transformed resource is information then the transformation process might be concerned with information properties (accounting), possession (marker research), store (library), or location (telecommunications). If the transformed resource is a customer then the transformation process might be concerned with physical properties (cosmetic surgeon), store (hotel), location (airline), physiological state (hospital), or psychological state (theatre).

The output of operations also differ in terms of their:

- **Tangibility –** can you physically touch the product or service? Goods are usually tangible; services are not.
- **Storability –** can you store the product or service? Goods are usually stored; services cannot.
- **Transportability –** can you transport the product or service from one location to another? Goods can usually be transported; services cannot.
- **Simultaneity –** when are the products and/or services produced? Goods are usually produced prior to customer receiving them. Services are often produced simultaneously to their consumption.
- **Customer contact –** customers usually have low contact with organisations producing goods and high contact with organisations providing services.
- **Quality –** how do customers judge the quality of the goods or services they received? As customers do not normally see goods being produced, they will tend to judge the quality of an operation producing goods by the quality of the goods themselves. As customers are intimately involved in the provision of services, they will tend to judge the quality of an operation providing services by looking at both the actual service and the way in which it is delivered.

Activity1.2 - CASE PROBLEM

Value-Added Operations at Land's End

Land's End, headquartered in Dodgeville, Wisconsin, is the largest specialty catalogue company in the United States. The company's products include casual and tailored clothing for men, women, and children, shoes and accessories, soft luggage, and items for bed and bath. Fast, efficient operations allows Land's End to offer convenient at-home shopping of quality merchandise at competitive prices.

Land's End catalogues are known for descriptive product narratives that tell customers everything they could want to know about a garment and its construction. The company's toll-free phone lines for sales and customer service are open twenty-four hours a day, 364 days a year. More than 1,000 phone lines handle about 50,000 calls each day--almost 100,000 calls daily in the weeks prior to Christmas. Eighty-five percent of all orders are placed by phone.

In-stock orders leave Land's End's Dodgeville distribution Center (a structure the size of sixteen football fields) the day after they are received. Standard delivery is two business days anywhere within the continental United States. Land's End works directly with some of the best fabric mills and manufacturers in the world. Garments are produced to Land's End's own quality specifications, not to less stringent industry-wide specifications. In addition to its booming U.S. business, the company now does business in 75 countries, with facilities or special licensing agreements in Canada, the United Kingdom, Japan, and Germany. The Land's End philosophy is outlined in its "Principles of Doing Business."

Principle 1: We do everything we can to make our products better. We improve material, and add back features and construction details that others have taken out over the years. We never reduce the quality of a product to make it cheaper.

Principle 2: We price our products fairly and honestly. We do not, have not, and will not participate in the common retailing practice of inflating mark-ups to set up a future phoney "sale."

Principle 3: We accept any return, for any reason, at any time. Our products are guaranteed. No fine print. No arguments. We mean exactly what we say: GUARANTEED, PERIOD.

Principle 4: We ship items in stock the day after we receive the order. At the height of the last Christmas season, the longest time an order was in the house was 36 hours, excepting monograms, which took another 12 hours.

Principle 5: We believe that what is best for our customer is best for all of us. Everyone here understands that concept. Our sales and service people are trained to know our products and to be friendly and helpful. They are urged to take all the time necessary to take care of you. We even pay for your call, for whatever reason you call.

Principle 6: We are able to sell at lower prices because we have eliminated middlemen; because we don't buy branded merchandise with high protected mark-ups; and because we have placed our contracts with manufacturers who have proved that they are cost conscious and efficient

Principle 7: We are able to sell at lower prices because we operate efficiently. Our people are hard-working, intelligent, and share in the success of the company.

Principle 8: We are able to sell at lower prices because we support no fancy emporiums with their high overhead. Our main location is in the middle of a 40-acre cornfield in rural Wisconsin.

Activity1.2

In groups of three attempt to answer the following questions:

Think about the operations function at Land’s End. What is involved in the transformation process? How does the company "add value" for its customers?

Examine Land’s End's eight principles for doing business. What image is the company trying to portray? What specific activities support the image?

Gather information on Land’s End's competitors, L. L. Bean and Eddie Bauer. Are there any obvious differences in their competitive strategies? Describe the global activities of each company.

Source: Prentice-Hall. "A Brief History of Land’s End." On Location at Land’s End Video Series. Video 4.1– CD in Operations Management (Russell & Taylor, 2000); ISBN 0-13-086959-7

Macro and Micro Operations

The input-transformation-output model can be used to describe macro and micro operations. All operations consist of micro operations, each of, which produces outputs by taking inputs and transforming them, or using them to transform something else. An example of macro operations that are made up of many micro operations is given by Slack et al. (2000: 17). This input-transformation-output model can be extended to the level of the individual.

There are two important implications of this model. *First*, the input-transformation-output model makes explicit the fact that other parts of the organisation can be viewed as 'operations' and hence some tools and techniques of operations management might be applied elsewhere in the organisation. *Second,* the input-transformation-output model underpins the concept of the internal customer-supplier. Each micro operation is a customer of, and a supplier to, another micro operation. Therefore, the organisation as a whole is made up of a network of internal customers and suppliers. (Note: internal customers and suppliers do not operate in a free market.)

Buffering the Operation against Environmental Uncertainty

Often operations exists in turbulent environments. So for operations to be efficient and stable buffering is required against environmental uncertainty. This can be achieved through;

- Physical buffering – keeping an inventory or safety stock of resources either at the input or the output side of the transformation process (see Figure 1.4).
- Organisational buffering – allocating responsibility so that the operations function is protected from the external environment by the other functions.

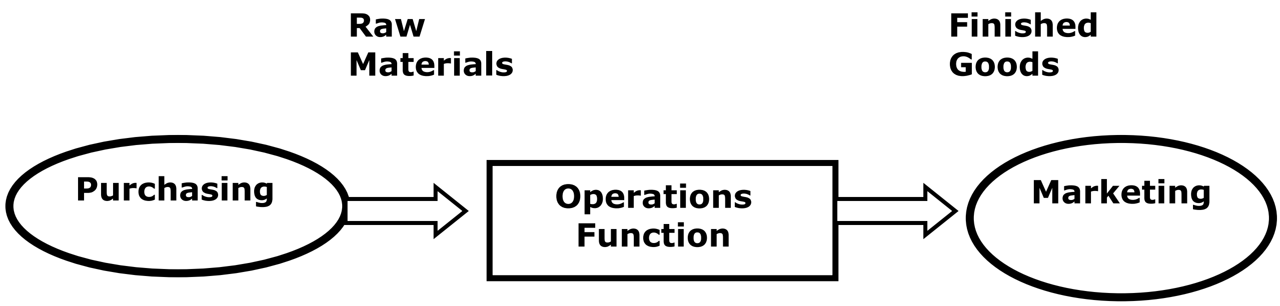

Figure 1.4

Is buffering an appropriate practice for operations management?

Although up to until recently, maintaining buffering was the way of running operations, in today's environment and buffering is being criticised for the following reasons:

- Operations never develops the understanding of the environment which would help it exploit new developments.
- Operations is never required to take responsibility for its action. Always there is another function to blame resulting in conflict between functions.
- Physical buffering often requires large stocks of input or output resources, which are both expensive (think of the opportunity cost) and prevent operations achieving continuous improvement (think of the KAIZEN and Just-in-Time philosophies).
- Physical buffering in customer processing operations means making the customer wait for the service, which could lead to customer dissatisfaction.

The above reasons have encouraged successful organisations to move towards exposing the operations function to environmental turbulence through the reduction or even elimination of buffering

The Many Different Types of Operations

All goods and services are produced via the transformation process (input-transformation-output mode), and operations can be categorised using four dimensions, namely, output volume; output variety, variation in demand and degree of customer contact.

High output volumes result in operations which:

- involve highly repetitive tasks;
- are easy to specialise;
- are easy to systemise
- are highly capital intensive;
- have low unit costs.

High output variety results in operations which:

- need to be flexible;
- are complex;
- provide a service which has to be closely matched to customer needs;
- have high unit costs.

High variation in demand results in operations which:

- need to be flexible;
- have to anticipate future demand;
- have to be able to change their capacity.

High customer contact results in operations which:

- need to be able to offer fast service as waiting tolerance is likely to be low;
- use customer perception to measure performance;
- need skilled staff.

Often operations with high customer contact have back-office as well as front-office jobs. Back-office jobs are those that are done behind the scenes and they involve little direct customer contact.

The Activities of Operations Managers

The operations manager is the key figure in the operations system: he or she has the responsibility for the creation of goods and the provision of services. The kinds of jobs that operations managers oversee vary tremendously from organisation to organisation due to the different products or services involved. Thus managing an insurance company operation requires different skills and experience than managing an aircraft manufacturing operation. However, in a very important respect, the jobs are essentially *managerial* and generally the activities of operations managers fall into two categories. These are those the operations manager has indirect responsibility for and those the operations manager has direct responsibility for.

Activities which operations managers have indirect responsibility for include:

- informing other functions of the opportunities and constraints provided by the operation's capabilities;
- discussing with other functions how operations plans and their own plans might be modified to the benefit of both functions;
- encouraging other functions to suggest ways in which the operations function can improve the service it provides to the rest of the organisation;

Activities which operations managers have direct responsibility for include:

Understanding operations strategic objectives which involves:

- developing a clear vision which explains how the operations function can help the organisation achieve its long-term goals;

- translating these goals into explicit performance objectives for operations.

In order for operations managers to manage all the activities of an operations system, which converts inputs into the organisation's products and services, they should be able to make decisions for all the activities that involve the operation system. Classifying operations management decisions is difficult, but decisions tend to fall into three general categories, namely, *strategic*; *operating*; and *control*; decisions.

Strategic decisions concern operations strategies and the long-range game plan for the organisation. These decisions are so important that typically people from the major functions (i.e., operations, marketing, accounting and finance, product and/or service development) and the support functions (i.e., human resources, purchasing, maintenance, engineering) get together to study the business opportunities carefully and arrive at a decision that puts the organisation in the best position for achieving it long-term goals. Examples of these decisions are:

- deciding whether to launch a new-product development project;
- deciding on the organisation's products, processes and services;
- deciding how to allocate scarce raw material, utilities, production/service capacity, and personnel among new and existing business opportunities (deciding for the optimal distribution of scarce resources among product line or business units);
- deciding what new facilities (factories, offices, etc) that are needed and where to locate them.

Operating decisions must resolve all the planning issues related to the delivery of products and services to meet customer's demands. The principal responsibility of operations is to take the orders for products and services from customers, which the marketing function has generated, and deliver products and services in such a way that there are *satisfied customers* at reasonable costs. Carrying out this responsibility, a number of decisions should be made, such as:

- deciding on the amount of inventory that has to be carried;
- deciding on the amount of overtime (extra capacity) required to meet customer's demand, or whether to subcontract some products or services;
- deciding about planning and controlling the production of services;
- deciding on the materials management techniques to be used and designing a detail plan for purchasing raw materials and services to support next month's products and services.

Control decisions are concerned with a variety of problems in operations. The facts of life for operations managers are that their workers do not always perform as expected, product and service quality can vary, and equipment can break down and usually does when it is least expected. Operations managers engage in planning, analysing, and controlling activities so that poor workers performance, inferior product/service quality, and excessive equipment (machine, systems, etc) breakdowns do not interfere with the profitable operation of the organisation. Examples of this type of decision are:

- deciding what to do about a department's failure to meet the planned labour cost target;
- developing labour cost standards for a revised product or service design that is about to go ahead;
- deciding what the new quality acceptance criteria should be for a product or service that has had a change in design;
- deciding how often to perform preventive maintenance on the facilities and resources (key

machines/systems/equipment) for the delivery of products or services.

The Strategic Role and Objectives of Operations

The principal role of operations is to produce the goods and services demanded by the organisation's customers. But this is not all an operations function does.

Operations must **help implement** the business strategy, a strategy that starts as a statement of intent and only comes into being as decisions are made and actions are taken. Because operations are usually accountable for the majority of an organisation's resources, for a strategy to be implemented requires the operation's resources to be deployed in a consistent manner over an extended period of time.

Operations **must support** the business strategy by ensuring that its technology, people, systems, procedures, etc are capable and available when needed to achieve its strategic objectives.

Operations **should drive** the business strategy by giving it a long-term competitive advantage via high quality products and services, and on time delivery.

In summary, operations have three distinct roles that are associated with business strategy:

(a) 'implementer' of strategy (operations as effector)

(b) 'support'of strategy (operations as follower)

(c) 'driver' of strategy (operations as leader)

How the Contribution of Operations Can Be Assessed

Professors Hayes and Wheelwright, of Harvard Business School, provide a useful model made up of four stages for assessing the contribution of the operations in organisations (see Table 1.2). The model can be used into two ways. *Firstly*, members of the operations can be asked what are their aspirations; and *secondly*, members of other major functions can be asked how they see operations. With these inputs, the model can trace the progression of operations in a continuum from the very poor level of contribution (Stage 1) to the one which is creative and proactive and is becoming central to strategic thinking (Stage 4). The four stages of Hayes and Wheelwright's model are used by scholars and operations managers to describe the operation's strategic development.

For stage 1 organisations, the objective is to minimise the negative impact of operations. In stage 1 organisations:

- external 'experts' will be used to make decisions of strategic importance to operations;
- internal management control systems will be used to monitor operational performance;
- operations will be encouraged to be flexible and reactive.

For stage 2 organisations, the objective is for operations to help the business maintain parity with its competitors. In stage 2 organisations:

- industry practice will be followed;
- the planning horizon for operations investment will be extended so that it incorporates a single business cycle;

- capital investment will be seen primarily as a way of catching up with the competition.

For stage 3 organisations, the objective is for operations to provide credible support for the business strategy. In stage 3 organisations:

- operations investments will be screened for consistency with the business strategy;

- the implications for operations of changes in business strategy will be considered;

- the systematic approach to the long-term development of the operations function will be adopted.

For stage 4 organisations, the objective is for operations to provide a source of competitive advantage. In stage 4 organisations:

- efforts will be made to anticipate the potential of new operations practices and technologies;

- operations will be involved in major marketing and engineering decisions;

- long-range programs will be pursued in order to acquire capabilities in advance of needs.

Table 1.2 Matrix Assessing the Contribution of the 'Operations'

	Neutral	Supportive
Internally	Stage 1 Objective is to minimise the negative impact of 'operations'	Stage 3 Objective is for 'operations' to provide credible support for the business strategy
Externally	Stage 2 Objective is for 'operations' to help the business maintain parity with its competitors	Stage 4 Objective is for 'operations' to provide a source of competitive advantage

The Meaning of the Five Performance Objectives – The Benefits of Excelling at the Performance Objectives

According to Slack et al. (2000: 44) an operation in an organisation contributes to achieving an operations-based advantage through five 'performance objectives', namely, quality; speed; dependability; flexibility; and cost.

Quality – doing things right: That is providing error-free goods and services, which are fit, for their purposes. In many operations quality is the most visible performance objective as it relatively easy for customers to judge.

In terms of the external benefit, providing 'error-free' products and services enhances customer satisfaction. Internally, quality reduces costs and increases dependability. In other words, an organisation does not have to spend money to rectify mistakes.

Speed – doing things fast: By doing things fast an operation minimises the time between the customer asking for and receiving the goods and/or services. The faster an organisation can deliver a particular product or service the less likely a customer is to go to the competitor.

In terms of the external benefit, speed means delivering products and services fast, and hence increasing their availability. Internally, doing things fast reduces inventories, eliminates queues and reduces risk of obsolescence.

Dependability – doing things on time: Doing things on time involves delivering promises. To be dependable organisations must be able to estimate delivery dates accurately, communicate them to the customer, and deliver when promised.

By delivering products and services on time an organisation meets its commitment to customers and hence enhancing customer satisfaction (external benefit). Internally, delivering products and services on time minimises disruptions, which often cost money and waste time. Thus, dependability saves money, time and provides stability.

Flexibility – being able to change what you do: That is adapting the operation's activities to change. The advantage of flexibility is that it helps the organisation to cope with unexpected circumstances. This performance objective could mean two things. a) being able to change fast enough and b) being able to change far enough. Flexibility could also be viewed as:

- product/service flexibility – being able to offer a wide range of products and services;
- mix flexibility – being able to change the mix of products and services offered;
- volume flexibility – being able to change the volume of product made;
- delivery flexibility – being able to cope with changing customer demands in terms of due dates.

Being able to change fast enough and far enough means that an organisation can cope with changing customer demands, hence the benefit comes from enhanced customer satisfaction (external benefit). As known, changing demands always causes problems, and being flexible means that an organisation is able to absorb some of these easily and early. By being flexible then, an organisation can benefit internally through a quick response to change and by saving money.

Cost – doing things at low cost: By definition every customer wants product and services at low cost. In many ways cost is the most important performance objective. Achieving low costs involves the correct mix of staff, facilities, materials, technology and processes.

By being able to create products and services at low cost means that an organisation can offer these to the market at a price it will bear, while still achieving a return on investment that would satisfy shareholders (external benefit).

Internally, quality operations do not waste time or effort having to re-do things nor are their internal customers inconvenienced by flawed services. Hence high quality could result in low costs. Fast operations reduce the level of work-in-process (inventory) between the micro operations as well as reducing the administrative overheads. Both effects can reduce the overall operating cost. Dependable operations do not spring any unwelcome surprises on their internal customers. This eliminates wasteful disruption and allows the other micro operations to operate efficiently. Flexible operation adapts to changing circumstances quickly and without disrupting the rest of the operation. Also flexible operations can change over between tasks quickly and without wasting time and capacity resulting in low costs.

Complete the following questions:

True/False Questions

1. An example of inputs in a transformation process is goods and services. **False**

2. Since service organisations such as barber shops and hospitals do not produce a product, the principles of operations management do not apply. **False**

3. The three primary functions of a firm are production, finance, and accounting. **False**

4. Of the three primary functions of a firm, operations typically has the largest investment in assets. **True**

5. In operations management, we try to ensure that the transformation process is performed efficiently. **True**

6. In operations management, we try to ensure that the transformation process' output is of greater value than the sum of the input. **True**

7. Any activities that do not add value during the transformation process are needed. **False**

8. Any activities that do not add value during the transformation process should be eliminated. **True**

9. The process chosen to provide the product or service need not be consistent with the product or service characteristics. **False**

10. Competing on speed, companies must expect radical change. **True**

11. Operating systems execute strategic decisions on a day-to-day basis. **True**

12. Planning and control systems should contain feedback loops. **True**

13. An organisation must never transform an internal competency into a saleable item. **False**

14. Leading companies focus most on achieving specific marketing or financial goals instead of building basic

internal capabilities. **False**

Multiple Choice Questions

1. Activities in operations management include all of the following except

a) arranging work

b) controlling quality

c) establishing demand

d) managing inventory

2. In operations, the transformation process can be

a) physical

b) locational

c) psychological

d) all of the above

3. Which activity is not part of operations?

a) location of facilities

b) financial control

c) inventory control

d) arrangement of plant layout

4. Which of the following is not an input to the transformation process?

a) material

b) machines

c) services

d) labour

5. The transformation process in the communications industry is typically __________.

a) physical

b) physiological

c) psychological

d) informational

6. Operations management can

a) reduce cost

b) increase sales

c) gain market share

d) all of the above

7. Strategic decisions in operations can involve

a) products and services

b) capacity and facilities

c) quality

d) all of the above

8. Forming alliances is one of the most effective ways of competing on

a) cost

b) quality

c) speed

d) flexibility

9. Competing on quality requires

a) a commitment from everyone in the company

b) defining quality as a comparison with the competition

c) the marketing strategy identify the product as "quality"

d) all of the above

10. A positioning strategy should consider

a) the strengths of the organisation

b) the needs of the marketplace

c) the position of the competition

d) all of the above

Short-Answer Questions

1. What constitutes "operations" at (a) bank, (b) a retail store, (c) a hospital, (d) a cable TV company, (e) an internet provider firm?

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2. Briefly describe how operations have been affected as we have moved from the Industrial Revolution to the current era of globalisation.

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3. Discuss the requirements from an operations perspective of competing on (a) quality, (b) speed, (c) dependability, (d) flexibility, and (e) cost. Give examples of manufacturing or service firms that successfully compete on each of the criteria listed.

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4. What role should operations play in corporate strategy?

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5. Name several strategic decisions that involve the operations management.

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Summary

This topic provided an introduction to operations management. In particular it focussed on the strategic importance of operations management and how operations management can provide a competitive advantage in the market place.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic establishes the context for the rest of the module?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Introduction to operations management

- O Definitions
- O Historical foundations

Strategy and role of operations management

- O The role operations manager
- O Position of operations in organisations
- O The input-transformation-output process model
- O Macro and micro operations
- O Types of operations
- O The strategic role of operations
- O Contribution of operations and its assessment
- O The meaning of five performance objectives
- O The benefits of excelling at the performance objectives

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues, which you may want to recall when discussing this topic with the lecturer or another student.

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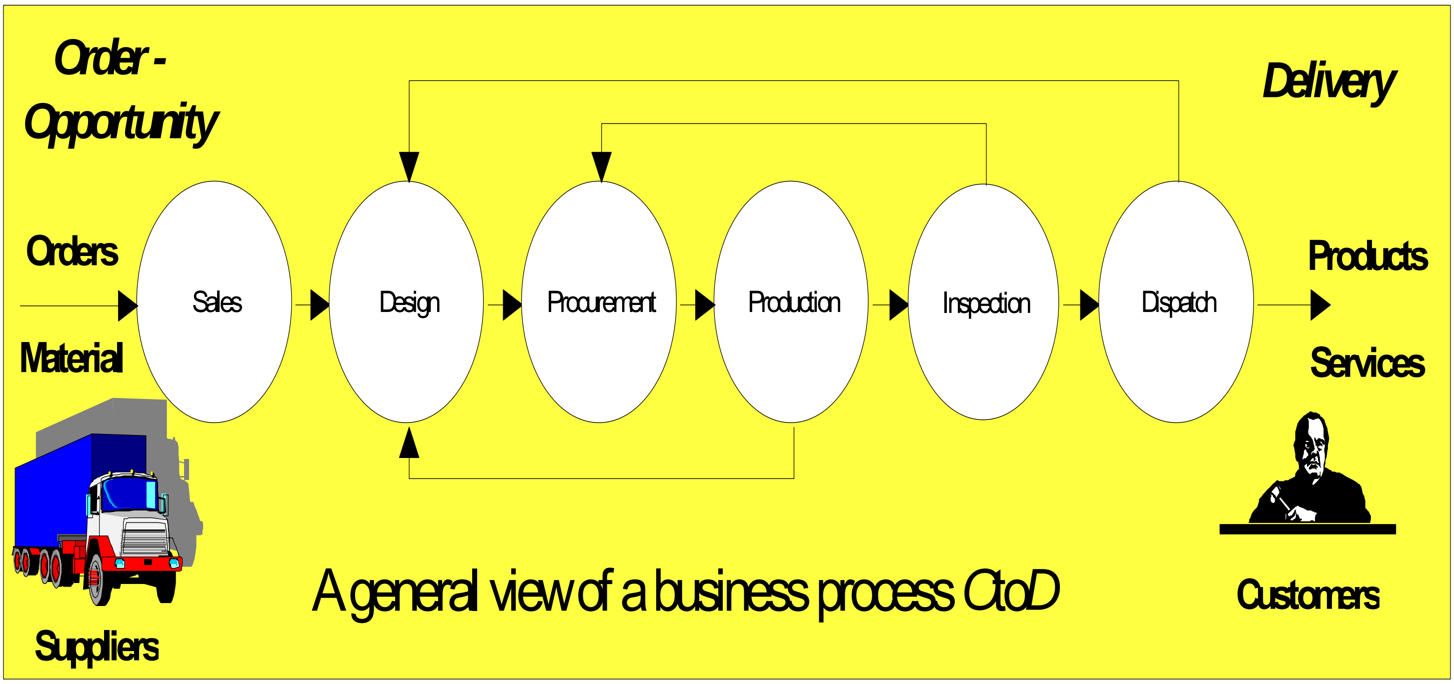
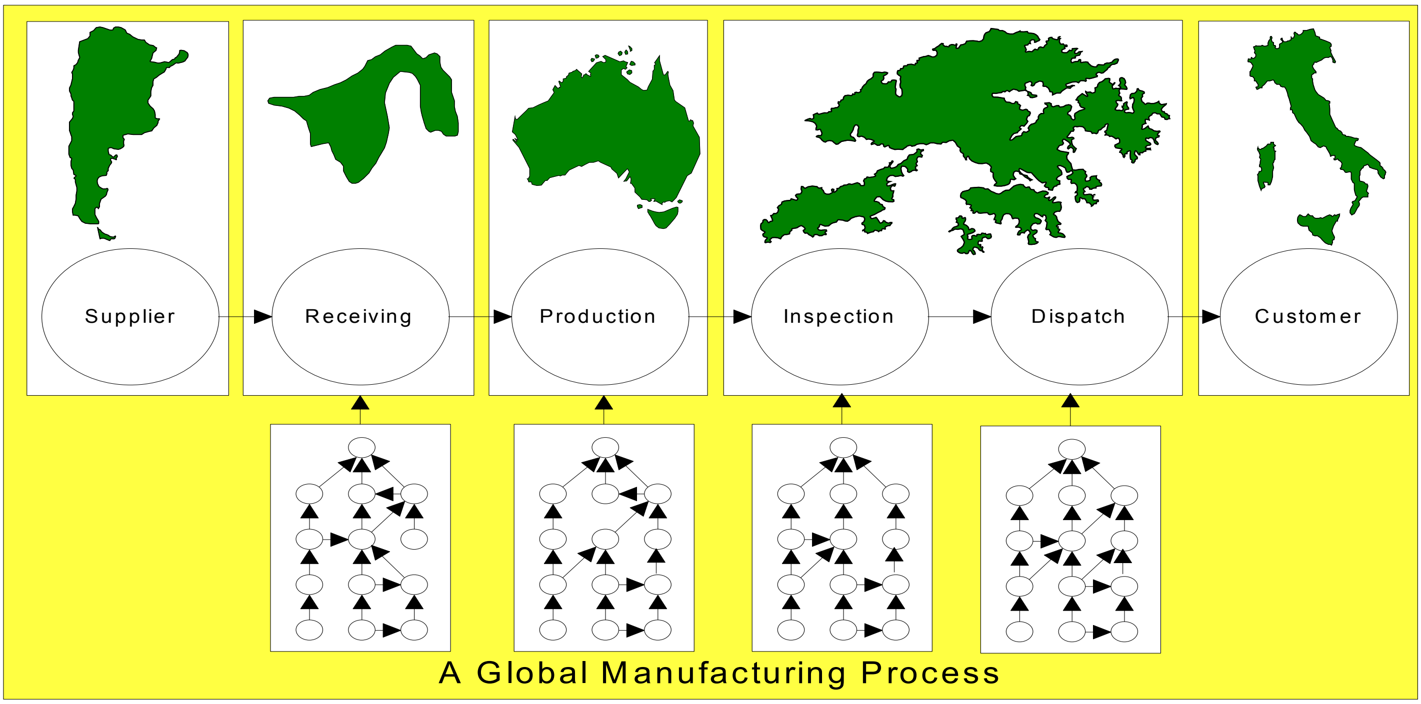

Order -
Opportunity
Delivery
Orders
Material
Sales
Design
Procurement
Production
Inspection
Dispatch
Products
Services
Suppliers
Customers
A general view of a business process OtoD


Supplier
Receiving
Production
Inspection
Dispatch
Customer
A Global Manufacturing Process

Operations Management

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FIEAust, FIPENZ, CPEng, AFAIM, MAMA, MASME, FEANI EUR ING, TEE

for

Higher Colleges of Technology, United Arab Emirates

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Chapter 1

The strategic role and objectives of Operations Management

Contents .... Page

The strategic role and objectives of operations management

Learning outcome

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- develop an understanding of the strategic importance of operations and how operations can provide a competitive advantage in the marketplace.

- appreciate the role of operations management and the people who manage the operation within the business.

- define the relationship between operations and other business functions, such as Marketing, Finance, Accounting, Engineering/Technical, Purchasing, and Human Resources.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Identify the strategic role of operations management in the running of organisations
- Understand operations as a Transformation Process
- Be familiar with the "characteristics" used to distinguish different operations
- Recognise the activities of operations management
- Understand the nature of the five performance objectives – quality, speed, dependability, flexibility and cost; and the internal and external benefits which an operation can derive from excelling in each of its objectives
- Appreciate the role the operations play in achieving strategic success

What you will need

Suggested study time	Text Book	5 hours
	Activities and exercises	2 hours
	Total	7 hours
Other resources:	Suggested readings	4 hours

Introduction

Operating a large amusement park, such as Disney's Epcot Center, is every bit as complicated as manufacturing an aircraft carrier. Thousands of activities must be co-ordinated on a daily basis. Equipment must be well-maintained, workers well-trained, and shelves well-stocked, while keeping costs down. On top of this, services typically deal with more customers (each with their own service expectations) more frequently than manufacturers, and handle more unexpected occurrences. Maybe that's why General Motors (GM), Xerox, IBM and other organisations routinely benchmark *Disney* operations.

Welcome to the study of operations management. Around the world and in the United Arab Emirates (UAE) in particular traditionally operations managers are "trained" rather than "educated". Service and manufacturing organisations prefer that their staff are given "on the job" training in preference to other forms of training or education. The end result is that management has a number of deficiencies, and operations management is one of the most serious. While other areas are important, there seems to be an overwhelming emphasis on the financial, marketing and human resource management areas. A poll I carried out over the last five years with students in three Australian Universities and in the Higher Colleges of Technology, UAE showed that students have a greater familiarity with these areas, knowing what is studied in the relevant courses, and knowing fairly accurately the role of the manager in each of these areas. However, when we consider the operations management area the results showed that an operations manager is one who deals only with engineering or design and development or managing blue-collar workers, and has been trained "on the job" to take on the role of manager.

While it appears that the student does not know the role of operations manager fairly accurately, over the last decade organisations realised the importance of "educated" operations managers. Companies in the UAE: Etisalat, Dubal , DEWA, Dubai Ports, Emirates Airlines, Department of Civil Aviation, Airforce, and Emirates Internet & Multimedia, and in Australia: Abbott Australasia, Arnott's Biscuits, Coca-Cola Amatil, Kodak Australia, Boeing Australia, Hawker de Havilland, Hewlett-Packard, Pacific Power, and Qantas are sending their managers to business colleges to major of what college course catalogues call operations management. It is now not uncommon for operations management to be a compulsory unit in graduate management courses. Wickham Skinner, of the Harvard Business School, believes that the skills and knowledge of operations managers in industry must be improved. He urges CEO's to upgrade their operations managers and give them latitude to handle the entirely new set of challenges arising from global competition and new technologies (Skinner, 1988).

In the twenty-first century, the effective management of operations - using concepts such as the extended value chain, total quality management, quality function deployment, process reengineering, concurrent engineering, benchmarking and business process problem solving, flexibility and economies of scope – will be the key source of competitive advantage. If this course results in you becoming a better-educated operations manager or a better-informed non-operations manager we will have achieved our objective. To understand better the role of operations and the operations manager it is important to be aware of some historical events in operations management.

A brief history

The history of production and hence operations systems goes back to the ancient times of the Great Wall of Chine, the Egyptian pyramids, the Athenian Parthenon, and the roads and aqueducts of Rome. In the modern sense, however, operations management has its roots in the Industrial Revolution. From the Industrial Revolution of the 1960s through to Globalisation and the Internet of the 1990s the field of operations is rapidly changing and growing in importance. The manager of operations is confronted with intense competition, global markets, global sourcing, product and service variety, mass customisation, advances in technology, worker involvement, and environment and ethical concerns. These are some of the reasons why operations management is such an exciting disciple. For the benefit of the future operations managers, and better informed non-operations managers, the players and events in operations management are summarised in Table 1.1 below.

Table 1.1 Some Historical Events in Operations Management

Era	Events/Concepts	Dates	Originator
Industrial Revolution	Steam engine Division of labour Interchangeable parts	1769 1776 1790	James Watt Adam Smith Ali Whitney
Scientific Management	Principles of scientific management Time and motion studies Activity scheduling chart Moving assembly line	1911 1911 1912 1913	Fred Taylor Frank & Lillian Gilbreth Henry Gantt Henry Ford
Human Relations	Hawthorne studies Motivation theories	1930 1940s 1950s 1960s	Elton Mayo Abraham Maslow Fred Herzberg Douglas McGregor
Management Science	Linear programming Digital computer Simulation, waiting line theory, decision theory, PERT/CPM MRP	1947 1951 1950s 1960s	George Dantzig Remington Rand Operations research groups Joseph Orlicky, IBM
Quality Revolution	JIT (just-in-time) TQM (total quality management) Strategy and operations Business process reengineering	1970s 1980s 1990s	Tsiichi Ohno, Toyota Edward Deming, Joseph Juran Wickham Skinner, Robert Hayes Michael Hammer, James Champy
Information Age	EDI, EFT CIM (computer-integrated manufacturing), PC's Internet, World Wide Web	1970s 1980s 1990s	Numerous individuals & companies Tim Berners-Lee
Globalisation	Worldwide markets and operations	1990s	Numerous companies & nations

	Supply chain management Electronic commerce Mass customisation		

Adapted from Russell and Taylor III (2000: 9).

The nature of activities of operations management can be found in the definitions that follow.

Definitions of Operations Management

A review of the literature revealed that the definitions of operations management closely reflect the diverse nature of activities to which its concepts and techniques are applied.

Wild (1995: 7) defines operations management in the following terms:

> "Operations Management is concerned with the design and the operation of systems for manufacture, transport, supply or service".

Gaither (1996: 4) includes in the term of 'production' into his definition. For Gaither production and operations management (POM) is:

> "the management of an organisations production system, which converts inputs into the organisation's products and services".

Stevenson (1999: 4) defines operations management as:

> "the management of systems or processes that create goods and/or provide services".

Krajewski and Ritzman (1999: 3) refers to operations management as:

> "the direction and control of the processes that transform inputs into finished goods and services". Similarly,

Heizer and **Render** (1999: 4) define operations management as transformation process.

> "Operations Management is the set of activities that creates goods and services through the transformation of inputs into outputs".

Slack et al. (1998: 6) distinguishes operations management from operations function. For Slack et al. **operations function** of the organisation is:

> "the arrangement of resources which is devoted to the production of its goods and services".

Operations management is the term which is used for the activities, decisions and responsibilities of operations managers who manage the arrangement of resources which, are devoted to the production of goods and services within an organisation.

Russell and Taylor (2000: 5) emphases that "operations management designs and operates productive systems – systems for getting work done" and distinguish the term operations as:

> "a function or *system that* transforms inputs into outputs of greater value".

The process of transformation of inputs into outputs can be illustrated using a service operation industry example. W.I. Carr Malaysia is the Malaysian operation of a specialist South East Asian stock-broking business head quartered in Hong Kong (Russell, 2000) The Malaysian operation is an equity research operation, which is to say that its principal function is to undertake and produce high quality corporate, industry and economic research on Malaysian listed companies, the Malaysian stock-market and the Malaysian economy.

Description of the business / service process of W.I. Carr Malaysia

The research product consisted of a weekly investment newsletter (the Weekly), in-depth but irregular research pieces on companies or industries of topical interest and frequent corporate research updates in response to company visits, company announcements and bi-annual earnings statements. Regular commentary and analysis of economic and political developments was also provided. Although the KL Stock Exchange has some 600 listed companies, the research department's efforts were more or less restricted to coverage of the top 100 companies by market capitalisation.

The brokerage business is highly competitive, with approximately 40 local firms and 20 international firms competing for business. The business has relatively high fixed costs – about 70 percent of costs are staff costs. The market is highly regulated, with nominally fixed commissions and onerous licensing requirements making it difficult but not impossible to compete on price. However, variable costs are negligible and once fixed costs are met by revenue, profitability increases exponentially. Therefore, the business can be extremely lucrative for successful firms and the emphasis in business management tends to be top-line revenue growth and market share, rather than cost control.

Essentially the service process is one of collating, processing, analysing, re-packaging and delivering information to a client base of professional, institutional investors – fund managers. Listing order winners is a subjective exercise, but most lists would include accuracy or forecasts, value-addition in research analysis, track record of stock recommendations, access to top management and speed and quality of research delivery. Similarly, order qualifiers would include breadth of coverage, regularity of research output, consistency of contact (sales and research) with customers and the basic readability (style and grammar) of the research product. The actual transformation process is shown in the flow diagram of Figure 1.1.

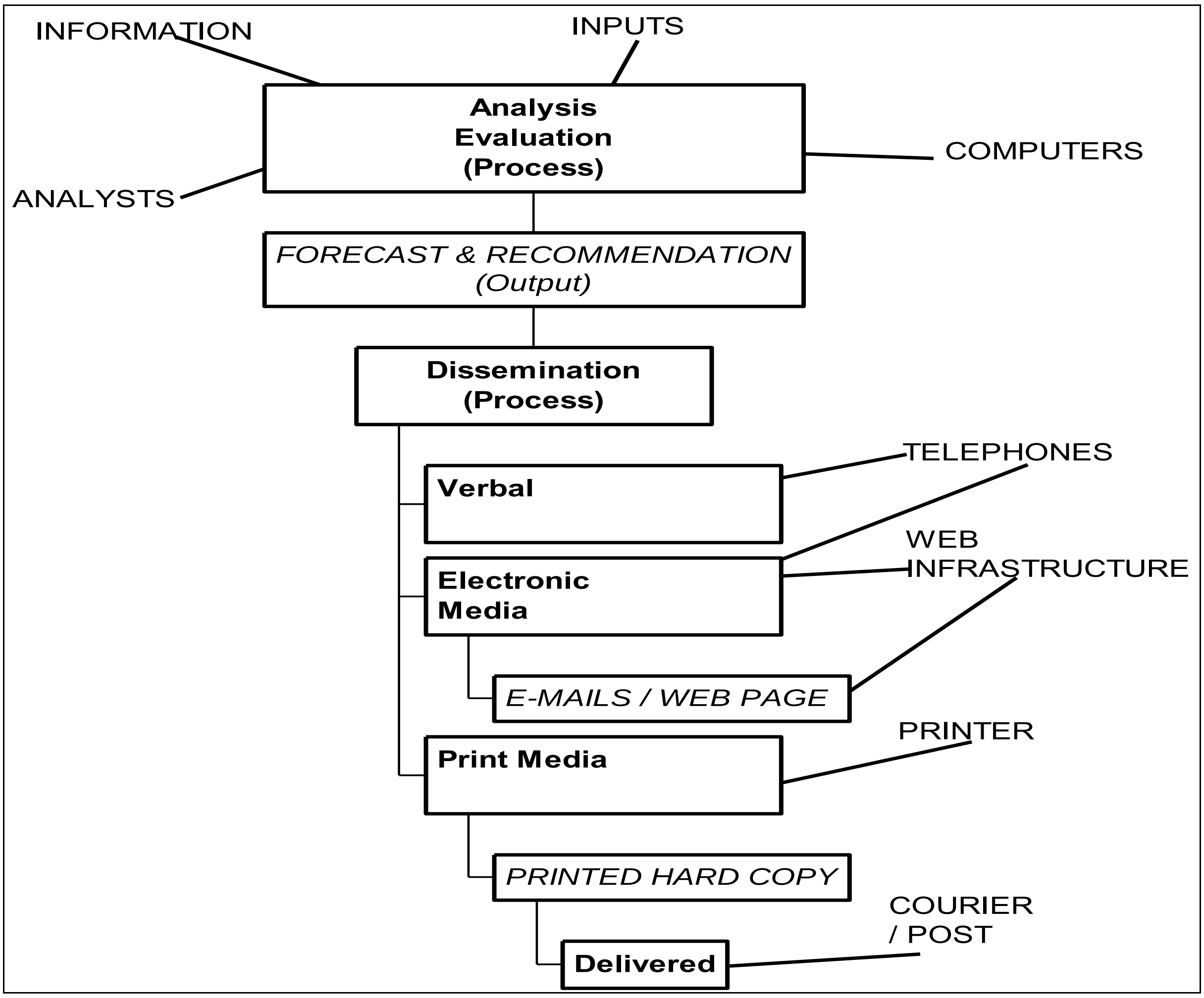


Figure 1.1 Simplified Process flow for Research Production and Dissemination

Figure 1.1 represents a simplified process flow chart for research production. The process flows down the chart from top (input) to bottom. Equity research is an information business and information represents the main raw material, or input. Other main inputs are the analyst's knowledge and experience, data processing equipment (PC's) and communications equipment. Once the information is processed (analysed and evaluated), the analyst will have to come up with an analysis including, in particular, a profit forecast and a recommendation as to whether the stock is attractive or not. These are the key outputs of the process. These outputs then have to be further processed for delivery to the firm's clients. There are three main forms of delivery – verbal (mainly by telephone), electronic (via e-mail, web-site and fax) and by printed hard copy (usually delivered by courier).

Activity 1.1

Provide workplace examples for each of the above definitions of operations management. Which of the above definitions would you expect to be the most suitable for your organisation? Explain.

What is Operations Management?

Operations management deals with the production of goods and services that we buy and use every day. Generally, it is the process that enables organisations to achieve their goals through efficient acquisition and utilisation of resources. Every organisation, whether public or private, manufacturing or service, has an operations function. The management of operations is the focus of this course.

Operations managers organise the production and delivery of the goods and service we all use. To understand operations management we need to understand:

- that operations is ‘the arrangement of resources which are devoted to the production of goods and services’;
- that an operations manager is ‘a member of the organisation who has the responsibility for managing some, or all, of the resources that comprise the operations function’;
- that operations management is ‘the term used to describe the activities, decisions and responsibilities of an operations manager’.

Operations managers have to ensure that the resources are used efficiently so that **today’s** customers can be satisfied and **today’s** competitors can be beaten. He or she also has to find ways of using resources more efficiently so that **tomorrow’s** customers can be satisfied and **tomorrow’s** competitors can be beaten.

The Position of Operations in the Organisation

Most organisations consist of two types of functions. 1) Major functions such as operations, marketing, accounting and finance, product and/or service development; and 2) Support functions such as human resources, purchasing, maintenance, engineering, etc. The basic (major) functions of business organisations are shown in Figure 1.2, while the operations intefaces with a number of supporting functions are shown in Figure 1.3.

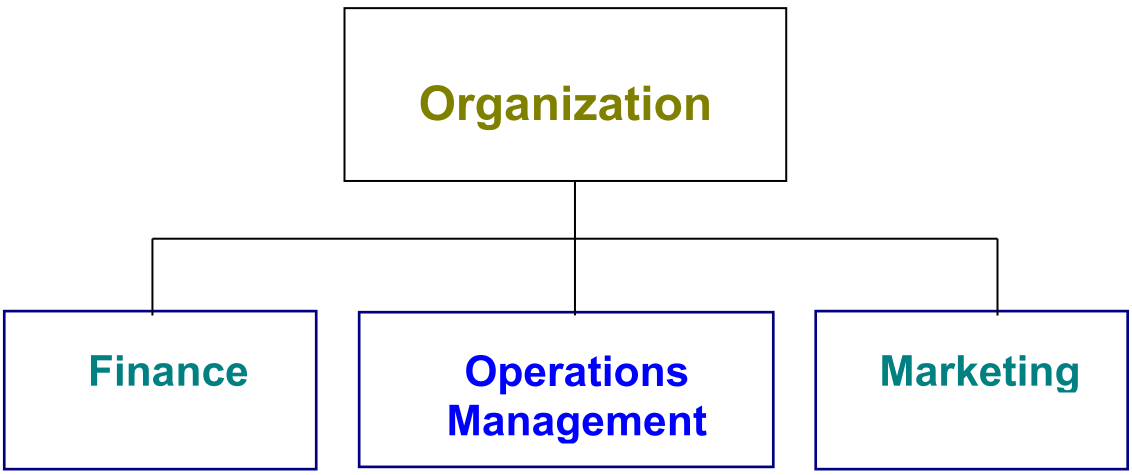


Figure 1.2 Major Functions of Business Organisations

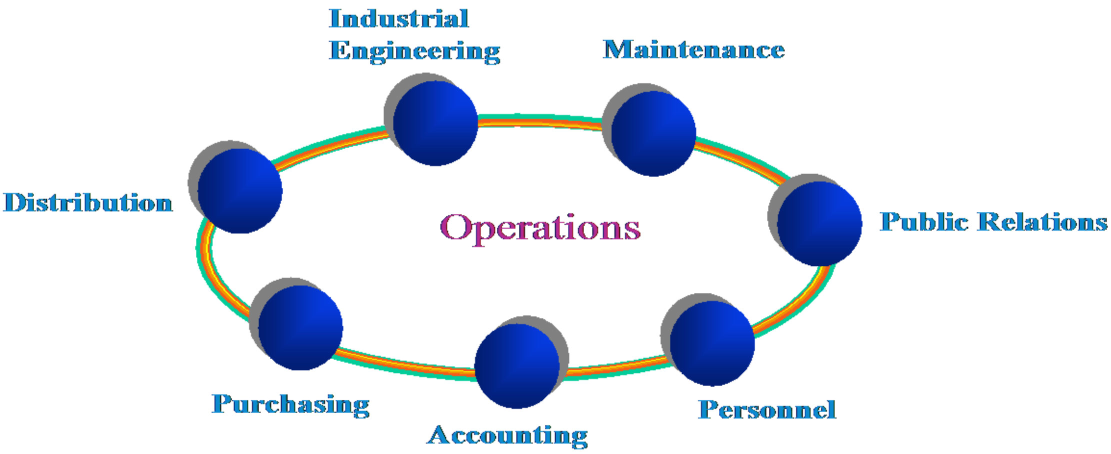


Figure 1.3 Support Functions Interfacing with Operations

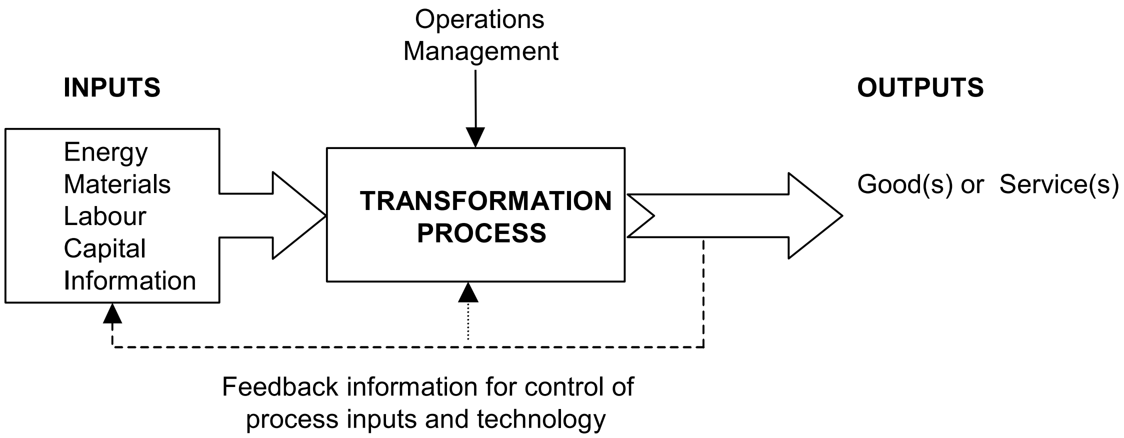
Although operations is the central function or the 'hub' of the organisation in contact with every functional area, the degree of overlap (the boundaries) between these functions vary from organisation to organisation. Depending on the organisation, operations might be responsible for developing products and/or services, choosing process technologies, devising delivery schedules, buying in materials, buying in services, originating budgets, recruiting and training staff.

The functional structure of organisations is a human creation. An alternative way however is to look at processes and examine the organisation in terms of the flows of information and materials within it, or the configuration of resources combined for the provision of good and services.

The Input-Transformation-Output Process Model

The essence of the operations is to *add-value* during the transformation process. Value-added is the term used to describe the difference between the cost of inputs and the value or price of outputs. In the general input-transformation-output model shown in Figure 1.4, inputs (such as capital, materials, machines, labour, data) are transformed into outputs (goods, services, profit, losses).

The output of an operation can usually be classified on a spectrum ranging from pure goods to pure services. Most operations produce either goods, which are accompanied by facilitating services, or services, which are accompanied by facilitating goods. Operations take inputs, transform them, or use them to transform something else, thereby producing outputs, which are of a higher value than the inputs (see Figure 1.4). Requirements and feedback from customers are used to adjust factors in the transformation process, which may in turn alter inputs. The challenge for operations management is to ensure that the transformation process is performed efficiently and that the output is of greater *value* than the sum of the inputs. The role of the operations is to create value. The transformation process itself can be viewed as a series of activities along a *value chain* extending from supplier to customer. Any activities that do not add value are superfluous and should be eliminated.



can be either transforming or transformed resources. Transforming resources include facilities and staff. Transformed resources include materials, information and customers.

The transformation process varies depending on the transformed resources. If the transformed resource is materials then the transformation process might be concerned with physical properties, location (parcel delivery), or possession (retail store). If the transformed resource is information then the transformation process might be concerned with information properties (accounting), possession (marker research), store (library), or location (telecommunications). If the transformed resource is a customer then the transformation process might be concerned with physical properties (cosmetic surgeon), store (hotel), location (airline), physiological state (hospital), or psychological state (theatre).

The output of operations also differ in terms of their:

- **Tangibility** – can you physically touch the product or service? Goods are usually tangible; services are not.
- **Storability** – can you store the product or service? Good are usually stored; services cannot.
- **Transportability** – can you transport the product or service from one location to another? Goods can usually be transported; services cannot.
- **Simultaneity** – when are the products and/or services produced? Goods are usually produced prior to customer receiving them. Services are often produced simultaneously to their consumption.
- **Customer contact** – customers usually have low contact with organisations producing goods and high contact with organisations providing services.
- **Quality** – how do customers judge the quality of the goods or services they received? As customers do not normally see goods being produced, they will tend to judge the quality of an operation producing goods by the quality of the goods themselves. As customers are intimately involved in the provision of services, they will tend to judge the quality of an operation providing services by looking at both the actual service and the way in which it is delivered.

Activity 1.2 - CASE PROBLEM

Value-Added Operations at Lands' End

Lands' End, headquartered in Dodgeville, Wisconsin, is the largest speciality catalogue company in the United States. The company's products include casual and tailored clothing for men, women, and children, shoes and accessories, soft luggage, and items for bedrooms and bathrooms. Fast, efficient operations allow Lands' End to offer convenient at-home shopping of quality merchandise at competitive prices.

Lands' End catalogues are known for descriptive product narratives that tell customers everything they could want to know about a garment and its construction. The company's toll-free phone lines for sales and customer service are open twenty-four hours a day, 364 days a year. More than 1,000 phone lines handle about 50,000 calls each day--almost 100,000 calls daily in the weeks prior to Christmas. Eighty-five percent of all orders are placed by phone.

In-stock orders leave Lands' End's Dodgeville distribution Center (a structure the size of sixteen football fields) the day after they are received. Standard delivery is two business days anywhere within the continental United States. Lands' End works directly with some of the best fabric mills and manufacturers in the world. Garments are produced to Lands' End's own quality specifications, not to less stringent industry-wide specifications. In addition to its booming U.S. business, the company now does business in 75 countries, with facilities or special licensing agreements in Canada, the United Kingdom, Japan, and Germany. The Land's End philosophy is outlined in its eight "Principles of Doing Business."

Principle 1: We do everything we can to make our products better. We improve material, and add back features and construction details that others have taken out over the years. We never reduce the quality of a product to make it cheaper.

Principle 2: We price our products fairly and honestly. We do not, have not, and will not participate in the common retailing practice of inflating mark-ups to set up a future phoney "sale."

Principle 3: We accept any return, for any reason, at any time. Our products are guaranteed. No fine print. No arguments. We mean exactly what we say: GUARANTEED, PERIOD.

Principle 4: We ship items in stock the day after we receive the order. At the height of the last Christmas season, the longest time an order was in the house was 36 hours, excepting monograms, which took another 12 hours.

Principle 5: We believe that what is best for our customer is best for all of us. Everyone here understands that concept. Our sales and service people are trained to know our products and to be friendly and helpful. They are urged to take all the time necessary to take care of you. We even pay for your call, for whatever reason you call.

Principle 6: We are able to sell at lower prices because we have eliminated middlemen; because we don't buy branded merchandise with high protected mark-ups; and because we have placed our contracts with manufacturers who have proved that they are cost conscious and efficient.

Principle 7: We are able to sell at lower prices because we operate efficiently. Our people are hard-working, intelligent, and share in the success of the company.

Principle 8: We are able to sell at lower prices because we support no fancy emporiums with their high overhead. Our main location is in the middle of a 40-acre cornfield in rural Wisconsin.

Activity 1.2

In groups of three attempt to answer the following questions:

Think about the operations function at Lands' End. What is involved in the transformation process? How does the company "add value" for its customers?

Examine Lands' End's eight principles for doing business. What image is the company trying to portray? What specific activities support the image?

Gather information on Lands' End's competitors, L. L. Bean and Eddie Bauer. Are there any obvious differences in their competitive strategies? Describe the global activities of each company.

Source: Prentice-Hall. "A Brief History of Lands' End." On Location at Lands' End Video Series. Video 4.1– CD in Operations Management (Russell & Taylor, 2000); ISBN 0-13-086959-7.

Macro and Micro Operations

The input-transformation-output model can be used to describe macro and micro operations. All operations consist of micro operations, each of, which produces outputs by taking inputs and transforming them, or using them to transform something else. An example of macro operations that are made up of many micro operations is shown in model of Figure 1.5. This input-transformation-output model can be extended to the level of the individual.

There are two important implications of this model. *First*, the input-transformation-output model makes explicit the fact that other parts of the organisation can be viewed as 'operations' and hence some tools and techniques of operations management might be applied elsewhere in the organisation. *Second,* the input-transformation-output model underpins the concept of the internal customer-supplier. Each micro operation is a customer of, and a supplier to, another micro operation. Therefore, the organisation as a whole is made up of a network of internal customers and suppliers. (Note: internal customers and suppliers do not operate in a free market.)

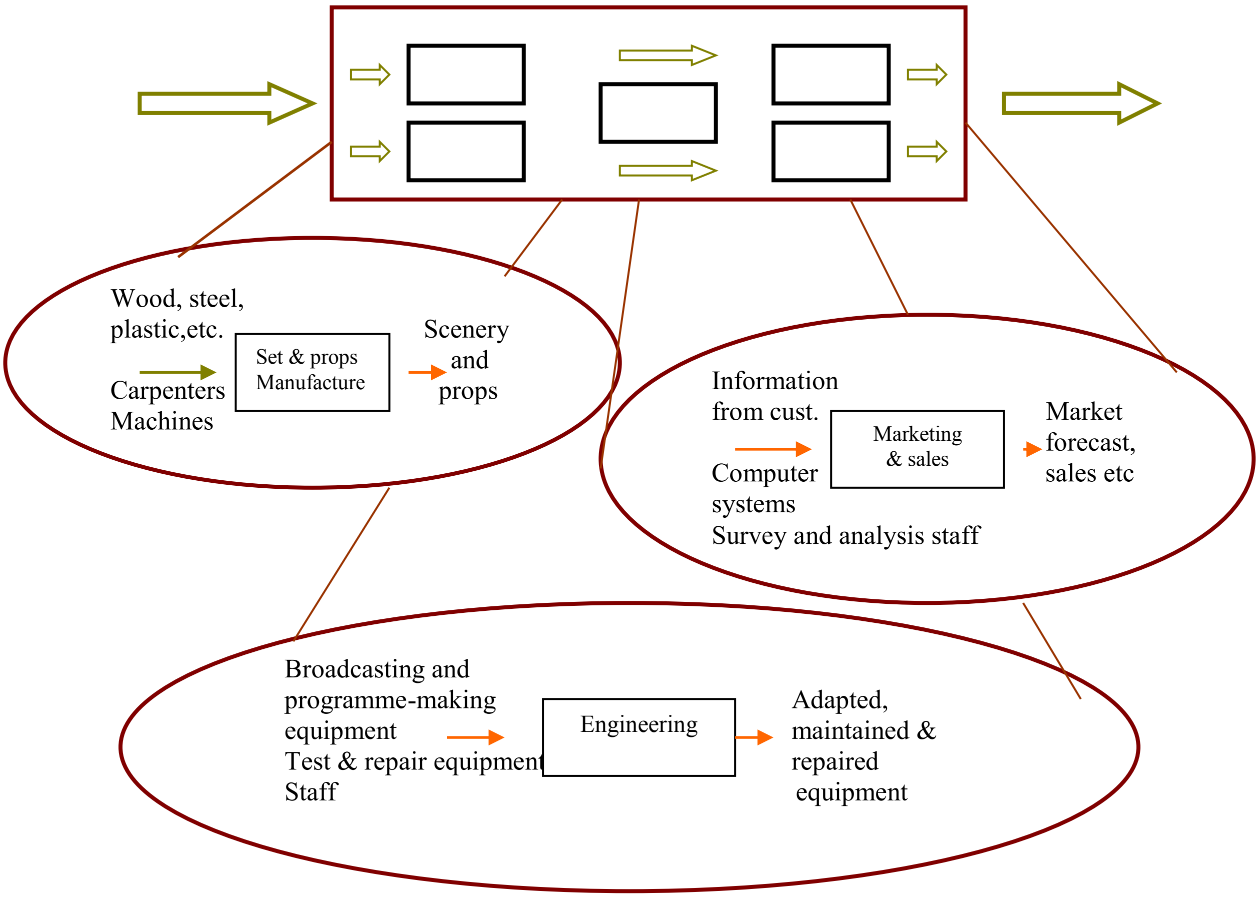


Figure 1.5 **Macro/Micro Operations Model**

Adopted from Slack et al. (2000: 17)

Buffering the Operation against Environmental Uncertainty

Often operations exist in turbulent environment. So for operations to be efficient and stable buffering is required against environment uncertainty. This can be achieved through;

- Physical buffering – keeping an inventory or safety stock of resources either at the input or the output side of the transformation process (see Figure 1.6).
- Organisational buffering – allocating responsibility so that the operations function is protected from the external environment by the other functions.

Figure 1.6 **Physical Buffering**

Is buffering an appropriate practice for operations management?

Although till recently, maintaining buffering was the way of running operations, in today's environment buffering is being criticised for the following reasons:

- Operations never develop an understanding of the environment which would help it exploit new development.
- An operation is never required to take responsibility for its action. Always there is another function to blame resulting in conflict between functions.
- Physical buffering often requires large stocks of input or output resources, which are both expensive (think of the opportunity cost) and prevent operations of achieving continuous improvement (think of the KAIZEN and Just-in-Time philosophies).
- Physical buffering in customer processing operations means making the customer waits for the service, which could lead to customer dissatisfaction.

The above reasons have encouraged successful organisations to move towards exposing the operations function to environmental turbulence through the reduction or even elimination of safety stock.

The Many Different Types of Operations

Although all goods and services are produced via the transformation process (input-transformation-output mode), and operation can be categorised using four dimensions, namely, output volume; output variety, variation in demand and degree of customer contact.

High output volumes result in operations which:

- involve highly repetitive tasks;
- are easy to specialise;
- are easy to systemise
- are highly capital intensive;
- have low unit costs.

High output variety results in operations which:

- need to be flexible;
- are complex;
- provide a service which has to be closely matched to customer needs;
- have high unit costs.

High variation in demand results in operation which:

- need to be flexible;
- have to anticipate future demand;
- have to be able to change their capacity.

High customer contact results in operation which:

- need to be able t offer fast service as waiting tolerance is likely to be low;
- use customer perception to measure performance;
- need skilled staff.

Often operations with high customer contact have *back-office* as well as *front-office* jobs. Back-office activities are those that are done behind the scenes and they involve little direct customer contact. For example, in an airport the *back-office* activities are those of baggage handling; overnight freight delivery; ground crew putting meals on board and refreshing the aircraft; cooking and administration. On the other hand, *front-office* activities are those of catering (meals and drinks) on board; answering people's questions; passport control; checking documentation and baggage; and ticketing travellers.

The Activities of Operations Managers

The operations manager is the key figure in the operations system: he or she has the responsibility for the creation of goods and the provision of services. The kinds of jobs that operations managers oversee vary tremendous from organisation to organisation due to the different products or services involved. Thus managing an insurance company operation requires different skills and experience than managing an aircraft manufacturing operation. However, in a very important respect, the jobs are essentially *managerial* and generally the activities of operations managers fall into two categories. These are those the operations manager has indirect responsibility for and those the operations manager has direct responsibility for.

Activities which operations managers have indirect responsibility for include:

- informing other functions of the opportunities and constraints provided by the operation's capabilities;
- discussing with other functions how operations plans and their own plans might be modified to the benefit of both functions;
- encouraging other functions to suggest ways in which the operations function can improve the service it provides to the rest of the organisation;

Activities which operations managers have direct responsibility for include:

Understanding operations strategic objectives which involves:

- developing a clear vision which explains how the operations function can help the organisation achieve its long-term goals;
- translating these goals into explicit performance objectives for operations.

In order for operations managers to manage all the activities of an operations system, which converts inputs into the organisation's products and services, they should be able to make decisions for all the activities that involve in the operation system. Classifying operations management decisions is difficult, but in my experience as an operations manager for 20 years and the experiences of others, decisions tended to fall into three general catagories, namely, *strategic*; *operating*; and *control*; decisions.

Strategic decisions concern operations strategies and the long-range game plan for the organisation. These decisions are so important that typically people from the major functions (i.e., operations, marketing, accounting and finance, product and/or service development) and the support functions (i.e., human resources, purchasing, maintenance, engineering) get together to study the business opportunities carefully and arrive at a decision that puts the organisation in the best position for achieving its long-term goals. Examples of these decisions are:

- deciding whether to launch a new-product development project;
- deciding on the organisation's products, processes and services;
- deciding how to allocate scarce raw material, utilities, production/service capacity, and personnel among new and existing business opportunities (deciding for the optimal distribution of scarce resources among product line or business units);
- deciding on the new facilities (factories, offices, etc) that are needed, and
- deciding where to locate them.

Operating decisions must resolve all the planning issues related to the delivery of products and services to meet customer's demands. The principal responsibility of operations is to take the orders for products and services from customers, which the marketing function has generated, and deliver products and services in such a way that there are *satisfied customers* at reasonable costs. Carrying out this responsibility, a number of decisions should be made, such as:

- deciding on the amount of inventory that has to be carried; (Note: there is a minimum inventory necessary to keep a perfect system running.)
- deciding on the amount of overtime (extra capacity) required to meet customer's demand, or whether to subcontract some products or services;
- deciding about planning and controlling the production of services;
- deciding on the materials management techniques to be used and designing a detail plan for purchasing raw materials to support next month's products and services.

Control decisions are concerned with a variety of problems in operations. The facts of life for operations managers are that their workers do not always perform as expected, product and service quality can vary, and equipment can break down and usually does when it is least expected. Operations managers engage in planning, analysing, and controlling activities so that poor workers performance, inferior product/service quality, and excessive equipment (machine, systems, etc) breakdowns do not interfere with the profitable operation of the organisation. Examples of this type of decision are:

- deciding what to do about a department's failure to meet the planned labour cost target;
- developing labour cost standards for a revised product or service design that is about to go ahead;
- deciding what the new quality acceptance criteria should be for a product or service that has had a change in design;
- deciding how often to perform preventive maintenance on the facilities and resources (key machines/systems/equipment) for the delivery of products or services.

The Strategic Role and Objectives of Operations

The principal role of operations is to produce the goods and services demanded by the organisation's customers. But this is not all an operations function does.

Operations must **help implement** the business strategy, a strategy that starts as a statement of intend and only comes into being as decisions are made and actions are taken. Because operations are usually accountable for the majority of an organisation's resources, for a strategy to be implemented requires the operation's resources to be deployed in a consistent matter over an extended period of time.

Operations **must support** the business strategy by ensuring that its technology, people, systems, procedures, etc are capable and available when needed to achieve its strategic objectives.

Operations **should drive** the business strategy by giving it a long-term competitive advantage via listening to the 'voice' of the customers, thereby delivering high quality products and services, and achieving on time delivery.

In summary, Slack et al. (1988) suggested that operations have three distinct roles that are associated with business strategy:

(a) 'implementer' of strategy (operations as effector);

(b) 'support'of strategy (operations as follower);

(c) 'driver' of strategy (operations as leader).

How the Contribution of Operations Can Be Assessed

Professor's Hayes and Wheelwright, of Harvard Business School, provide a useful model made up of four stages for assessing the contribution of the operations in organisations. The model can be used in two ways. *Firstly*, members of the operations can be asked what are their aspirations; and *secondly*, members of other major functions can be asked how they see operations. With these inputs, the model can trace the progression of operations in a continuum from the very poor level of contribution (Stage 1) to the one which is creative and proactive and is becoming central to strategic thinking (Stage 4). Scholars and operations managers to describe the operation's strategic development use the four stages of Hayes and Wheelwright's (1984) model.

For stage 1 organisations, the objective is to minimise any negative impact of operations. In stage 1 organisations:

- external 'experts' will be used to make decisions of strategic importance to operations;
- internal management control systems will be used to monitor operational performance;
- operations will be encouraged to be flexible and reactive.

For stage 2 organisations, the objective is for operations to help the business maintain parity with its competitors. In stage 2 organisations:

- industry practice will be followed;
- the planning horizon for operations investment will be extended so that it incorporates a single business cycle;
- capital investment will be seen primarily as a way of catching up with the competition.

For stage 3 organisations, the objective is for operations to provide credible support for the business strategy. In stage 3 organisations:

- operations investments will be screened for consistency with the business strategy;
- the implications for operations of changes in business strategy will be considered;
- a systematic approach to the long-term development of the operations function will be adopted.

For stage 4 organisations, the objective is for operations to provide a source of competitive advantage. In stage 4 organisations:

- efforts will be made to anticipate the potential of new operations practices and technologies;
- operations will involved in major marketing and engineering decisions;
- long-range programs will be pursued in order to acquire capabilities in advance of needs.

Finally, Hayes and Wheelwright's four stages model for assessing the contribution of the operations in an organisation can be depicted in the matrix of Table 1.2 below.

Table 1.2 Matrix Assessing the Contribution of the 'Operations'

	Neutral	**Supportive**
Internally	**Stage 1** Objective is to minimise any negative impact of 'operations'	**Stage 3** Objective is for 'operations' to provide credible support for the business strategy
Externally	**Stage 2** Objective is for 'operations' to help the business maintain parity with its competitors	**Stage 4** Objective is for 'operations' to provide a source of competitive advantage

The Meaning of the Five Performance Objectives – The Benefits of Excelling at the Performance Objectives

According to Slack et al. (1998: 51) an operation in an organisation "contributes to achieving an operations-based advantage through five 'performance objectives'", namely, quality; speed; dependability; flexibility; and cost.
Quality – doing things right: That is providing error-free goods and services, which are fit, for their purposes. In many operations quality is the most visible performance objective as it is relatively easy for customers to judge.

In terms of the external benefit, by providing 'error-free' products and services enhances customer satisfaction. Internally, quality reduces costs and increases dependability. In other words, an organisation does not have to spend money to rectify mistakes.

Speed – doing things fast: By doing things fast an operation minimises the time between the customer asking for and receiving the goods and/or services. The faster an organisation can deliver a particular product or service the less likely a customer is to go to the competitor.

In terms of the external benefit, speed means delivering products and services fast, and hence increasing their availability. Internally, doing things fast reduces inventories, eliminates queues and reduces risk of obsolescence.

Dependability – doing things on time: Doing things on time involves delivering promises. To be dependable organisations must be able to estimate delivery dates accurately, communicate them to the customer, and deliver when promised.

By delivering products and services on time an organisation meets its commitment to customers and hence enhancing customer satisfaction (external benefit). Internally, delivering products and services on time minimises disruptions, which often cost money and waste time. Thus, dependability saves money, time and provides stability.

Flexibility – being able to change what you do: That is adapting the operation's activities to change. The advantage of flexibility is that it helps the organisation to cope with unexpected circumstances. This performance objective could mean two things. a) being able to change fast enough and b) being able to change far enough. Flexibility could also be viewed as:

- product/service flexibility – being able to offer a wide range of products and services;
- mix flexibility – being able to change the mix of products and services offered;
- volume flexibility – being able to change the volume of products made;
- delivery flexibility – being able to cope with changing customer demands in terms of due dates.

Being able to change fast enough and far enough means that an organisation can cope with changing customer demands, hence the benefit comes from enhanced customer satisfaction (external benefit). As known, changing demands always causes problems, and being flexible means that an organisation is able to absorb some of these easily and early. By being flexible than an organisation can benefit internally through a quick response to change and by saving money.

Cost – doing things at low cost: By definition every customer wants products and services at low cost. In many ways cost is the most important performance objective. Achieving low costs involves the correct mix of staff, facilities, materials, technology and processes.

By being able to create products and services at low cost means that an organisation can offer these to the market at a price it will bear, while still achieving a return on investment that would satisfy shareholders (external benefit).

Internally, quality operations do not waste time or effort having to re-do things nor are their internal customers inconvenienced by flawed services. Hence high quality could result in low costs. Fast operations reduce the level of work-in-process (inventory) between the micro operations as well as reducing the administrative overheads. Both effects can reduce the overall operating cost. Dependable operations do not spring any unwelcome surprises an their internal customers. This eliminates wasteful disruption and allows the other micro operations to operate efficiently. Flexible operation adapts to changing circumstances quickly and without disrupting the rest of the operation. Also flexible operations can change over between tasks quickly and without wasting time and capacity resulting in low costs.

Complete the following questions:

TRUE/FALSE QUESTIONS

1. An example of inputs in a transformation process is goods and services. **False**

2. Since service organisations such as barber shops and hospitals do not produce a product, the principles of operations management do not apply. **False**

3. The three primary functions of a firm are production, finance, and accounting. **False**

4. Of the three primary functions of a firm, operations typically has the largest investment in assets. **True**

5. In operations management, we try to ensure that the transformation process is performed efficiently. **True**

6. In operations management, we try to ensure that the transformation process' output is of greater value than the sum of the input. **True**

7. Any activities that do not add value during the transformation process are needed. **False**

8. Any activities that do not add value during the transformation process should be eliminated. **True**

9. The process chosen to provide the product or service need not be consistent with the product or service characteristics. **False**

10. Compete on speed, companies must expect radical change. **True**

11. Operating systems execute strategic decisions on a day-to-day basis.

True

MULTIPLE CHOICE QUESTIONS

1. Activities in operations management include all of the following except

a) arranging work

b) controlling quality

c) establishing demand

d) managing inventory

2. In operations, the transformation process can be

a) physical

b) locational

c) psychological

d) all of the above

3. Which activity is not part of operations?

a) location of facilities

b) financial control

c) inventory control

d) arrangement of plant layout

4. Which of the following is not an input to the transformation process?

a) material

b) machines

c) services

d) labour

5. The transformation process in the communications industry is typically __________.

a) physical

b) physiological

c) psychological

d) informational

6. Operations management can

   a) reduce cost

   b) increase sales

   c) gain market share

   d) all of the above

7. Strategic decisions in operations can involve

   a) products and services

   b) capacity and facilities

   c) quality

   d) all of the above

8. Forming alliances is one of the most effective ways of competing on

   a) cost

   b) quality

   c) speed

   d) flexibility

9. Competing on quality requires

   a) a commitment from everyone in the company

   b) defining quality as a comparison with the competition

   c) the marketing strategy identify the product as "quality"

   d) all of the above

10. A positioning strategy should consider

   a) the strengths of the organisation

   b) the needs of the marketplace

   c) the position of the competition

   d) all of the above

SHORT-ANSWER QUESTIONS

1. What constitutes "operations" at (a) a bank, (b) a retail store, (c) a hospital, (d) a cable TV company, (e) an internet provider firm?

2. Fully describe how operations have been affected as we have moved from the Industrial Revolution to the current era of globalisation.

3. Discuss the requirements from an operations perspective of competing on (a) quality, (b) speed, (c) dependability, (d) flexibility, and (e) cost. Give examples of manufacturing or service firms that successfully compete on each of the criteria listed.

4. What role should operations play in corporate strategy?

5. Name several strategic decisions that involve the operations management.

6. Many organisations see the role of operations as getting on with the job of making products or serving customers. Discuss the implications of this view of the operations function.

Summary

This topic provided an introduction to operations management. In particular it focussed on the strategic importance of operations management and how operations management can provide a competitive advantage in the market place.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic establishes the context for the rest of the module?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your understanding. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember if you need assistance in your study, the faculty is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Introduction to operations management

- ☐ Definitions
- ☐ Historical foundations

Strategy and role of operations management

- ☐ The role of operations manager
- ☐ Position of operations in organisations
- ☐ The input-transformation-output process model
- ☐ Macro and micro operations
- ☐ Types of operations
- ☐ The strategic role of operations
- ☐ Contribution of operations and its assessment
- ☐ The meaning of five performance objectives
- ☐ The benefits of excelling all the performance objectives

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this topic with the lecturer or another student.

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Chapter 2 Operations Strategy

Contents .... **Page**

Operations strategy

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this topic, you should be able to:

- develop an understanding of how operations strategy fits into a company’s overall strategy.

- understand what are the specific decision areas which are usually included in an operations strategy and how an operations strategy can be put together.

- appreciate the impact of the operations strategy decisions areas on the firm’s performance objectives.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Understand the content and process of operations strategy
- Formulate an operations strategy within the overall strategic decision making in the organisation
- Be familiar with the types of decisions, which an operation will have to take to establish the content of operations strategy
- Examine the strategy hierarchy of which operations strategy is a part and demonstrate how performance objectives will have different priorities depending upon the organisation’s customers, competitors and the position of its products and services on their life cycle
- Understand the importance of the order-winning and order-qualifying criteria
- Assess the effectiveness of an operations strategy.

What you will need

Suggested study time	Text Book	6 hours
	Activities and exercises	3 hours
	Total	9 hours
Other resources:	Suggested readings	3 hours

Introduction

Operations strategy is the total pattern of decisions and actions which set the role, objectives and activities of the operation so that they contribute to and support the organisations business strategy. Strategic decisions in operations involve products and services, processes and technology, capacity and facilities, human resources, quality, sourcing, and operations systems. According to Rusell and Taylor III (2000: 42), "these decisions should "fit" like pieces in a puzzle" as shown in Figure 2.1 below.

Figure 2.1 The Puzzle of Operations Strategy

Adapted from Rusell and Taylor III (2000: 42)

An operations strategy has *content* and *process*. The *content* of an operations strategy deals with the relative importance of the performance objectives to the operation as well as with giving general guidance to decision-making activities within the operations. The *process* of the operations strategy is the procedure, which is used within the operation to formulate the operations strategy.

Slack et al. (2000) have argued that strategic decisions can be viewed at a number of levels namely, *corporate strategy*, *business strategy* and *operational* (*functional) strategy*. *Corporate strategy* sets the objectives for the different businesses, which make up a group of businesses. It contains the basic beliefs about business, and its goals of survival, growth, and profitability. *Business strategy* sets the objectives for each individual business and how it positions itself in the market place. It is a long-range game of an organisation and provides the road map of how to achieve the corporate strategy. O*perational (functional) strategies* set the objectives for each function's contribution to its business strategy. In this sense we use the term operations strategy as a functional strategy which deals with the parts of the organisation which creates goods and provides services. It includes decisions on such issues as allocation of resources, what new products and services must be developed, what new facilities are needed and when are needed, what new technologies and processes must be developed and when they are needed, and what new production/delivery schemes will be followed to produce products and deliver services.

In general, the strategy of any organisation or part of an organisation is the total pattern of decisions and actions, which position the organisation in its environment by achieving competitive advantage. That is, the strategy creates the systems that have a unique advantage over competitors. Competitive advantage can be achieved via *low cost*, *differentiation*, and *response* and the important concept here is the distinction between order-winning performance objectives and order-qualifying performance objectives. This distinction is used in some operations strategy formulation processes such as the Hill's methodology and Platts-Gregory's procedures (Slack et al. 1998: 94-98). The Hill's methodology for example is based on the idea of making connections between different levels of strategy-making from corporate objectives through marketing strategy, operations objectives and structural and infrastructural decisions. The Platts-Gregory's procedure is based on identifying the gaps between, on one hand what the market requires from an operation and on the other, how the operation is performing against market requirements.

The strategy hierarchy of which operations strategy is a part

Strategies commit organisations to particular courses of action. They define what the organisation is going to do, and, by implication, what it is not going to do. Strategic commitments are those which: (a) have widespread effect; (b) are significant; (c) define the position of the organisation relative to its environment; and (d) move the organisation closer to its long term goals. All in all, strategies provide general guidelines, which, if followed, ensure that future decisions and actions move the organisation towards its goals. As a result, everyone in the organisation should understand the strategic plan, be able to derive several goals from the plan and determine how each goal ties into their own daily activities.

The scope of a strategy depends upon the organisation being considered, and as discussed in the introductory part of this chapter, can be viewed as ***corporate***, ***business*** and ***operational strategy***.

Corporate strategy: Corporate strategy is usually conceived as being developed in large diversified corporations that consist of many business units. Senior management, with input and participation from different levels of the organisation, develops a corporate strategic plan in agreement with the organisation's mission and vision, customer requirements (voice of the customer), and business condition (voice of the business). Corporate strategy will define where the organisation positions itself in its global, economic, political and social environment and will consist of decisions about the type of business the corporation wants to be in, what parts of the world it wants to operate in, what business to acquire and what to divest, how to allocate cash between its different businesses and so on.

The corporate strategic plan focuses on the gap between the organisation's vision and its current position. It identifies and prioritises what needs to be done to close the gap and provides direction for formulating strategies in the functional areas of the company such as marketing, finance and operations (Russell & Taylor III, 2000). The relationship between the organisation's mission and vision, voice of the customer, voice of the business, corporate strategy and their link to operations strategy is shown in Figure 2.2 below.

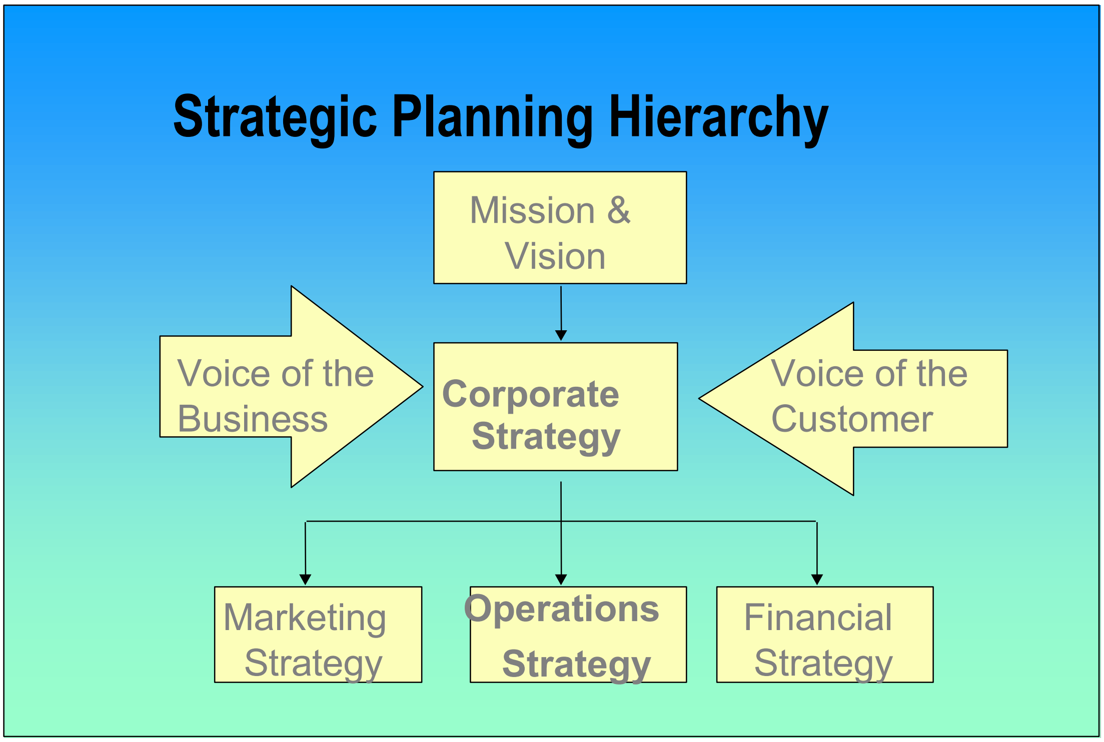

Figure 2.2 Strategic Planning Hierarchy

Adapted from Rusell and Taylor III (2000: 40)

Business strategy: If the organisation is a business unit within the corporation it will need to put together is own business strategy. Business strategy sets out its individual mission and objectives as well as defining how it intends to compete in its markets (Slack et al. 2000). The business strategy guides the business in an environment, which consists of its customers, markets and competitors, but also includes the corporate group of which it is a part.

Operations strategy: Finally, each function (marketing, finance, research and development (R&D), operations, etc) within the business unit will need to consider what part it should play in contributing to the strategic and/or competitive objectives of the business. **Operations strategy**, for example, will need to translate the business objectives into terms, which have meaning for them and consider how best they should organise their resources to support them. Suppose the business strategy requires a reduction of 50 percent in the length of the business cycle time. Senior management from operations, marketing, finance would get together to assess how their activities could reduce the business cycle time by 50 percent.

Operations might try to reduce its purchasing and production cycles by reducing its supplier base, certifying suppliers, and implementing a just-in-time (JIT) strategy. **Marketing** might decide to create strategic alliances with its distributors that would shorten the average time to release a new product. **Finance** might decide to eliminate unnecessary approval loops for expenditures by introducing electronic funds transfer (EFT) payments in conjunction with operation's JIT strategy. All these activities are listed in an action plan, which shows who is going to be responsible to implement the initiatives listed above. Figure 2.3 shows a typical action plan using a tree diagram for reducing the business cycle time by 50 percent.

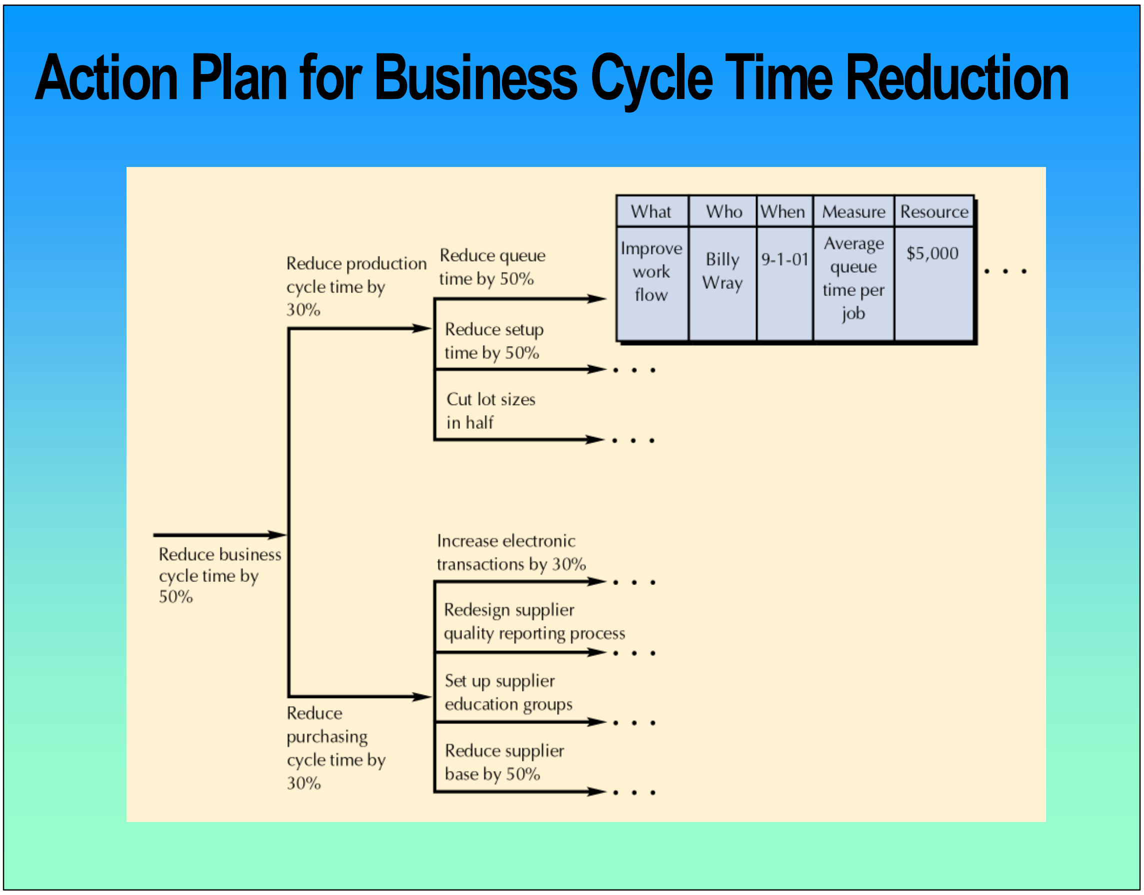

Figure 2.3 Typical Tree Diagram of Business Cycle Time Reduction

Adapted from Rusell and Taylor III (2000: 42)

For simplicity, however, only the top branch of the tree diagram is completed in which Billy Wray is given $5,000 to reduce the average queue time per job by 50%. Similarly, all the branches of the tree diagram are completed for each activity, which will, in turn, contribute to strategic plan (i.e., a reduction of 50% in the length of the business cycle time).

The nature and content of operations strategy

As discussed earlier in the introduction section, operations strategy has two dimensions, namely, *content* and *process*. Content explores what the strategy should contain including the collection of policies, plans and behaviour, which the operation chooses to pursue. Process explores how the strategy should be developed and shows the way in which the policies, plans and behaviour are decided.

Content splits into *performance objectives* and *policy decisions*. The performance objectives specify what the organisation wants to be good at, while the policy decision areas specify how the organisation will seek to achieve the level of performance it desires. For example, if the organisation wants to be good at meeting its quality promises (performance objective), it might choose to buy state of the art technology equipment that will enhance quality standards (policy decision).

In terms of the performance objectives, we have discussed in Chapter 1 that an operation in an organisation "contributes to achieving an operations-based advantage through five 'performance objectives'" (Slack et al. 2000: 44), namely, quality; speed; dependability; flexibility; and cost. The real question however is: Is it possible for an organisation to be able to excel always in all five-performance objectives? Unfortunately, it is not possible to be always good in quality; speed; dependability; flexibility; and provide services and products at the right prices simultaneously, therefore, priorities have to be assigned to the performance objectives.

In terms of policy decision, there are three main types of policy decision. (a) Design decisions: are those, which relate to the number, size, location of facilities, product/service design, layout technology and human resources. (b) Planning and control decisions: are those concerned with capacity adjustments and the systems, which manage the delivery of products and services. (c) Improvement decisions: are those focused on monitoring and improving the operations performance. Operations performance can be improved in a variety of ways.

To improve quality, for example, an organisation can invest in advanced manufacturing technology, known as the Sate-of-Art Technology in Operations (Heizer & Render, 1999: 271-285), and/or simplify the assembly process, and/or increase the use of statistical process control, and/or hire more inspectors, and/or implement total quality management, etc. The problem however is that companies do not have the resources to do all of the things they might wish to. Even if they did, some approaches, e.g., employ more inspectors and implement total quality management might be in conflict with one another.

To improve operations performance then an organisation needs a rational and holistic decision process which will help it to determine what it should be doing at a particular point in time, and why. Formulating an operations strategy is one way of improving performance.

Finally, it should be acknowledged that operations strategy is *dynamic* because of the *changes within the organisation*. All areas of an organisation are subject to change. Changes may be in a variety of areas, including finance, technology, procurement, etc. All may make a difference in an organisation's strengths and weaknesses and therefore its strategy. Strategy is also dynamic because of changes in the *environment*. The Internet caused Microsoft's shift in strategy. Microsoft moved to distributing some software products over the Internet to provide both fast and economic delivery. Also KPMG is known as the company that became an e-business "digital transformation" (Patel & McCarthy, 2000). Along with the digital conversion, KPMG has changed the business process associated with them. For example, information formerly exchanged as text on paper, such as an order form, can now be exchanged as a digital file and distributed to several "subscribers" simultaneously, without first having to be copied. KPMG is an example of how strategy must change as the environment changes.

The relative importance of the performance objectives

In the first chapter of this course we have discussed the meaning of the five performance objectives (i.e., quality, speed, dependability, flexibility, and cost) but we did not discuss under what circumstances some of the performance objectives might become particularly important to an organisation. According to Slack et al (1998) the relative importance of the performance objectives is a function of at least three different influences: (a) the specific needs of the company's customer groups; (b) the activities of the company's competitors; and

(c) the stage the product/service is in its life cycle. The influences on the relative importance of the performance objectives are shown in Figure 2.4 below.

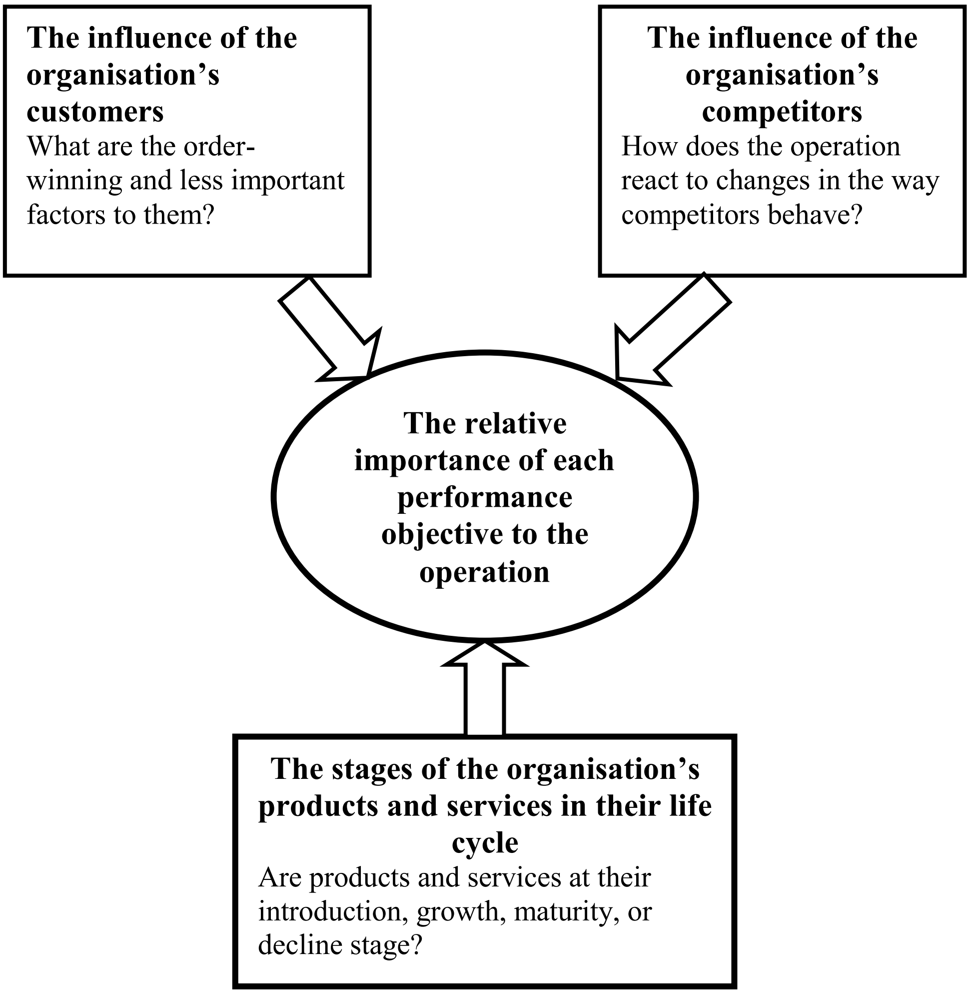

Figure 2.4 Influence of Performance Objectives

Adapted from Slack et al. (1998: 79)

Different customers want different things: If your customer purchases your products/services because you offer low prices, then low cost becomes important. For example, the emphasis of Southwest Airlines is on its cost performance. Southwest Airlines' strategy of low cost and controlled growth is supported by carefully designed services, efficient operations, and committed personnel. Southwest uses only one type of aircraft, the Boeing 737, to facilitate crew changes and to streamline training, record-keeping, maintenance, and inventory costs.

Since its flights are limited to short routes (about an hour), all flights are direct. That means no baggage transfers and no meals to be served. There are no assigned seats and no printed boarding passes for flights. Southwest also saves $30 million per year in travel agent commissions by requiring customers to call the airline directly to book flights. In summary, the essence of the operations at Southwest Airlines is to add value during the transformation process by emphasising continuous service design improvements. Activities that do not add value are considered by Southwest Airlines to be wasteful and hence are eliminated. The result? Southwest Airlines boasts the lowest cost per passenger mile and the highest number of passengers per employee in the industry, as well as the most on-time arrivals. Then, low cost becomes of strategic importance to Southwest Airlines.

Similarly, if your customers want error-free products and services, then quality becomes important. (The Ritz Carlton Hotel Company is a Baldrige Award winner and a recognised symbol of quality.) If the customers want fast delivery, then speed becomes of strategic importance. (Service organisations such as Citicorp, McDonald's, LensCrafters, and Federal Express have always competed on speed.) If customers want reliable delivery, then dependability becomes important. If they want a wide range of products and services, then flexibility becomes of strategic importance. The typical example of the strategic importance of flexibility is the so-called H-Y war in Japan in the early 1980s, when Honda challenged Yamaha's dominance of the motorcycle market by introducing and retiring 113 models within 18 months. Yamaha was able to introduce only 37 new models in that time frame.

Most companies have to satisfy various groups of customers: The majority of organisations deal with so-called heterogeneous customers. For example, an airline has to serve both business passengers and holidaymakers. The business passengers want to arrive at their destination fresh and ready to work, thus quality of service is of primary importance to them rather than cost. On the other hand, holidaymakers are not so interested to pay extra for better quality, so, cost to them is more important than quality of service. Since different customers have different requirements, organisations would be in trouble if they do not set up independent operating systems. In the case of the airline firms, the companies have divided the operation into business and economy class passengers.

The competition also influences customer preferences: Competitors actions can influence what customers value. Competitors can provide 'one-stop-shop' service, deal with customer complaints promptly, innovate continuously, be decisive when dealing with customer complains, create frequent buyers out of customers, reduce costs, increase speed, and develop systems to support customer service. A prominent example in Australia has been the need for Telstra to adjust to the introduction of competition in the telephone market. Nowhere has been more noticeable than in the long-distance call market where Telstra has had to respond to major price competition from new entrants in the telecommunications market such as Optus and OneTel. In the computer industry Apple's 'what you see is what you get (WYSIWYG) policy has had major ramifications. Traditionally computer users accepted that they had to enter long strings of apparently meaningless characters to access their systems. Now 'user-friendliness' is a major selling feature.

Order-winning and order-qualifying criteria: To be successful, organisations must identify and capitalise on what sets them apart from their competitors – their core competencies. To examine how to develop and fully utilise their core competencies organisations must determine *order-winners* and *order-qualifiers*. In other words, it is essential to determine what influences customers' purchase decisions. ***Order-winning*** criteria are those things, which directly and significantly contribute to winning business. They are regarded by customers as key reasons for purchasing the product or service. They are, therefore, the most important aspects of the way a company defines its competitive stance.

Raising performance for example is an order-winning factor if it either results in significantly more business or improves the chances of gaining more business. ***Order-qualifying*** criteria may not be the major competitive determinants of success, but are important in another way. They are those aspects of competitiveness where the operation's performance has to be above a particular level even to be considered by the customer. Below this 'qualifying' level of performance many customers probably will not even consider the company. Above the 'qualifying level', it will be considered, but mainly in terms of its performance in the order-winning criteria. Any further improvement in qualifying factors above the qualifying level is unlikely to gain much competitive benefit (Slack et al. 2000).

Order-winners and *order-qualifiers* can evolve over time, just as competencies can be gained and lost. Japanese carmakers initially competed on price but had to assure certain levels of quality before entering in the U.S. market. Over time, the customers were willing to pay higher price for the assurance of a superior-quality Japanese car. Price became a qualifier, but quality won the orders. In today's automobile market, high quality (standard of the automotive industry) has become an order- qualifier, and innovative design wins the orders. Therefore, it is of strategic importance for an organisation to meet the order-qualifiers and excel on the order-winners. Today, operations are called to develop additional competencies that are more in tune with customer preferences and market needs.

Activity 2.1

Visit the web site of two companies in the same industry. Can you identify how each company has chosen to compete? Use at least two order-winners and two order-qualifiers for each company to justify your answer.

The impact of the product life cycle

From our marketing colleagues we know that during the course of its ‘life’, a product or service passes through four main stages, namely, *introduction*, *growth*, *maturity*, and *decline*.

Introduction: When the product or service is first introduced to the market. Although this stage is characterised by slow growth in sales, it is the best period to increase market share.

Growth: When the product or service gains market acceptance. This stage is characterised by rapid growth in sales volume and it is practical to change price or quality image.

Maturity: When the market needs start to be fulfilled. This stage is characterised by sales slow down and level off and it is the worst time to change image, price, or quality. Competitive costs become critical and organisations usually defend market position.

Decline: When the market needs have been largely met. This stage is characterised by sale decline and cost control is often critical.

During each stage of the product/service life cycle both the overall strategy and the operations management strategy go through change. For example, Heizer and Render (1999) have suggested that as the product/service moves from introduction to growth, product/service and process design move from development to stability. As the product/service moves to the growth stage, forecasting and capacity planning become critical issues. Tables 2.1, 2.2, 2.3, and 2.4 show typical organisational strategies and operations management (OM) strategies and issues during the product/service stages of introduction, growth, maturity and decline, respectively.

Table 2.1 Strategy and Issues during Life Cycle - Introduction

Strategy & Issues During Life Cycle

	Introduction
Company Strategy & Issues	**Best period to increase market share** **R&D engineering are critical**
OM Strategy & Issues	**Product/service design and development are critical** **Frequent product/service and process design changes** **Over-capacity** **Short production runs** **High skilled-labor content** **High production/service costs** **Limited number of models** **Utmost attentions to quality** **Quick elimination of market-revealed design defects**

Table 2.2 Strategy and Issues during Life Cycle – Growth

Strategy & Issues During Life Cycle

Growth

Company Strategy & Issues	Practical to change prices or quality image Marketing is critical Strengthen niche
OM Strategy & Issues	Forecasting is critical Product/service and process reliability Competitive product/service improvements and options Shift toward product/service oriented Enhance distribution

Table 2.3 Strategy and Issues during Life Cycle - Maturity

Strategy & Issues During Life Cycle

Maturity

Company Strategy & Issues	Poor time to increase market share Competitive costs become critical Poor time to change price, image, or quality Defend position via fresh promotional and distribution approaches
OM Strategy & Issues	Standardization Less rapid product/service changes and more minor annual model changes Optimum capacity Increasing stability of manufacturing/servicing process Lower labor skills Long production runs Attention to product/service improvement and cost cutting Re-examination of necessity of design compromises

Table 2.4 Strategy and Issues during Life Cycle - Decline

Strategy & Issues During Life Cycle

Decline

Company Strategy & Issues	Cost control critical to market share
OM Strategy & Issues	Little product/service differentiation Cost minimization Overcapacity in the industry Prune line to eliminate items not returning Good margin Reduce capacity

Regarding the organisational strategies and operations management strategies further discussion will be carried out in a later section of this chapter dealing with the structural and infrastructural decisions of the operations (see section 'The operations strategy decision areas and their impact" below).

Having viewed the organisational strategies and operations management strategies from the product/service life cycle perspective, it is of particular importance to understand the relation (link) between the stages of product/service life cycle and the competitive factors of order-winners, order-qualifiers, and operations performance objectives. Table 2.5 below shows how product/service and industry characteristics are likely to vary through the different stages of the product/service life cycle.

Introduction: As shown (Table 2.5), when the product or service is first introduced it is likely to be presented to the market on the basis that it is offering something new in terms of design or performance. If the product or service is really novel, few if any competitors will be offering the same product/service and, because the number of customers is relatively low and because their needs are possibly not perfectly understood, the design of the product or service could be subject to frequent changes. Given the relatively high uncertainty inherent in these market conditions the operations management of the company can best contribute by developing the flexibility to cope with changes in the specification of the product or service and possibly also in output volume. At the same time operations must maintain the quality level so as not to undermine the performance of the product or service which is the main basis of competition.

Table 2.5 The Impact of the Product/Service Life Cycle

Stage	Introduction	Growth	Maturity	Decline
Volume	Low	Rapid growth	High and level	Declining
Customers	Innovators	Early adopters	Bulk of market	Laggards
Competitors	Few/none	Increasing number	Stable number	Declining number
Variety of product or service	High customisation	Increasingly standardised	Emerging dominant types	Commodity standardisation
Likely order winners	Performance or novelty	Availability of quality products and services	Low price, dependable supply	Low price
Likely order qualifiers	Quality, product range	Price, product range	Product range, Quality	Dependable supply
Operations performance objectives	Flexible Quality	Speed Dependability Quality	Cost Dependability	Cost

Growth: Table 2.5 shows that if the product or service survives its introduction to the market it will begin to be more widely adopted and the volume will start to grow rapidly. Competitors, seeing the high volumes of product/service will be motivated to develop their own versions both to keep up with the market and to protect their own position within it. In order to win customers in such an environment, the operations challenge is on its ability to keep supplying quality products and service to customers. This could be achieved with the standardisation of the products or services. Standardisation would obviously assist the operations to support market's high demands. In fact, experience has shown that standardisation of the operations could prove to be the main preoccupation of operations. The increasing competition also means that the company cannot afford to let its quality levels drop as it ramps up its level of activity. Thus, in terms of the operations performance objective, the crucial performance variables are speed, dependability and quality.

Maturity: After a period of growth, products or services are no longer the novel or even the 'up-and-coming' forces in the market. Demands begin to level off and new variety of products or services emerge. The basis of competition shifts to price or value for money and dependability of supply (see Table 2.5). During the maturity stage of the product/service life cycle the operations are called to deliver products and services at low prices.

Decline: When the product or service has been in the market for some time and demand has largely been met the basis of competition shifts almost entirely to price. Operations concerns will be therefore in innovating methods/techniques that will drop prices at the lowest level.

The operations strategy decision areas and their impact

There are two major categories of decision areas: Structural and infrastructural.

Structural decisions are concerned with:

- New product/service development strategy – should the operations develop its own products or services? If so, how?
- Vertical integration strategy – should the operation expand by acquiring its suppliers or customers? If so, who should it acquire and why?
- Facilities strategy - what number of geographically separate sites should the operation have? Where should they be? What should they do?
- Technology strategy – what broad types of technology should the operation be using? What types of technology, if any, should it be developing? For example, Intel estimates that it "takes 70 percent less time to process a transaction using e-business" (Patel & McCarthy, 2000:75).

Infrastructural decisions are concerned with:

- Workforce and organisation strategy – what role should the people who staff the operation play in its management? How should responsibilities for the activities of the operations be split between the different teams?
- Capacity adjustment strategy – how should the operation forecast and monitor demand?
- Supplier development strategy – how should the operation choose its suppliers? How should it develop its relationship with its suppliers?

- Inventory strategy – how much inventory should the operation have? Where should it be located?
- Planning and control systems strategy – what systems should the operation use to plan its future activities?
- Improvement process strategy – who should be involved in the improvement process? What they should do? How fast should the operation expect/seek to improve?
- Performance measurement strategy – how should the performance of the operation be measured? How should the operation decide whether its performance is satisfactory?
- Failure prevention and recovery strategy – how should the operation maintain its resources so as to prevent failure? How should the operation plan to cope with a failure if one occurs?

Slack et al. (2000: 79) illustrates the impact of the structural and infrastructural decisions on the performance objectives of quality, speed, dependability, flexibility, and cost (see Table 2.6). As shown, all structural and infrastructural decisions impact the performance objective of cost.

Table 2.6 Structural and Infrastructural Strategic Decision Areas

Structural and Infrastructural Decisions	Q	S	D	F	C
New product/service development	√				√
Vertical integration strategy		√	√		√
Facilities strategy		√	√	√	√
Technology strategy	√			√	√
Workforce and organisation strategy	√			√	√
Capacity adjustment strategy		√		√	√
Supplier development strategy	√		√		√
Inventory strategy		√	√		√
Planning and control strategy		√	√		√
Improvement process strategy	√	√	√	√	√
Failure prevention and recovery strategy	√		√		√

Legend: √ = denotes impact
Q = Quality;
S = Speed;
D = Dependability;
F = Flexibility; and
C = Cost

How operation strategies are put together

Organisational managers can either adopt generic strategies, common approaches to organising the operations, or develop company-specific strategies. Review of the literature revealed two well-established processes for helping managers develop company-specific strategies. These are: the Hill methodology (Hill, 1993) and the Platts-Gregory methodology (Platts & Gregory, 1990). A detailed discussion of these two methodologies is given by Slack et al. (1998:94–98). We have selected however, to present in this chapter the most frequently used-by-managers-strategy formulation methodologies (see below).

Most used strategy formulation methodologies:

- provide a process which formally links the organisation's strategic objectives to resource level objectives;
- use competitive factors as the translation device between business strategy and operations strategy;
- include a step which involves judging the relative importance of the various competitive factors in terms of customer's preference;
- include a step which involves assessing current achieved performance, usually as compared against competitor performance levels;
- emphasise that operations strategy formulation is an iterative process; and
- build on the concept of 'ideal' or 'green field' models.

If you were starting from scratch what would you do and how?

The effectiveness of an operations strategy:
Operations strategies should be:

- appropriate – they should show how the operation can support the company's competitive advantage;
- comprehensive – they should indicate how all parts of the operation are expected to perform;
- coherent – the policies recommended for each part of the operation should all point roughly in the same direction;
- consistent over time – the lead time of operations improvement means that consistency must be maintained over a reasonable time period; and
- credible -the strategy must be regarded as achievable otherwise it will not be supported

In conclusion, Table 2.7 shows the basic steps that managers usually follow in order to put the operations strategies together.

Table 2.7 Formulation of Operations Strategies in Practice

How Operations Strategies Are Put Together

Identify what is wanted in the market place

⇩

Established how well the operation performs versus its competitors

⇩

Identify what the operation needs to do better

⇩

Identify how the operation could do these things better

⇩

Implement the strategy

Activity 2.2 - CASE PROBLEM

Whither an MBA at Strutledge?

Strutledge is a small private liberal arts school located within 80 Km of a major urban area in the South East United States. As with most institutions of higher education, Strutledge's costs are rising, and its enrolments are decreasing. In an effort to expand its students base, build valuable ties with area businesses, and simply survive, the Board of Regents is considering establishing an MBA program.

Currently, no undergraduate degree is given in business, although business courses are taught. The dean of the school visualises the MBA as an interdisciplinary program emphasising problem solving, communication, and global awareness. Instructors from local industry would supplement faculty expertise. The use of local faculty would better connect the university with the business community and provide opportunities for employment of the program's graduates.

In terms of competition, a major state-funded university that offers an MBA is located in the adjacent urban area. Strutledge hopes that state budget cutbacks and perceptions of overcrowded classrooms and overworked professors at public institutions will open the door for a new entrant into the market. The Board of Regents also feel that the school's small size will allow Strutledge to tailor the MBA program more closely to area business needs.

Several members of the Board are concerned about recent reports of the dwindling value of an MBA and are wondering if a better niche could be found with another graduate degree, perhaps a Master of Science in business or something in the education or health-care field.

Activity 2.2

In groups of three attempt to answer the following questions:

1. What action would you recommend to the Board of Regents?

2. How should Strutledge go about making a strategic decision such as this?

Source: Russell & Taylor III (2000: 50)

Complete the following questions

TRUE/FALSE QUESTIONS

1. Strategy is a common vision that unites an organisation. **True**

2. The primary task of a firm is never found in the mission statement. **False**

3. Core competency is what a firm does better than most anyone else. **False**

4. To be successful, companies must identify and capitalise on what sets them apart from other firms. **True**

5. Companies that compete on cost relentlessly pursue the elimination of waste. **False**

6. The forming of an alliance is not an effective method for competing on speed. **False**

7. The process chosen to provide the product or service need not be consistent with the product or service characteristics. **False**

8. The term "order qualifier" refers to the characteristic of a product or service that wins orders in the marketplace. **False**

9. A key aspect of a firm's strategy is to identify what they do best. **True**

10. A key aspect of a firm's strategy is to identify what makes the most money. **False**

11. To compete on speed, companies must expect radical change. **True**

12. Strategy produces inconsistency in decision making. **False**

13. Companies that compete on cost must rely on short-term cost reductions. **False**

14. An organisation should excel on order-winners. **True**

15. An organisation should meet order-qualifiers. **True**

16. An effective positioning strategy considers the needs of the marketplace. **True**

17. Core competencies are the essential capabilities that create a firm's sustainable competitive advantage. **True**

18. When competing on speed, decision making is pushed down the organisation structure. **True**

19. It is easier to identify core competencies when strategies centre around processes. **True**

20. Formulating strategies is more difficult than implementing the strategy. **False**

21. It is not important that everyone in an organisation understand the strategic plan. **False**

22. The strategic plan should focus on the gap between the firm's vision and its current position. **True**

23. Operating systems execute strategic decisions on a day-to-day basis. **True**

MULTIPLE CHOICE QUESTIONS

1. Firms can compete on

   a) cost

   b) capitalisation

   c) primary task

   d) direction

2. Made-to-order products and services are

   a) produced in standard modules

   b) made in anticipation of demand

   c) made to customer specification

   d) made to standard modules in anticipation of demand

3. A good positioning strategy considers

   a) strengths and weaknesses of the organisation

   b) needs of the marketplace

   c) position of competitors

   d) all of the above

4. Which of the following is *not* one of the basic steps of strategy formulation?

   a) defining a secondary task

   b) assessing core competencies

   c) determining order-winners and order-qualifiers

   d) positioning the firm

5. Order-qualifiers

   a) are characteristics that win orders

   b) never change

   c) are characteristics that qualify an item

   d) none of the above

6. Order-winners

   a) are characteristics that win orders

   b) never change

   c) are characteristics that qualify an item

   d) none of the above

7. A positioning strategy should consider

   a) the strengths of the organisation

   b) the needs of the marketplace

   c) the position of the competition

   d) all of the above

8. A company that works to be able to adjust to changes in product mix, production volume, or design is

   a) competing on cost

   b) competing on quality

   c) competing on speed

   d) competing on flexibility

9. Strategic decisions in operations can involve

   a) products and services

   b) capacity and facilities

   c) quality

   d) all of the above

10. Which of the following is *not* a strategic human resource issue?

    a) degree of worker autonomy

    b) skill level required of workers

    c) performance evaluation policies

    d) handling excess demand

11. Which of the following is *not* a strategic quality question?

    a) What is the target level of quality?

b) How will it be measured?

c) How many workers should be hired?

d) What will be the employees' involvement with quality?

SHORT-ANSWER QUESTIONS

1. What are the two roles that operations can play in corporate strategy?

2. What are some key strategic issues that a firm faces in terms of capacity and facilities?

3. What are the key issues of strategic quality?

4. In sourcing, what are major strategic decisions?

Summary

This chapter provided an introduction to operations strategy. In particular, it focussed on the strategic importance of operations management and how operations management can provide a competitive advantage in the market place. The chapter also examined the strategy hierarchy, of which operations strategy is a part, and discussed the importance of the order-winning and order-qualifying criteria.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic establishes the context for the rest of the chapter?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember that if you need assistance in your study, the faculty is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Introduction to operations strategy

- [ ] The content of operations strategy
- [ ] The process of operations strategy

Operations strategy

- [ ] The strategy hierarchy of which operations is a part
  - [ ] Corporate strategy
  - [ ] Business strategy
  - [ ] Operational strategy
- [ ] The nature and content of operations strategy
- [ ] The relative importance of the performance objectives
  - [ ] Order-winning and order-qualifying criteria
- [ ] The impact of product life cycle
  - [ ] Strategy and issues during life cycle (Ref.: Tables 2.1- 2.4)
- [ ] The operations strategy decision areas and their impact
- [ ] How operation strategies are put together
  - [ ] The effectiveness of an operations strategy

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this topic with the lecturer or another student.

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Chapter 3 Design in Operations Management

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Design in operations management

Learning outcome

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- develop an understanding of the basic principles of *both* the design of products and services and the design of the processes, which create them.
- understand how the design principles will be related to an organisation's customers, as well as its competitors.
- understand the nature and purpose of the design activity in operations; the way in which the purpose of the design activity must always be to satisfy customers and the way in which products, services and processes are designed; how design can be considered to be a decision-making process.
- understand the responsibility/influence that operations managers have on the 'technical' design of the products and services they produce.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Understand, what is design in operations management; what objectives should the design activity have; how can design decisions be made; how the design activity differs in different types of operations; and what are 'process types'
- Understand the nature and purpose of the design activity
- Understand that design means satisfying customer needs
- Understand and accept that products, services and processes can all be designed
- Acknowledge that the design activity is a decision-making process
- Be familiar with the process types in manufacturing and service
- Examine the consequences of cost and flexibility using the product-process matrix and customisation-labour intensity matrix.

What you will need

Suggested study time	Text Book	6 hours
	Activities and exercises	2 hours
Other resources:	Suggested readings	4 hours
	Total:	12 hours

Introduction

Many organisations today are on the forefront by selling smaller and more compact products and by providing less expensive and a lower level of customer contact services. Designing and developing products and services of this nature are key elements to gain competitive edge in today's global economy. Innovative design can bring new ideas to the market quicker, aiming at meeting or exceeding customers' expectations. Listening to the 'voice' of the customers and learn exactly what they want is the only way to lever core competencies for achieving competitive advantage (Mizuno & Akao, 1994). But how can organisations determine how best to fulfil customers' expectations with available resources? What is the role of design in operations management in this effort? What is the difference between *product*, *service* and *process* design?

Product design specifies which materials are to be used, determines dimensions and tolerances, defines the appearance of the product, and sets standards for performance. Service design specifies what physical items, sensual benefits, and psychological benefits the customer is to receive from the services (Rusell & Taylor III, 2000). Finally, Process design specifies the capacity to produce the volume of the products and services that customers want and makes provision for expanding or contracting the capacity to keep pace with the trends of sales (Gaither, 1996).

Generally, design is the activity, which shapes the physical form and purpose of *both* products and services and the processes, which produce them. It is an activity, which starts with a concept and ends in the translation of that concept into a specification of something, which can be created. According to Rusell and Taylor III (2000), customers (the 'voice' of the customers) generate ideas for a *product/service concept* that is sent to the marketing department, which in turn is developed into preliminary *performance specifications* and then detailed into *design specifications* by the design professionals. These specifications are then sent to the operations department to form the *production specifications* through which the process operators will generate the products or services that will meet and/or exceed customers' expectations. In the language of Total Quality Management this is known as Quality Function Deployment (Besterfield, Besterfield-Michna, Besterfield, & Besterfield-Sacre, 1999). (see discussion on Quality Function Deployment later in this chapter.)

In operations management the chain of activities that take place from the product concept to the final product or service is known as 'sequential design', with physical and mental "walls" which tend to build between the different departments that are associated in the design process. The steps of this sequential design are shown in Figure 3.1 (a) below. As shown, in this approach, the output from one design stage is "thrown over the wall" to the next stage, with little discussion or feedback. The *modern operations management design* however, has introduced a more enlightened view of product and service design aiming at "*breaking down the barriers*", and increasing communication and feedback by bringing representatives from the various departments *together* to work on the design. This modern approach to design is known as *"concurrent design"* and the representatives from the various departments are called the *"design team"*. (see Figure 3.1(b), below.) Because of its significance, a detail discussion of concurrent design will be presented later in this chapter.

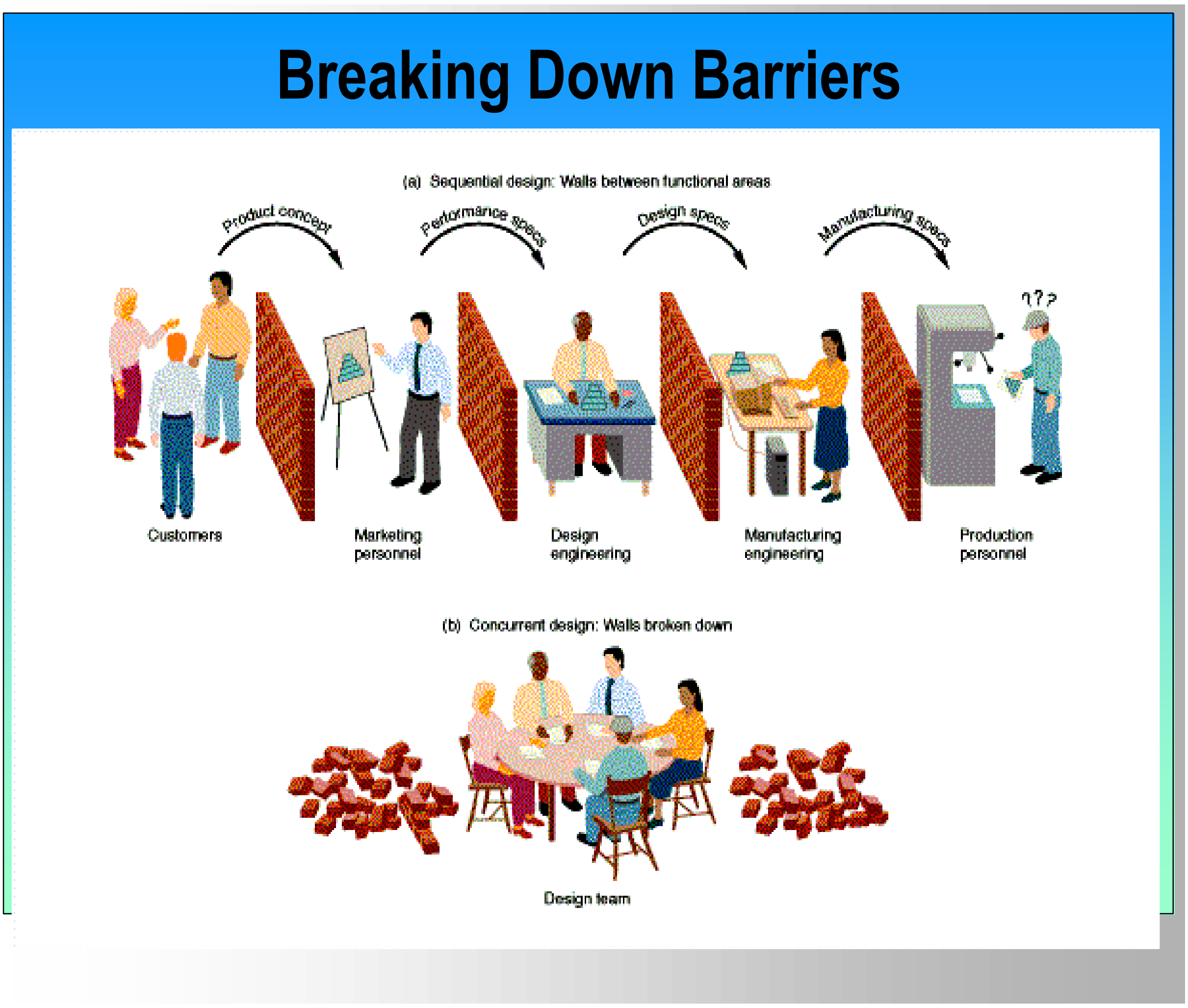

Figure 3.1 Breaking down the Barriers to Effective Design

Adapted from Rusell and Taylor III (2000: 188)

Whether it is concurrent or sequential design, the design activity can be viewed as a *transformational process* in the same way as any other operation. It therefore can be judged in terms of its *quality, speed, dependability, flexibility and cost.* The design activity must also take into account the environmental issues. These include examination of the source and suitability of materials, the sources and quantities of energy consumed, and amount and type of waste material, the life of the product itself and the end-of-life state of the product.

In general, design is a multi-stage process, which moves from concept through to a detailed specification. At each stage it is important to understand the design options and evaluate these in terms of their feasibility, acceptability and vulnerability. As the design activity progresses through its stages uncertainty regarding the finished design is reduced. This makes it increasingly difficult to change previous decisions.

The nature and purpose of the design activity

All operations managers make decisions, which shape the design of the manufacturing or service delivery process. These decisions are associated with buying new equipment; changing the layout of the operations; introducing new systems; and providing resources, which are capable of producing the product or service to its design specifications. Operations managers also have an influence on the technical design of the product and services by providing designers with information, which specifies what the operation can do, and, by implication what the operation cannot do.

As discussed earlier in the introductory section of this chapter the purpose (objective) of design is to satisfy customers needs, and meet and exceed customers' expectations. These objectives can be achieved through an effective design process which:

- matches product or service characteristics with customer requirements;
- ensures that customer requirements are met in the simplest and least costly manner;
- reduces the time to design a new product or service; and
- minimises the revisions necessary to make a design workable.

The success of such an effective design process is based upon the **four Cs** of design namely, *creativity*, *complexity*, *compromise*, and *choice*.

Creativity: design requires the creation of something that has not existed before;

Complexity: design involves decisions on a large number of parameters and variables;

Compromise: design requires balancing multiple and sometimes conflicting requirements;

Choice: design requires making choices between many options.

Finally, the design activity has to comply with the **Uniform Commercial Code** practices (i.e., products and services carry an implication of merchantability and fitness), that is, a product and service must be usable for its intended purpose (Stevenson, 1999). It is therefore important to design products and services that are free of hazards. When hazards do exist, it is necessary to install safety guards or other devices for reducing accident potential, and to provide adequate warning notices of risk. Complying with commercial code practices means that the design should be environmentally sensitive, that is, increasing customer awareness of product/service safety and taking into account 'green" issues. Increasing environmental awareness means that design will change. Change of design would include key factors that the *design team* needs to take responsibly into account, knowing that these factors trade-off with one another. Such factors include:

- sources of materials used in a product
- quantities and sources of energy consumed in a process
- the amount and type of waste material that is created during the production process
- the life of the product itself
- the end-of-life of product – can the product be disposed of safely? Can it be recycled?

To help make more rational decisions in the design process, some organisations are experimenting with *Life Cycle Analysis* to explore these tradeoffs (Slack et al. 2000). For example, Volvo (www.volvocars.com) automobile maker together with the Federation of Swedish Industries (www.industriforbundet.se) and the Swedish Environmental Research Institute (www.ivl.se/en) have developed Volvo's environmental strategies (EPS) system aiming at assessing the energy costs of producing, running and disposing of their products (Horkeby, 1993). Similarly, Ford (www.ford.com), GM (www.gm.com) and Chrysler (www.chryslercorp.com) have jointly formed the Vehicle Recycling Partnership in hopes of improving the technology to recover plastics and other material found in "fluff". Suppliers of materials and the recycling industry are included in the partnership.

The purpose of design is to satisfy customers

Product and service design plays a strategic role in the degree to which an organisation is able to achieve it goals (Stevenson, 1999). It is a major factor in customer satisfaction, quality, and cost. In relation to customer satisfaction, experience in Australia, the United Arab Emirates and elsewhere has shown that employees (peers), or managers usually ignore the satisfaction of the internal customer. It must be emphasised that the purpose of the design activity is to satisfy *both* internal and external customers. Product and service designers seek to create things which:

- are aesthetically pleasing;
- satisfy needs;
- meet or exceed customer's expectations;
- perform well;
- are reliable; and
- are easy to produce and deliver.

Operations managers tend to focus on the design of the transformational process aiming to satisfy *both* internal and external customers. A typical design of the transformation process from the generation of an idea to producing and delivering products or services is shown in Figure 3.2 below. Following is a brief description of each of the main steps of the design process.

Idea generation: Ideas come from many sources, including customers, competitors, and research and development. Building the 'House of Quality' matrix as part of the Quality Function Deployment (http://mijuno.larc.nasa.gov/dfc/qfd.html) means that the 'voice' of the customer is translated into the technical and process design requirements (Besterfield et al. 1999).

Feasibility study: A feasibility study consists of a market analysis, an economic analysis, and a technical/strategic analysis.

Preliminary design: Preliminary design involves testing and revising a prototype product and service. The preliminary design is concerned with how the product/service will perform or how the product/service will be received/evaluated by customers. Both *maintainability* and *reliability* are also considered during the preliminary design.

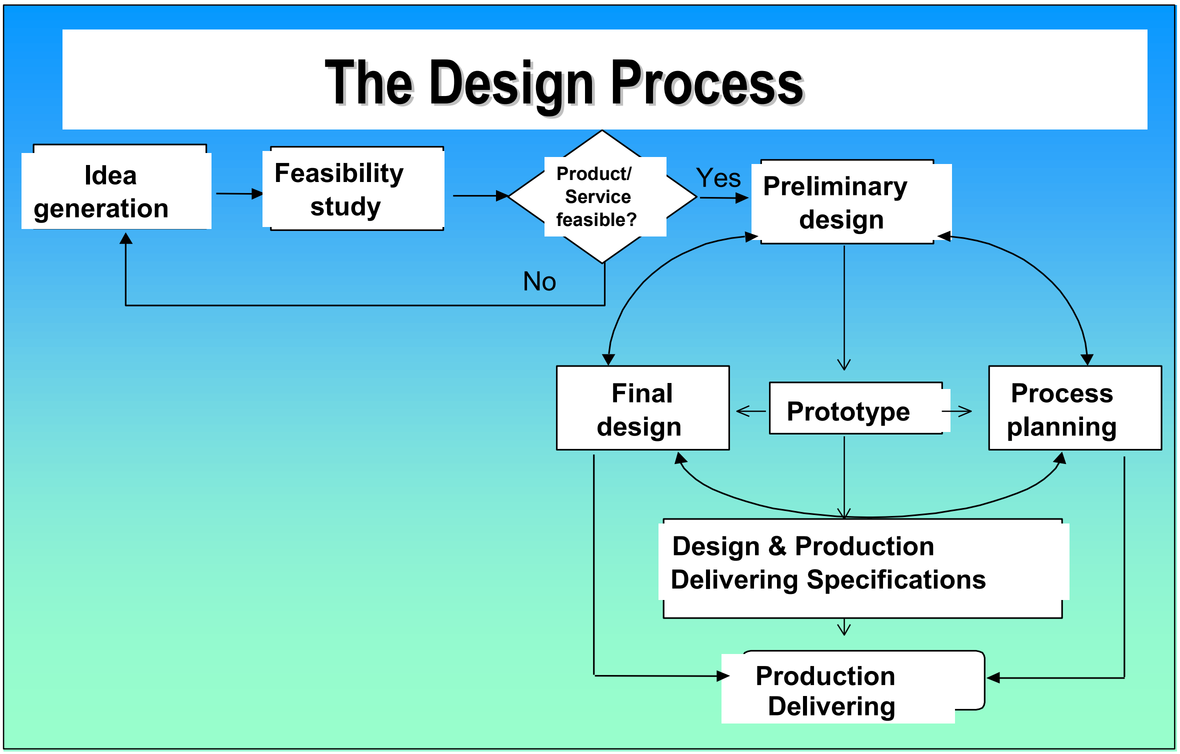

Figure 3.2 The Design Process

Adapted from Rusell and Taylor III (2000: 189) and modified by the author to accommodate service process

Final design and process planning: Final design produces detailed drawings of the new product or detailed specifications of the new service after the preliminary design has been tested and a trial production or delivery has taken place. Process planning converts designs into workable instructions for the production of the product or the delivery of the service. It also selects and orders resources necessary for the production of the new product or the delivery of the new service.

Table 4.1 illustrates the elements of the process planning and design and its inputs and outputs. Knowledge about operations strategies, product/service designs, technologies of the operations system, and markets are used to develop the detailed plan producing or delivering products and services. The outputs of these studies results in a complete determination of the individual technological process steps to be used and the linkages among the steps; the selection of equipment; design of buildings, and layout facilities; and the number of personnel required, their skill level, and their supervision requirements.

Once process planning has been completed, the fundamental structure and character of the operations activities is set. This important activity determines in large measure the details of how products/services will be produced and it positions operations to be used by the business to capture world markets. But who does the planning? Is it an effort of an individual department or an individual expert (the planner)?

Table 4.1 The Process Planning and Design System

Inputs	Process Planning & Design	Outputs
1. Product/Service Information • Product/service demand • Prices/volumes • Patterns • Competitive environment • Consumer wants/needs • Desired product/service characteristics	**1. Select Process Type** • Coordinated with strategies	**1. Technological Processes** • Design of specific processes • Linkages among processes
2. Production System Information • Resource availability • Production economics • Known technologies • Technology that can be acquired • Predominant strengths weaknesses	**2. Vertical Integration Studies** • Vendor capabilities • Acquisition decisions • Make-or-buy decisions	**2. Facilities** • Building design • Layout of facilities • Selection of equipment
3. Operations Strategy • Positioning strategies • Competitive weapons needed • Focus of factories & service facilities • Allocation of resources	**3. Process/Product Studies** • Major technological steps • Minor technological steps • Product/service simplification • Peroduct/service standardization • Product design for producibility • Service design for deliverability	**3. Personnel Estimates** • Skill level requirements • Number of employees • Training/retraining requirements • Supervision requirements
	4. Equipment Studies • Level of automation • Linkages of machines • Equipment selection • Tooling	
	5. Production/Delivery Procedures Studies • Production/delivery sequence • Materials specification • Personnel requirements	
	6. Facilities Studies • Building/office designs • Layout of facilities	

Adapted from Gaither (1996: 125) and modified to accommodate service process

The team approach to product and service process planning and design has proved to be successful worldwide. Full-time participants from marketing, engineering, operations, quality, customers, dealers, suppliers, accountants, lawyers, and others are all useful team-members. A recent study of new product launching in high-technology firms concluded that the critical factor between success and failure was the involvement and interaction of the "create, make, and market" operations from the beginning of the design project (Rusell and Taylor III, 2000). Ford Motor Company (www.ford.com) for example, has been a leader in the team approach to product design in the automotive industry and in the U.S. industrial world. Similarly, Federal Express (www.fedex.com), and Nordstrom (store.nordstrom.com) among others have used the team approach to service design.

In summary, it is to be emphasised that the product/service and process designs are interrelated and this interrelationship means that there is a certain overlap between them (see Figure 3.3). It is pointless committing to a detailed product design without considering how the product can be made. Changing product or service design can have major process implications, especially in terms of costs and delivery. Because of this implication, product/service and process design have to be managed together. In other words, product/service designs should be evaluated in terms of their implications for processing costs as well as their functionality.

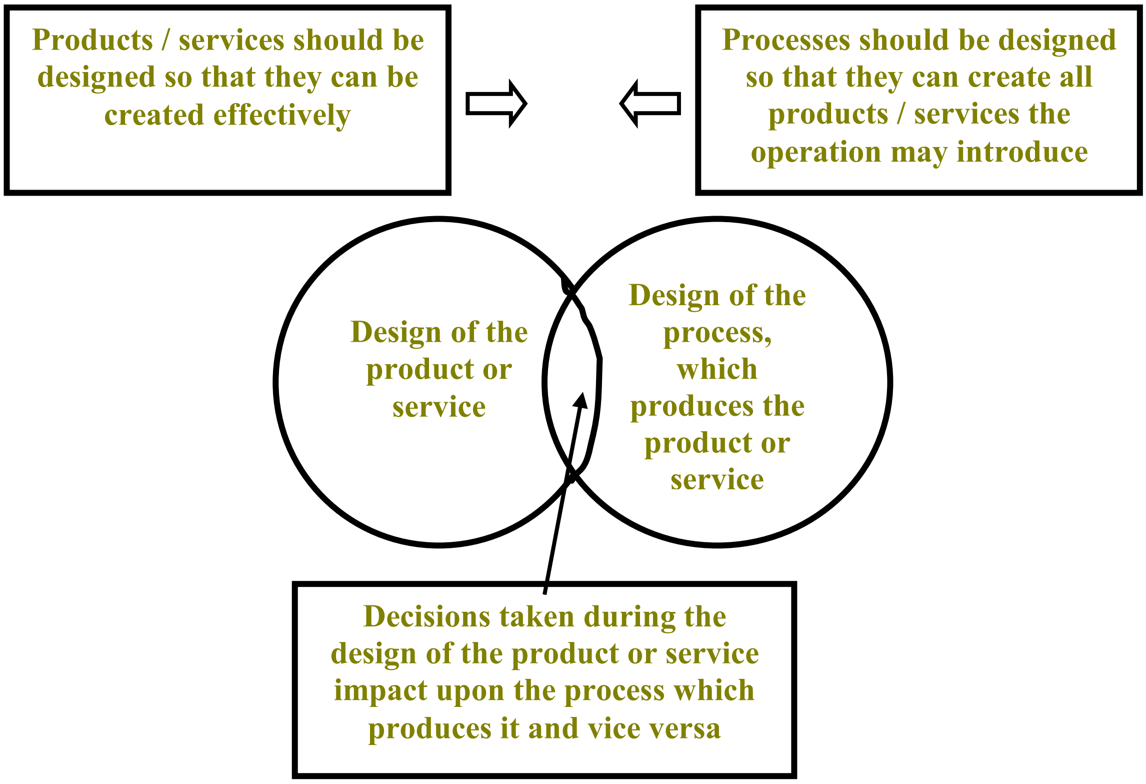

Figure 3.3 Interrelationship between Product/Service and Process Design

Adapted from Slack et al. (1998: 112)

The degree of overlap between product/service and process design governs the speed to market performance objective. Reducing time to market involves managing the product/service and process overlap carefully. Often this overlap is greater in services, as services can rarely be separated from the process, which delivers them. Thus, the design of services is crucial for organisations that aim at becoming world-class service providers.

Design of Service

Services that are allowed to just 'happen' rarely meet customer needs. The service provider is left to figure out what the customer wants and how the service should be provided without sufficient support from management, policies and procedures, or physical surroundings. World-class services such as McDonalds (www.mcdonalds.com), Nordstrom (www.nordstrom.com), Federal Express (www.fedex.com), and Disney World (www.disney.go.com) are all characterised by impeccable design. McDonald's plans every action of its employees (including forty-nine steps to making perfect french fries); Nordstrom creates a pleasurable shopping environment with well-stocked shelves, live music, fresh flowers in the dressing rooms, and legendary salespersons; Federal Express designs every stage of the delivery process for efficiency and speed; and Disney World in Japan (www.disney.co.jp) was so well designed that it impressed even the zero-defect Japanese.

Can services be designed in the same manner as products? Although there are some important differences between products and services the service process design would look much the same as the product process design. Figure 3.4 shows a generic service process design that is not that different from that of product process design. (Note changing service with product and delivery with manufacturing gives the product process design.)

The differences between products and services are presented in the section that follows.

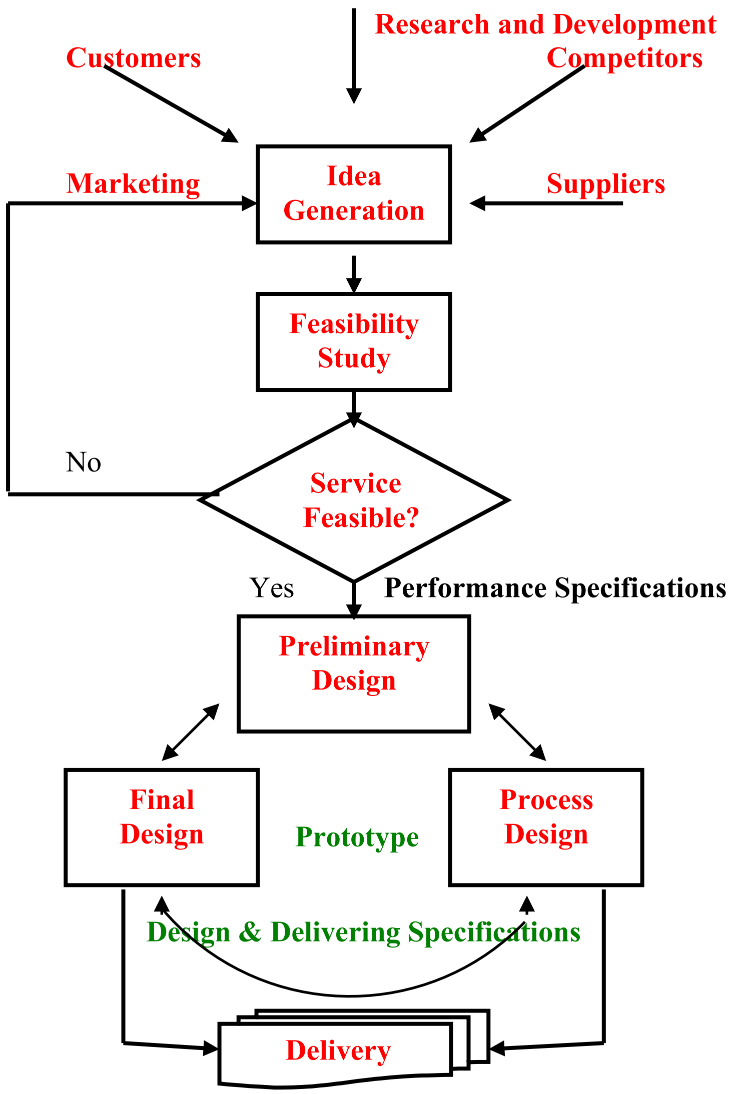

Figure 3.4 Generic flowchart of Service Process Design

Characteristics of Services

Services can be distinguished from manufacturing by the following eight characteristics. Although not all services possess each of these characteristics, they do exhibit at least some of them to some degree.

1. Services are intangible

It is difficult to design something you cannot see, touch, store on a shelf, or try on for size. Services are experienced, and that experience may be different for each individual customer. Designing a service involves describing what the customer is supposed to 'experience', which can be a difficult task. Designers begin by compiling information on the way people think, feel, and behave, an approach that is called psychographics or Quality Function Deployment.

Because of its intangibility, consumers perceive a service more risky to purchase than a product. Cues (such as physical surroundings, server's demeanor, and service guarantees) need to be included in service design to help form or reinforce accurate perceptions of the service experience and reduce the consumer's risk. The quality of a service experience depends largely on the customer's service expectations. Expectations can differ according to a customer's knowledge, experience, and self-confidence. The medical profession has done a masterful job of conditioning patients to be told little, accept what happens to them on faith, and not to be disappointed when medical problems are not corrected. Medical personnel who exceed these expectations, even by a small margin, are perceived as delivering outstanding service (Heskett, Sasser & Hart, 1990).

Customers also have different expectations of different types of service providers. You probably expect more from a department store than a discount store or from a car dealer's service centre than an independent repair shop. Understanding the customer and his or her expectations is essential in designing good service.

2. Service output is variable

This is true because of the various service providers employed and the variety of customers they serve, each with his or her own special needs. Even though customer demands vary, the service experience is expected to remain consistent. According to a survey, reliability and consistency are the most important measures of service quality to the customer (Berry, Parasuraman & Zeithaml, 1988). Service design, then, must strive for predictability or robustness. Examples of services known for their consistency includes: McDonald's, Holiday Inn (www.sixcontinentshotels.com/holiday-inn), and ServiceMaster (www.servicemaster.com). Extensive employee training, set operating procedures, and standardised materials, equipment, and physical environments are used by these companies to increase consistency.

3. Services have high customer contact

The service 'encounter' between service provider and customer is the service in many cases. Making sure the encounter is a positive one is part of service design. This involves giving the service provider the skills and authority necessary to complete a customer transaction successfully. Studies show a direct link between service provider motivation and customer satisfaction. Moreover, service providers are motivated primarily not by compensation but rather by concurrence with the firm's *service concept* and being able to perform their job competently (Heskett et al. 1990).

High customer contact can interfere with the efficiency of a service and make it difficult to control its quality (i.e., there is no opportunity for testing and rework). However, direct contact with customers can also be an advantage for services. Observing customers experiencing a service generates new service ideas and facilitates feedback for improvements to existing services. (Note that service providers should listen to the 'voice' of the customer and translate it into the technical and process design requirements.)

4. Services are perishable

Because services can not be inventoried, the timing and location of delivery are important. Service design should define not only what is to be delivered but also where and when.

5. Consumers do not separate the service from the delivery of the service

That means service design and process design must occur concurrently. (This is one area in which services have an advantage over manufacturing - it has taken manufacturing a number of years to realise the benefits of concurrent design.) In addition to deciding "what, where, and when", service design also specifies how the service should be provided. "How" decisions include the degree of customer participation in the service process, which tasks should be done in the presence of the customer (called front-office activities) and which should be done out of the customer's sight (back-office activities), the role and authority of the service provider in delivering the service, and the balance of "touch" versus "tech" (i.e., how automated the service should be).

6. Services tend to be decentralised and geographically dispersed

Many service employees are on their own to make decisions. Although this can present problems, careful service design will help employees deal successfully with contingencies. Multiple service outlets can be a plus in terms of rapid prototyping. New ideas can be field-tested with a minimum disturbance to operations. McDonald's considers each of its outlets a "laboratory" for new ideas.

7. Services are consumed more often than products, so there are more opportunities to succeed or fail with the customer

Jan Carlzon of SAS Airlines (www.sas.se) calls these opportunities "moments of truth". In a sense, the service environment lends itself more readily to continuous improvement than does the manufacturing environment.

8. Services can be easily emulated

Competitors can copy new or improved services quickly. New ideas are constantly needed to stay ahead of the competition. As a result, new service introductions and service improvements occur even more rapidly than new product introductions.

A Well-Designed Service System

According to Chase and Aquilano (1995) a well-designed service system is:

- *Consistent* with the strategic focus of the firm--if the firm competes on speed, then every element of the service process should encourage speed;
- *User-friendly*: Clear signs and directions, understandable forms, logical steps in the process, and accessible service providers;
- *Robust*: Able to cope with surges in demand, resource shortages, and varying customer expectations;
- *Easy to sustain*: Workers are given manageable tasks and the technology is supportive and reliable;
- *Effectively linked* between front office and back office activities;
- *Cost-effective*: No wasted time or resources, or appearance of inefficiency; and
- *Visible to the customer*: Customers should clearly see the value of the service provided.

Service design is more comprehensive and occurs more often than product design. The inherent variability of service processes requires that the service system be carefully designed. In services, the design process incorporates both service design and delivery. As shown in Figure 3.5, service design begins with a service concept and ends with service delivery. A brief discussion of each step is given below.

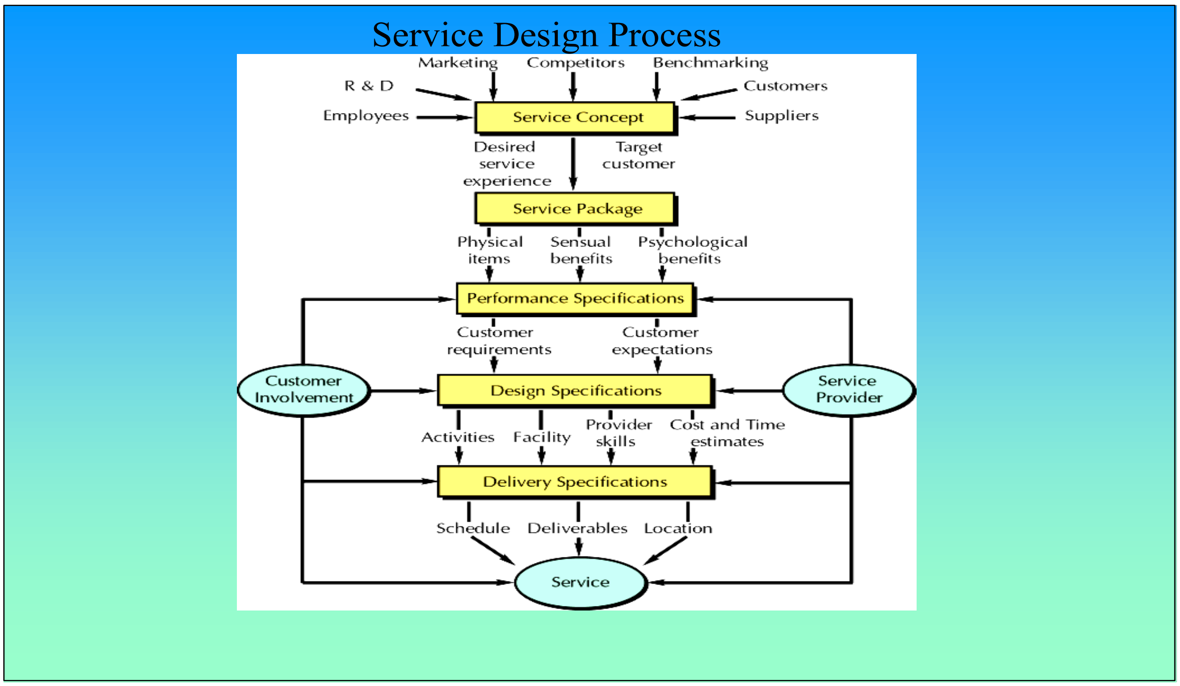

Figure 3.5 Service Design Flow Chart

Adapted from Rusell and Taylor III (2000: 219)

The Service Concept

Like the service concept described in Figure 3.4, ideas for new or improved services are generated from many sources—from customers to R&D, from suppliers to employees. The service concept that emerges defines the target customer and the desired customer experience.

From the service concept, a *service package* or bundle is created to meet customer needs. The package consists of a mixture of physical items, sensual benefits, and psychological benefits (Sasser, Olsen & Wyckoff, 1978). For a restaurant the physical items consist of the facility, food, drinks, tableware, napkins, and other touchable commodities. The sensual benefits include the taste and aroma of the food and the sights and sounds of the people. Psychological benefits could be rest and relaxation, comfort, status, or a sense of well being.

The key to effective service design is to recognise and define all the components of a service package and none of the components should be left to chance. Finding the appropriate mix of physical items and sensual and psychological benefits and designing them to be consistent with each other is also important. A fast-food restaurant promises nourishment with speed. The customer is served quickly and is expected to consume the food quickly. Thus, the tables, chairs, and booths are not designed to be comfortable, nor does their arrangement encourage lengthy or personal conversations. The service package is consistent. This is not the case for an upscale restaurant located in a renovated train station. The food is excellent, but it is difficult to enjoy a full-course meal sitting on wooden benches in a drafty facility, where conversations echo and tables shake when the trains pass by. In the hospitality industry, Marriott Corporation (www.marriott.com) is known for its careful design of speciality hotels. From its Courtyard Marriott to Fairfield Inn (www.fairfieldinn.com) to residential centres, each facility 'fits' its clientele with a well-researched service concept.

Sometimes services are successful because their service concept fills a previously unoccupied niche or differs from the generally accepted mode of operation. For example, Club Med (www.clubmed.com) perfected the *packaged vacation* concept for a carefree vacation experience. Citicorp (www.citibank.com) offers 15-minute mortgage approvals through online computer networks with real estate offices, credit bureau's, and builder's offices, and an expert system loan-application advisor. Shouldice Hospital (www.shouldice.com) performs only inguinal hernia operations, for which its doctors are very experienced and its facilities carefully designed. Local anaesthesia is used; patients walk into and out of the operating room under their own power; and telephones, televisions, and dining facilities are located in a communal area some distance from patient rooms. As a result, patients quickly become ambulatory, are discharged within hours (compared to normal weeklong stays), and pay one-third less for their operations.

Service Specifications

From the service package, service specifications are developed for performance, design, and delivery. Performance specifications outline expectations and requirements for general and specific customers. Performance specifications are converted into design specifications and, finally, delivery specifications (in lieu of manufacturing specifications).

Design specifications must describe the service in sufficient detail for the desired service experience to be replicated for different individuals at numerous locations. The specifications typically consist of drawings, physical models, and narrative descriptions of the service package. Employee training or guidelines for service providers as well as cost and time estimates are also included. Service delivery specifications outline the steps required in the work process including the work schedule, deliverables, and the location at which the work is to be performed.

Notice in Figure 3.5 that both customers and service providers may be involved in determining performance, design, and delivery specifications. The degree of involvement will vary by type of service. For example, a charter airline flight entails more customer and provider participation than a commercial flight. As shown in Figure 3.6 (service-process matrix), service processes are classified according to degree of customisation (involvement of the customer in service design and delivery) and labour intensity (involvement of the service provider in service design and delivery).

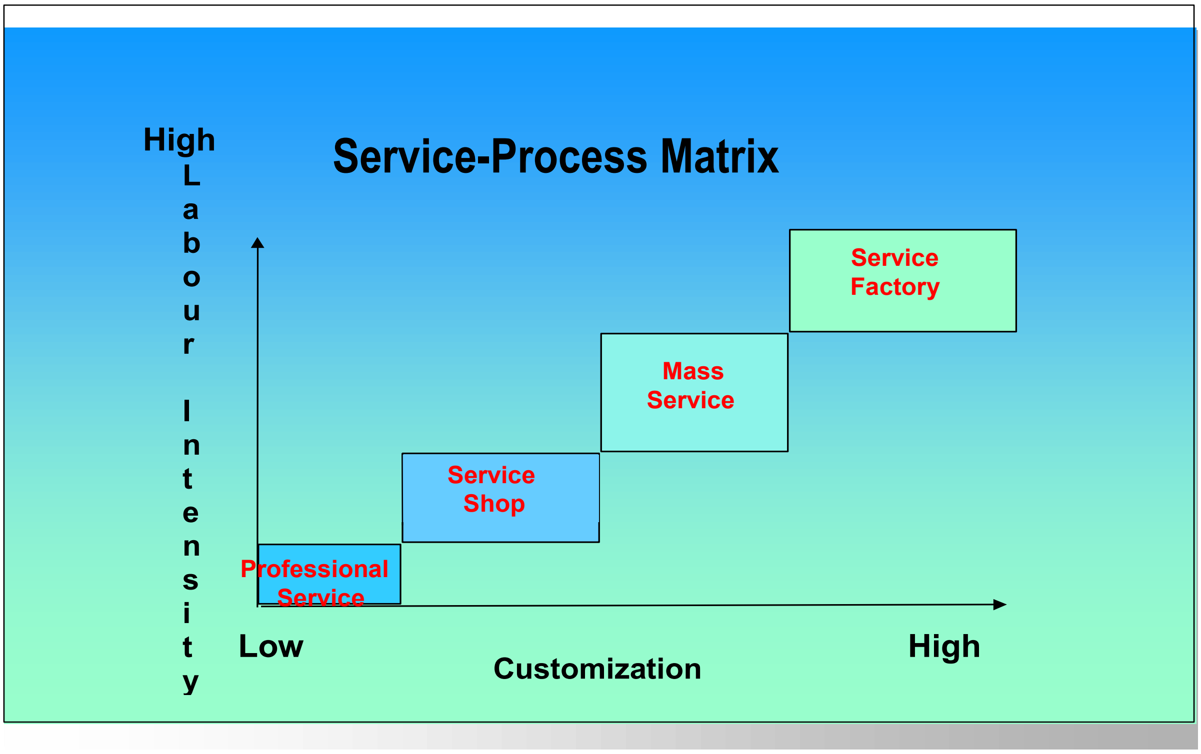

Figure 3.6 Service-Process Matrix

Source: Schmenner (1986: 29)

Taking the time to design a service carefully (often with direct customer participation) helps to prevent disagreements between customer and service provider and results in higher levels of customer satisfaction. For example, suppose a house-painting service based on the concept of fast, guaranteed work receives the following performance specifications from a customer (Xerox, 1988):

> Paint the exterior of the house grey with white trim. Get rid of mildew stains on the north side of the house and use a type of paint that is resistant to peeling and fading from the sun. Complete the work as soon as possible for an amount not to exceed $2,500.

The service provider, in turn, translates the performance specifications into the following design specifications:

> Paint exterior of house with 10 gallons of SwissBoy oil-base enamel, colour Driftwood. Paint house trim with 3 gallons of SwissBoy White Smoke. Put two coats on all outside surfaces, including the garage. Trim does not include gutters, downspouts, or cement foundation. Scrape and sand surfaces to prevent peeling. Treat north-facing surfaces with 3 gallons of RotAway as primer coat. Begin the job on Monday and complete it within 10 working days (weather permitting). Provide three-year guarantee against peeling but not fading. Cost: $2,750 payable upon completion by personal check.

At this point, the customer and the service provider obviously have some negotiation to do. Cost and guarantees will have to be reconciled. The customer will need to approve a colour swatch and may request testimonials or opinions of others who have used RotAway. The painter may suggest painting the garage first to identify any potential areas of discrepancy between the design specifications and service delivery. After reaching agreement, the service provider creates the following service delivery specifications:

- Order consumable materials (see design specifications).
- Contract labour (three full-time workers for eight days each).
- Deliver materials to site (three ladders, six brushes, and six cloths).
- Scrape loose paint and sand and fill holes.
- Apply RotAway primer.
- Apply first white trim coat and first grey coat.
- Apply second trim coat.
- Apply second grey coat.
- Scrape windows and clean up.
- Collect fee and evaluate accuracy of time and cost estimates.

Service specifications are often more useful in a visual format, commonly known as *blueprints*. A *blueprint* is used to reinforce the idea that service delivery needs to be as carefully designed as a physical product and documented with a blueprint of its own. For example, the delivery specification for a discount brokerage is shown as a service blueprint (see Appendix I).

The next section discusses the essential steps required for the development of a blueprint.

Developing a Blueprint for Services

G. Lynn Shostack, a senior vice-president in charge of the private Clients Group at Bankers Trust Company, urges managers of services to move away from the traditional trial-and-error method of designing production processes for services. Shostack believes that:

1. Provision must be made for customers input in the production processes of services.

2. Designing production processes for services requires more judgement and a less mechanical approach when compared to products.

3. Managers must allow for special problems of market position, advertising, pricing, and distribution.

Toward these ends, Shostack urges managers to develop a more non-subjective and quantifiable approach that is referred to as a blueprint for production process of services (i.e., process flowcharts, diagrams, and maps). This approach is said to allow "a company to explore all the issues inherent in creating or managing a service (Shostack, 1984: 135).

To explore the issues, the following steps should be taken:

Identify processes. Develop flowcharts or diagrams that connect the production steps in the overall production system. Include steps that the customer does not see, such as purchasing suppliers.

Isolate fail points. Once the process is diagrammed, determine the decision points where the production system might fail. Build in corrective steps that avoid the consequences of possible errors.

Establish time frame. Estimate the amount of time that each step of the service should require. These time estimates become standards against which to measure performance of the system. If services are provided in more time than the standard, productivity and profitability will be lower than should be expected.

Analyse profitability. Continuously monitor the profitability of the service. This monitoring allows unprofitability to be avoided, productivity to be measured, and quality to be controlled.

"Such a blueprint approach to designing services is more precise than verbal definitions and less subject to misinterpretation. The alternative – leaving services to individual talent and managing the pieces rather than the whole – makes a company more vulnerable and creates a service that reacts slowly to market needs and opportunities" (Ibid., 139).

Activity 3.1

Use the above steps to show the delivery specifications for a discount brokerage as a service blueprint.

Compare your solution with that of Shostack's (1984: 138). (see Appendix I).

The design activity is a decision - making process

As discussed earlier, designers seek to create things, which are: *aesthetically pleasing*; *satisfy needs*; *meet or exceed customer's expectations*; *perform well*; *are reliable*; and *are easy to produce and deliver*. Within this mandate, designers have continually to identify new ways (design alternatives) to produce their services and products according to the customers' desires for *quality*, *speed*, *dependability*, *flexibility* and *cost* (i.e., the five performance objectives). But each design alternative carries uncertainty and risk, a risk that is incurred by the designers in choosing an option. Therefore, different options have to be considered and evaluated before accepting the final design specification.

If options are to evaluated design criteria are necessary. According to Slack et al. (2000) there are at least three basic design criteria, namely, *feasibility*; *acceptability*; and *vulnerability*.

Feasibility: can we do it (the investment)? Key questions to assess the feasibility of a design option include:

- Do we have the skills (quality of resources) to cope with this option?
- Do we have the organisational capacity (quantity of resources) to cope with this option?
- Do we have the financial resources to cope with this option?

Acceptability: do we want to do it (the return)? Key questions to assess the acceptability of a design option include:

- Does this option satisfy the performance criteria, which the design is trying to achieve?
- Will this option give a satisfactory financial return?

Vulnerability: do we want to take the risk? Key questions to assess the vulnerability of a design option include:

- Do we understand the full consequences of adopting this option?
- Being pessimistic, what could go wrong if we adopt the option and what would be the consequences if everything went wrong?

The essence of evaluating the above three design criteria is to provide designers with some confidence in making decisions prior to the creation of the final (real) product, service or process. To increase their own confidence in their design decisions, they will probably try to simulate how the product and the lay out would work in practice.

Simulation has a major role to play in the design activity. As design involves the designer making decisions before the product or service has been created, the designers cannot be sure of the consequence of their decisions. Under these circumstances simulation is used in a predictive mode as a way of increasing the probability that the designer will make the right decision. Simulations can vary from physical to computer models. For example, among the best tools provided by the information sciences for better, cheaper and more rapid design of a product are:

- Computer-aided design (CAD) – interactive use of a computer to develop and document a design

- An exchange of information standard known as STEP – provides a format allowing the electronic transmittal of three-dimensional data. It is defined in the European Union's International Organisation for Standardisation (ISO) 10303

- Computer-aided manufacturing (CAM) – the use of information technology to control machinery

- Virtual reality technology, which is relative new – a visual form of communication where images substitute for reality and typically allow the user to respond interactively

- Artificial intelligence – computer-based systems that attempt to duplicate the function of the human brain.

Process types in manufacture and service

Volume and variety influence process and service design. Virtually every product or service is made by using some variation of one of the three process strategies: 1) *process focus*, 2) *repetitive focus*, and 3) *product focus*. Figure 3.7 below shows the relationship of these three strategies to volume and variety. The product-process matrix represents process choice on a matrix with volume-variety as one dimension and process types as another. The diagonal describes the lowest cost position for a given type of operation.

Operations to the right of the diagonal could save money by further standardisation of their processes. Operations to the left of the diagonal could save money by enhancing their flexibility.

Therefore, it is important for operations managers to understand the influence (impact) of volume and variety on the: 1*) performance objectives*; 2) *design activity*; 3) *process design;* and 4*) design for services,* in order to position their operations along the diagonal and build processes that will meet the necessary volume and variety requirements. The impact of volume and variety on the performance objectives, design activity, process design and process design for services is discussed separately below.

The impact of volume and variety on the performance objectives: *Quality* – if volumes are low the operation will seek to customise products/services. *Speed* – if volumes are low the operation will seek to negotiate delivery times on an item-by-item basis. *Dependability* – if volumes are low the operation will seek to meet individually negotiated delivery promises. *Flexibility* – if volumes are low the operation will seek flexibility. *Cost* – if volumes are low the operation is likely to have a high unit cost. If volumes are high the operation is likely to have a low unit cost.

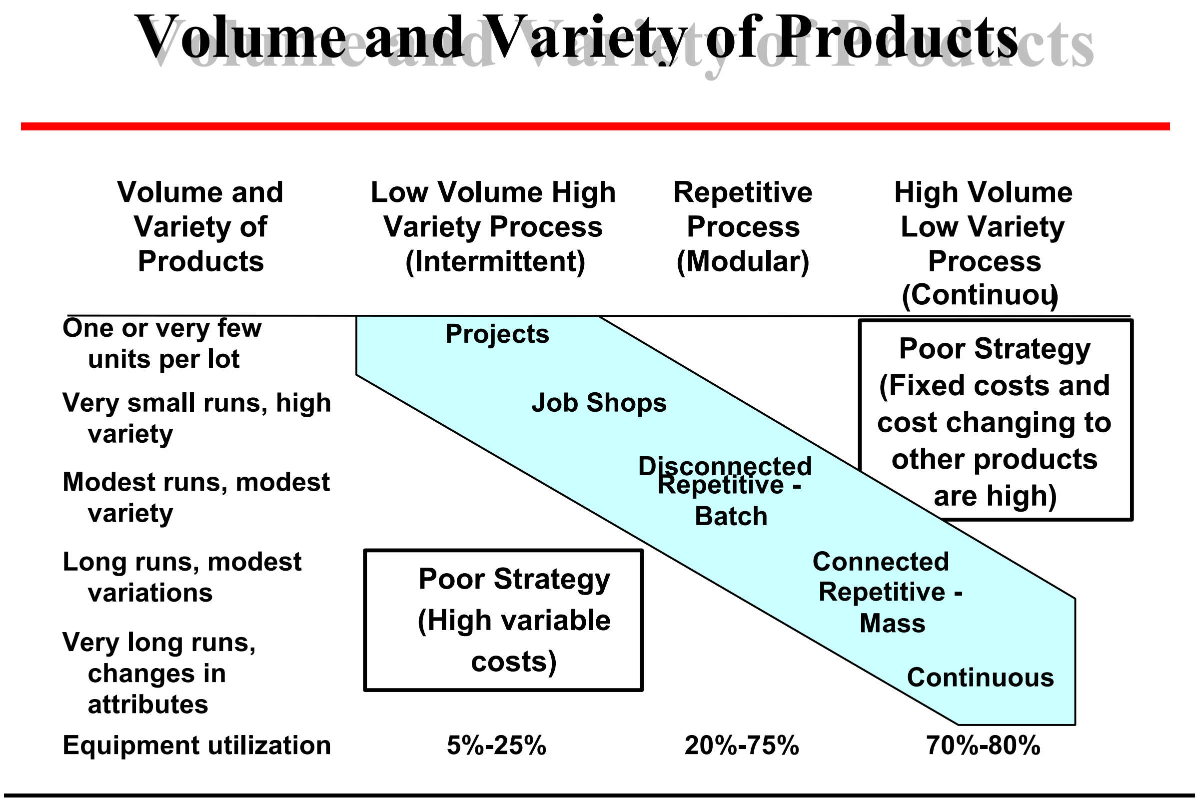

Figure 3.7 **Volume-Variety Matrix**

Adopted from Heizer and Render (1999: 228)

The impact of volumes and variety on the design activity: Operations with low volumes and high variety will: 1) have little design standardisation; 2) invest in general technology; 3) have to cope with complex flows of information; and 4) have to employ highly skilled people.

Operations with high volumes and low variety will: 1) have little design variety; 2) invest in dedicated equipment; and 3) need system management skills.

The impact of volume and variety on process design: There are five basic process designs. In order of appropriateness for increasing volume and decreasing variety these are: 1) *project* – each project has its own start and finish times. Resources are dedicated to particular projects for their duration. 2) *Job Shops* (*jobbing)* – each product shares resources with many other different products. Equipment utilisation varies between 5% to 25%; 3) *Batch* – products are produced in batches of varying sizes. Each part of the operation has periods when it is repeating an activity; 4) *mass* – high volume and essentially repetitive. Low variety in terms of the basic product; and 5) *continuous* – very high volumes and predictable flow. Usually capital intensive and inflexible with high equipment utilisation (>70%).

The impact of volume and variety on process design for services:

While services can be thought of as falling on the process along the diagonal (i.e., the process continuum from project process to continuous process) shown in Figure 3.8, the four quadrants in Figure 3.8 provide additional insight into services process.

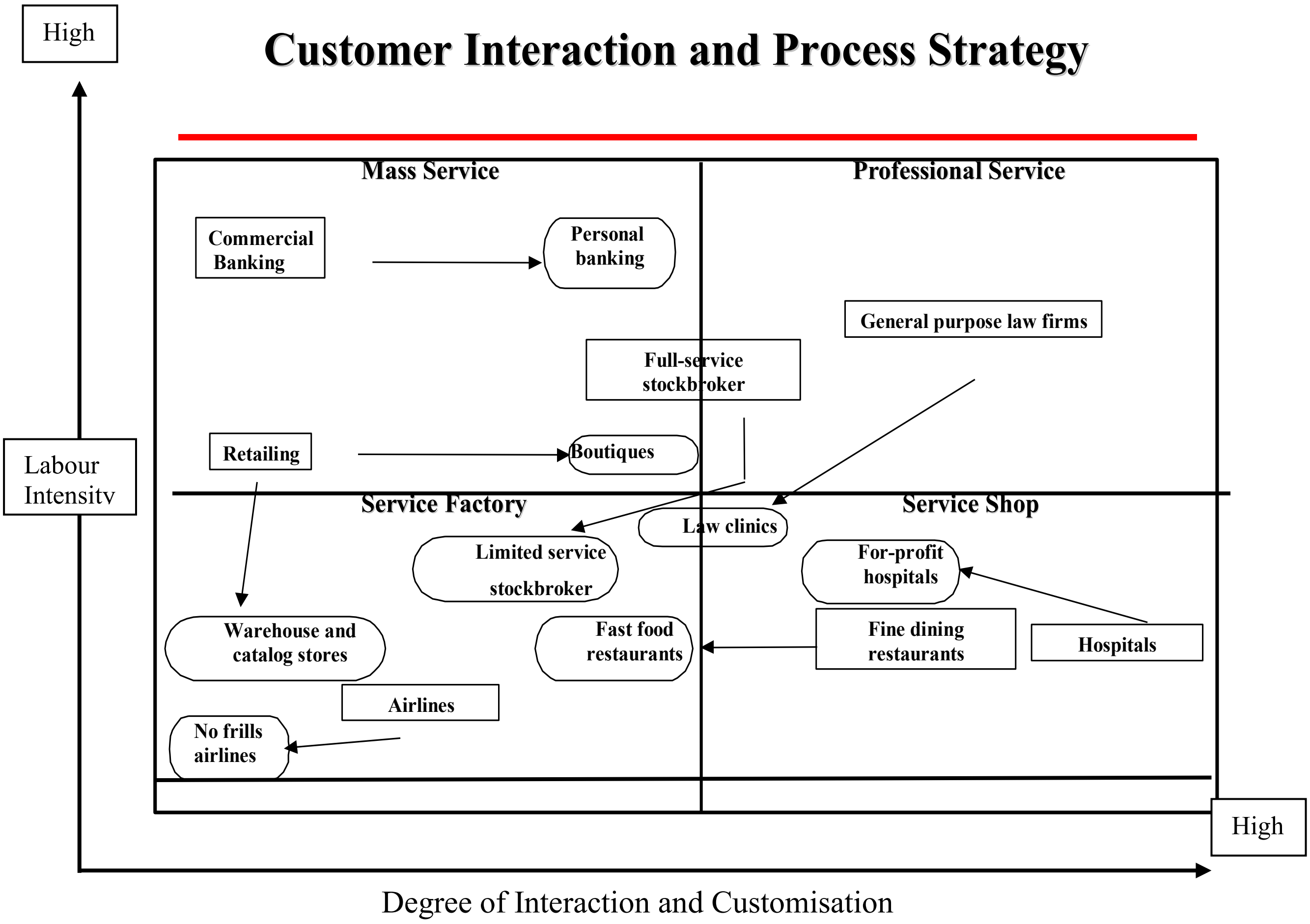

Figure 3.8 Operation Changes within the Service Process Matrix

Adopted from Heizer and Render (1999: 242)

In the upper sections (quadrants) for *mass service* and *professional service*, where *labour intensity is high*, we expect the manager to focus extensively on human resources. This is particularly true in the quadrant with *high interaction* and *customisation* (i.e., professional service). Consulting companies/law firms fall in this category because they have high-contact operations, which tend to be people based. *Mass Service* and *Professional Service* companies managers must find ways of addressing unique issues that satisfy customers to win orders. This is often done with very personalised service, some of which requires labour intensity and therefore significant selection and training issues in the human resources area.

The quadrants with *low interaction* and *low customisation* may be able:

- to standardise or restrict some offerings of the service, as do fast-food restaurants

- to automate, as have some organisations like the CityRail (www.cityrail.nsw.gov.au) that have ticket-vending machines

- to remove some services, such as seat assignments, as has Southwest Airlines (www.southwest.com) (see Chapter 2).

Off-loading some aspects of the service through automation may require innovations in process design as well as capital investment. Such was the case with the CityRail ticket vending machines and bank ATMs. This move to standardisation and automation may require added capital expenditure, as well as putting operations managers under pressure to develop new skills for the purchase and maintenance of such equipment.

It should be acknowledged that a reduction in a customisation capacity would require added strength in other areas because:

- customer feedback is lower in the quadrants with *low interaction*, and hence tight controls may be required to maintain quality standard

- operations with *low labour intensity* may lend themselves to innovation in process, technology, and scheduling capacity.

Activity 3.2

Product-process matrix or service operation matrix exercise.

Select a product, service, or process that you are familiar with and position the operating system of your chosen product, service or process on an appropriate product-process matrix or service operation matrix. What are the management challenges and implications of being on a position in the product/service-process matrix? Using the matrix of Figure 3.7 or 3.8 as a framework, discuss the product/service/ process/ market "fit" and make suggestions for improvement.

Concurrent Design: Walls Broken Down

As discussed earlier in the introductory section of this chapter, *modern operations management design* has introduced a "*breaking down the barriers"* approach to increase communication and feedback by bringing representatives from the various departments *together* to work on the design. These representatives are called the *"design team"* and this modern approach to design is known as *"concurrent design"* (see Figure 3.1b). Concurrent design is a new approach to design that involves the simultaneous design of products, services and processes by the design team (Russell & Taylor III, 2000) aiming at breaking down the walls (barriers) of communication. Concurrent design helps improve the quality of early decisions and thereby reduces the length and cost of the design process. For example, IBM called their concurrent design efforts as EMI (early manufacturing involvement). Initially, one manufacturing engineer was assigned to each product-development group. Later, more engineering staff were reassigned and physically relocated. In at least one instance, new design facilities were built within walking distance of where manufacturing occurred. The increased communication between design and manufacturing improved the quality of the final product so much that IBM quickly threw out the term EMI and adopted CMI (continuous manufacturing involvement). For example, Boeing Australia (www.boeing.com.au), and former Hawker de Havilland (www.hdh.com.au), an aircraft manufacturing company located at Bankstown Airport, Sydney, has gone one-step further by physically relocating the manufacturing engineers and Computer-Aided Design (CAD) terminals on the shop floor together with the process operators. Therefore, manufacturing engineers and design facilities (CAD machines) were available "on the spot" to solve process related problems. Increased communication between design staff and process operators improved the quality of the final product (aircraft components).

Differences exist between sequential design and concurrent design for setting product/service prices and determining costs. In the traditional process, the feasibility study includes some estimate of the price to be charged to the customer. But the selling price is not firmed up until the end of the design process, and when all the product/service costs are accumulated, a profit margin is attached, and it is determined whether the original price estimate and the resulting figure are close. This is a *cost-plus* approach. If there are discrepancies, either the product/service is sold at the new price, or the designers go back and try to cut costs via a new feasibility study. Remember that because the design decisions are interrelated, the further back in the process you go; the more expensive are the changes.

In the concurrent design the *price-minus* approach is used. A selling price that will give some advantage in the marketplace is determined before design details are developed. Then a *target cost* of the product or service is set and evaluated at very early stages of the product, service or process design. Techniques such as *value analysis* are used to keep costs in line with the predetermined *target cost*. Finally, because concurrent design requires that more tasks be performed in parallel, scheduling of the tasks is more complex than ever. So project scheduling techniques such as Program Evaluation Review Technique (PERT) and Critical Path Method (CPM) are being used to co-ordinate the myriad of interconnected decisions that constitute concurrent design. As shown in Figure 3.9, information technology is also being used to accelerate the decision making between the design team representatives. (Note that operations managers should be utilising the technology available for integrating systems that best serve the organisation.)

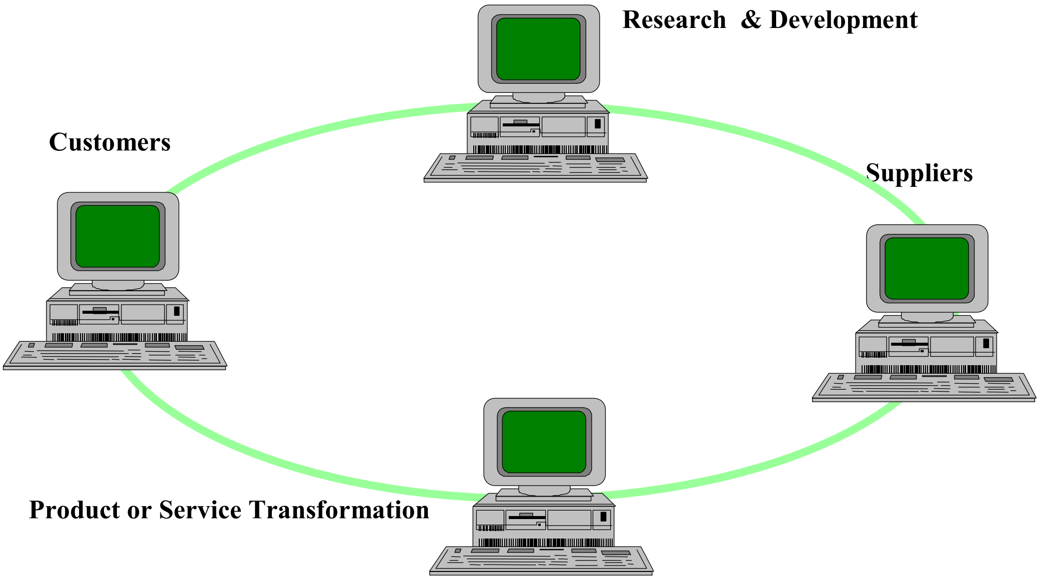

Figure 3.9 Cost Effective, Leading Edge Technology

Activity 3.3

Class Exercise

Look around your classroom and make a list of companies that use the *cost-plus* approach and a list of companies that use the *price-minus* approach. Based on these statistics find out which companies have gained a competitive edge with products or services. Discuss several methods for generating new product or service ideas for your organisation.

Complete the following questions

TRUE/FALSE QUESTIONS

1. Design cannot provide a competitive advantage. **False**

2. Product design specifies what sensual or psychological benefits the customer is to receive. **False**

3. Service design specifies what materials are to be used. **False**

4. The quality of a product or service is ensured when design specifications are strictly followed. **False**

5. An important aspect of a quality design process is to be first to market, even if the initial design is not quite perfect. **False**

6. Traditionally, the design process has been performed sequentially by different personnel from separate departments in a company. **True**

7. Traditionally, the design process brought together people from various departments and functions to work on the design simultaneously. **False**

8. Concurrent design has proven to be more effective than the sequential design process. **True**

9. In general terms, only one in twenty ideas ever become a product. **True**

10. In general, only one in every ten new products is successful. **True**

11. Isolating research and development teams from the rest of the organisation has been effective in producing a steady stream of new ideas. **False**

12. Standardisation refers to reducing the number of parts in a product. **False**

13. One of the risks of standardisation is losing the product's market advantage of variety and uniqueness. **True**

14. One part of process planning involves selecting equipment. **True**

15. One part of process planning involves making make-or-buy decisions. **True**

16. One part of process planning involves determining the order of operations. **True**

17. The team approach to product design involves lawyers and accountants as well as people from marketing, manufacturing, and engineering. **True**

18. Concurrent design improves the quality of early design decisions. **True**

19. Concurrent design increases the length and cost of the design process. **False**

20. One difference between sequential and concurrent design is that concurrent design uses a "cost-plus" approach rather than a "price-minus" approach. **False**

21. One problem with concurrent design is that scheduling of parallel tasks is very complex. **True**

22. Services tend to be intangible. **True**

23. Customers generally perceive services to be more risky to purchase. **True**

24. The quality of a service experience depends largely on the customer’s service expectations. **True**

25. Services tend to be perishable. **True**

26. Services tend to be consumed more regularly than products. **True**

27. A well-designed service system needs to be user-friendly. **True**

28. The service system should be consistent with the strategic focus of the firm. **True**

29. Service delivery specifications outline the steps required in the work process. **True**

30. Value analysis is an analytical approach for eliminating unnecessary design features and functions. **True**

31. The service concept involves creating a service package that includes only sensual and psychological benefits. **False**

MULTIPLE CHOICE QUESTIONS

1. Trends in product design include all of the following except:
   a) design for manufacture
   b) design for assembly
   c) design for environment
   d) design for profitability

2. _________ refers to the ease with which a product can be repaired.
   a) reliability
   b) maintainability
   c) standardization
   d) modular production

3. A complex computer program that tests and analyses designs on the computer screen is called:
   a) CAD (Computer-Aided Design)
   b) CAM (Computer-Aided Manufacturing)
   c) CIM (Computer Integrated Manufacturing)
   d) CAE (Computer-Aided Engineering)

4. Services are more______________ than products.
   a) tangible
   b) centralized
   c) easily emulated
   d) consistent

5. The house of quality
   a) converts the voice of the customer into design technical requirements
   b) is one of the matrices used in quality function deployment
   c) does not produce an optimal solution
   d) all of the above

6. Good design practices include
   a) designing unique parts for each product
   b) simplifying operations
   c) using separate fasteners when possible
   d) all of the above

7. Design quality can be measured by
   a) cost of first production run
   b) total product sales
   c) total product cost
   d) **all of the above**

8. The design process begins with
   a) ideas
   b) mass production
   c) finance
   d) coordination

9. A well-designed service system is
   a) user-friendly
   b) cost effective
   c) easy to sustain
   d) all of the above

10. Which of the following is true about the design process?
    a) Traditionally, representatives from various departments and functions worked together on the design.
    b) The design process involves four basic steps, which, when followed in sequential order, ensure success.
    c) The better way to work on a design process is to separate marketing, engineering, and production personnel from each other so each can work in their own area of expertise.
    d) Concurrent design has proven to be the more effective method for design.

SHORT-ANSWER QUESTIONS

1. Explain the relationship between variety and volume and describe why you are unlikely to find many high volume-high variety and low volume-low variety operations.

2. List six characteristics that distinguish services from physical products.

3. What is service blue print? Why is it of value in service design?

4. Name the basic steps in the design process. Discuss the traditional approach to process design, as well as the more enlightened view.

Summary

This chapter provided an introduction to design in operations management. In particular, it focussed on the nature and purpose of the design activity and how design activity can differ in different types of operations. The chapter also examined the process types in manufacturing and service operations with particular emphasis on the customer interaction and process strategy. The chapter also investigated how volume and variety could impact the performance objectives; design activity; and the process design.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to design in operations management

- ☐ The content of design in operations management
- ☐ The general process of design in operations management
- ☐ The *modern operations management design* approach

The nature and purpose of design in operations management

- ☐ The nature and purpose of the design activity
  - ☐ Creativity
  - ☐ Complexity
  - ☐ Compromise
  - ☐ Choice

- ☐ The purpose of design is to satisfy customers
  - ☐ Idea generation
  - ☐ Feasibility study
  - ☐ Preliminary design
  - ☐ Final design and process planning
  - ☐ developing a blueprint for services

- ☐ The design activity as a decision making process
  - ☐ Feasibility
  - ☐ Acceptability
  - ☐ Vulnerability

- ☐ Process types in manufacturing and service

- Volume and variety matrix (Figure 3.7)
- Operation Changes within the Service Matrix (Figure 3.8)

- Concurrent design -Walls broken down
  - Effectiveness of communication & concurrent design

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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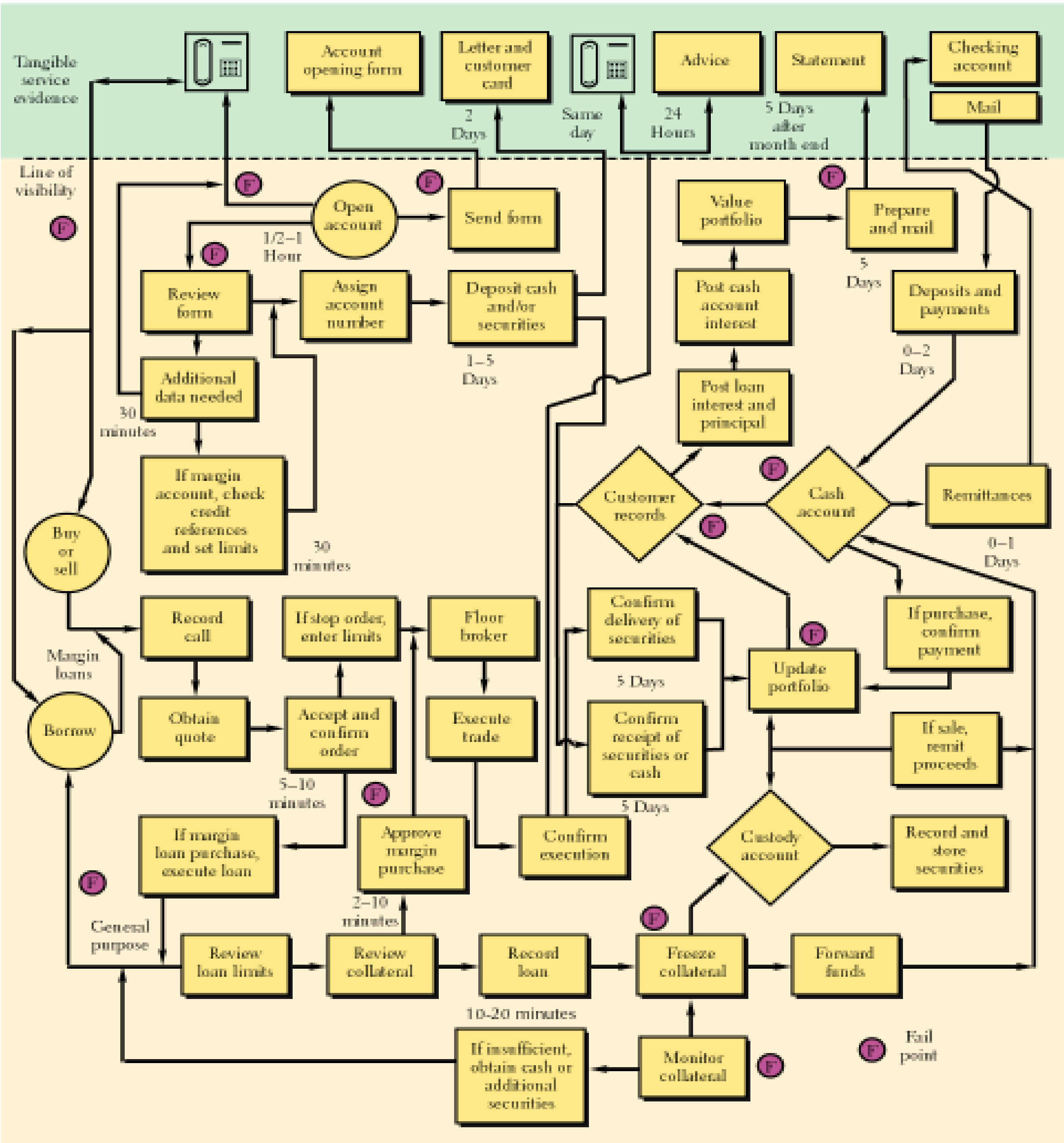
Appendix I

Service Blueprint



Adopted from Shostack (1984: 138)

Chapter 4 Design of the Operations Network

Contents .... **Page**

Design of the operations network

Learning outcome

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- understand the nature of operations networks and the concepts of the 'supply-side' and the 'demand-side' parts of the network.
- examine the advantages of taking a network perspective in making strategic design decisions.
- determine the extent to which an operation chooses to be 'vertically integrated' into the network, and how much of the network should an operation own.
- understand the limitations to 'vertical integration' and the alternative approaches to provide services on demand.
- determine the location of each operation within networks, and the capacity of each part of the network.
- become aware of the advantages of information technology within the network.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Understand why an organisation should take a total supply network perspective, and understand how much of a network an operation should own
- Understand the relationship between facilities and functions along the 'supply-demand' chain and decide where an operation should be located
- Examine how much capacity an operation plan should have and be prepared to 'flex' capacity if demand is different from forecast
- Be familiar with the more recent network approaches of Keiretsu, Hollow Corporations, and Virtual Companies
- Recognise the power of information technology within networks
- Be familiar with and examine the consequences of the more recent network systems such as SAP and EDI.

What you will need

Suggested study time	Text Books	5 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	3 hours
	Total	11 hours

Introduction

Around the world, McDonald's (www.mcdonalds.com) operates more than 11,000 restaurants in 51 countries, with approximately 4,000 outside the U.S (Russell & Taylor III, 2000). Similarly, General Motors (www.gm.com) has more than 2,500 suppliers that serve its 120 parts plants and 30 auto and truck assembly plants. The challenge then for McDonald and General Motors is to identify and use a system that interrelates the operations and their suppliers in order to create and deliver products and services to the end customer. An approach that comes immediately into mind is that of the Japanese *keiretsu*, whereby, organisations and suppliers become members of a coalition (network) and its members are assured long-term relationships and expected to function as partners, providing technical expertise and stable environment to satisfy an ever-changing marketplace. We should discuss *keiretsu* in more detail later in this chapter. Alternatively, an approach that encompasses all the facilities, functions, and activities involved in producing and delivering a product or service, from the supply (and their suppliers) to customers (and their customers) is known as a *total supply network*.

Because global organisations strive to increase their competitiveness via product/service customisation, high quality, cost reductions, and speed-to-market, they have placed added emphasis on the operations network by taking a *total supply network* perspective. The main advantage of the total supply network approach is that it helps the operation to understand how it can compete effectively within the network. This is because a supply network approach requires operations managers to think about their suppliers and their customers as *operations*. Taking a total supply network perspective can also help to identify particularly significant links within the network and hence identify long-term strategic changes which will affect the operation.

The starting point for all these advantages is taking a broad perspective not only of the immediate supply network, that is the customer and suppliers with which an operation has immediate contact, but also of the total supply network, that is their customers and their suppliers respectively. In this chapter we refer to a total supply network as all the significant operations on the supply side and the demand side of an operation. Figure 4.1 illustrates one such network. As shown, in the total supply network there are first-tier suppliers, second-tier suppliers, and so on. Similarly, there are first-tier customers, second-tier customers, etc. We should discuss this later in this chapter under the heading of 'the nature of operations network'.

An effective supply network requires that suppliers (and their suppliers) and customers (and their customers) work together in a co-ordinated manner by sharing and communicating information by talking to one another. It is the rapid flow of information within the network (i.e., customers, suppliers, distribution centres, and transportation systems) that has enabled some organisations to develop efficient supply networks.

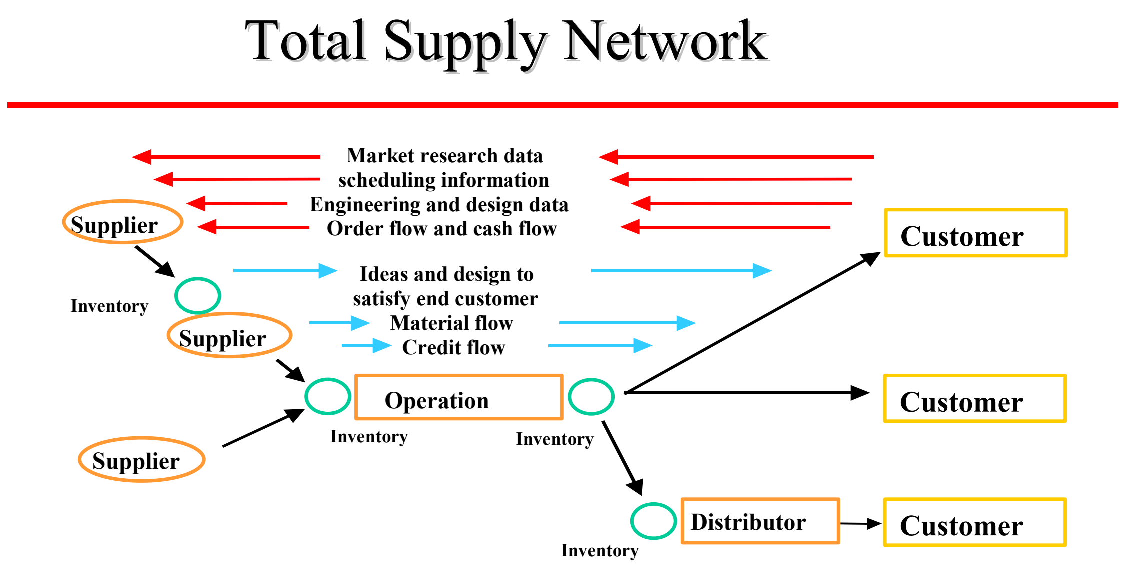


Figure 4.1 Total Supply Network

Adopted from Heizer and Render (1999: 416)

Some organisations are faced with the challenge of how much of a network should their operations own and control, and what sort of structure should be used. An attempt to own and gain control of all the different activities along the supply chain from materials and parts procurement to delivery of the final product and customer service is called *'vertical integration'*. Vertical integration is defined by the *direction* of ownership, the *extent* of ownership and the type of *relationships* envisaged.

- The direction of ownership decision refers to whether an organisation wants to own the operations on its supply-side (backward integration) or on its demand-side (forward integration).

- The extent of ownership decision relates to how many of the demand-side or supply-side operations the organisation wants to own.

- The nature of the relationship decision relates to whether stages in the network involve exclusive relationships in which each stage serves only its own in-house customers, or alternatively, where each stage is free to trade with parts of the network which are not owned by the organisation.

Whatever the type of organisational structure within the network, for an organisation to be successful in the global environment it is important to focus on co-ordinating its different activities to achieve overall company goals. Such co-ordination is more complex and requires extended *'global'* networks. When organisations enter growing global markets such as Eastern Europe, China, and South America, expanding their networks becomes a strategic challenge, because in the global environment the network must be:

- Flexible enough to react to sudden changes in parts availability, distribution or shipping channels, import duties, and currency rates.

- Able to use the latest computer and transmission technologies to manage the shipment of goods and flow of information among customers, suppliers, distribution centres, and transportation systems.

- Staffed with local specialists to handle duties, trade, freight, customs, and political issues.

- Able to forecast market instability, especially, among the newly emerging global markets.

As part of the global network approach, some organisations have banded together to form consortiums for consolidating shipping, warehousing, and distribution, although problems inevitably arise when competing products travel through the same distribution channel. Some other companies have addressed their supply problems by vertically integrating; for example, investing in their own trucking fleets and distribution systems to control their own product delivery. Regardless of the type of the network and its efficiency, the location of an organisation tends to be crucial in terms of the firm's profitability and long-term survival. That is because often businesses have to be "in the right place at the right time" to be successful. For a service operation for example, such as a restaurant, hotel, or retail store, being in the right place usually means in the location that is convenient and easily accessible to customers.

Therefore, organisations tend to relocate their operations. An existing operation will relocate only if the costs and disruption of moving are less than the benefits it believes it will gain from its new location. Furthermore, the stimuli, which act on an organisation during the location decision, can be divided into supply-side and demand-side influences. Supply-side influences are the factors such as labour, land and utility costs, which change as the location changes. Demand-side influences include such things as the image of the location, its convenience for customers, and the suitability of the site itself. All these factors can be applied (to different degrees) at three levels:

- The choice of a country or region

- The choice of an area within a country or region, and
- The choice of a specific site itself.

Finally, an organisation should schedule how much capacity an operation plan must have. The amount of capacity an organisation will have depends on its view of current and future demand. When an organisation has to cope with changing demand a number of capacity decisions need to be taken. These include choosing the optimum capacity for each side, balancing the various capacity levels of the operations in the network, and timing the changes in the capacity of each part of the network. Important influences on these decisions include the concepts of economy and diseconomy of scale, supply flexibility if demand is different from forecast and the profitability and cash-flow implications of capacity timing changes. If the network itself has not sufficient capacity to satisfy future demands, an organisation has to choose different options and the one that comes immediately into mind is that of outsourcing.

The nature of operations network

Every operation is part of a network of suppliers and customers. As discussed earlier in the introductory section of this chapter, an operation's network encompasses all the facilities, functions, and activities involved in producing and delivering a product or service, from suppliers (and their suppliers) to customers (and their customers). It includes planning and managing supply and demand; acquiring materials; producing and scheduling the product or service; warehousing, inventory control, and distribution; and delivery and customer service. The network should be able to co-ordinate all these activities so that customers can be provided with prompt and reliable services of high-quality products at the least cost. Successful co-ordination of these activities in turn can provide the organisation with a competitive advantage. In other words, the successful flow of materials, parts, assemblies, information, ideas, people and money through the network can enhance the competitive advantage of those organisations, which are members of the network.

On the supply-side all operations have suppliers who provide parts, information and services. On the demand-side all operations have customers, who may not be the end users of the product or service. As discussed earlier and presented in Figure 4.1, the total supply network can be described in terms of tiers. Direct suppliers and customers of a given operation are known as first-tier suppliers and customers. The suppliers to operations first-tier suppliers are the operations second-tier suppliers, and so on. Usually operations deal only with their first-tier suppliers and customers, but this is not always the case. Wal-Mart (www.walmart.com/) for example, has developed relationships with some of its second, and even third-tier suppliers (i.e., Johnson Wax (www.scjohnsonwax.com)) to take over warehousing and forecasting demands to reduce supply costs (Wieland, 1992). Johnson Wax must forecast demand for its own products (shaving gel and air fresheners) using Wal-Mart's weekly sales data and then place its own products on the store shelves of Wal-Mart's stores.

In summary, the objectives of the total supply networks are to:

- Reduce the cost of making the purchase, delivering the product or service

- Reduce transportation costs
- Improve product and service quality
- Reduce the time it takes to get the product or service to market
- Improve customer satisfaction
- Reduce inventory and inventory related (i.e., holding, obsolescence, etc) costs, and
- Introduce new products, services and processes.

Advantages of taking a network perspective

In today's global competitive environment taking a network perspective helps a company to understand how to compete effectively. The reason behind this is that operations need to look beyond their immediate customers to understand their needs and what the end users of their products and services want. There are two ways in which they can do this. Either they can rely on the opinions of others or they can find out for themselves. Experience has shown that relying on one's immediate network is putting too much faith in someone else's judgement of things, which are critical to an organisation's success.

Taking a network perspective helps identify particularly significant links in the network. The key to understand networks is to understand who contributes to achieving the performance objectives that are valued by the end customers. To analyse a network it is therefore necessary to:

- Identify what the end user/customers want; and
- Identify who helps to provide what the end user/customers want.

Operations managers, however, should be aware that not all parts of the network would be able to contribute equally to providing what the end customers want. The best way for the network to win and retain end-customer business is for those parts of the network, which cannot provide exactly what the end-customer wants, to find out how they can support those parts, which can.

Taking a network perspective helps an organisation to focus on its long-term position in the network. The balance of power in any network will vary over time. A key issue for a given operation is whether it should seek to exploit power when it has it. In the longer term this is probably not a sensible strategy. It might be better for the more powerful organisations to help the weaker organisations improve.

Taking a network perspective also highlights the three key network design decisions of ***vertical integration****;* ***operations location*** *and* ***long-term capacity***. We should discuss these design decisions in the following sections.

Direction, extent and balance of vertical integration

By **vertical integration**, we mean "developing the ability to produce goods or services previously purchased or actually buying a supplier or a distributor" (Heizer & Render, 1999: 422). In other words, at the product or service level, vertical integration is all about the make-buy decision. It involves deciding what the operation should make and what it should buy from outside. The key issues that are associated with making these decisions are the *direction of expansion*; the *extent of process span*; and the *balance of capacity*.

Direction of vertical integration: Vertical integration can take the form of *forward (downstream)* or *backward (upstream)* integration, see Figure 4.2 below.

- **Backward integration** suggests a firm purchase its suppliers, as in the case of Ford Motor Company (www.ford.com) deciding to produce its own radios. Such backward integration is often considered a defensive move.

- On the other hand, **forward integration**, suggests that a producer of detail components make the finished product, a strategy that brings an organisation closer to the market (customers). An example, is Texas Instruments (www.ti.com), a producer of integrated circuits that also makes calculators and computers containing integrated circuits. Forward integration is often considered an offensive move.

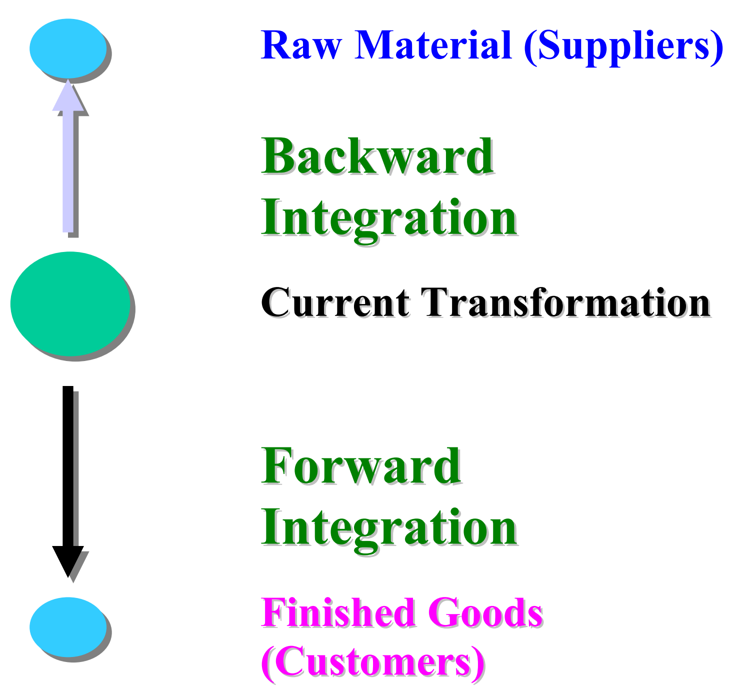


Figure 4.2 **Forward or Backward Integration**

Vertical integration can offer a strategic opportunity for the operations managers. For organisations with the necessary capital, managerial talent, and required demand, vertical integration may provide substantial opportunities for cost reduction. Other advantages in inventory reduction and scheduling can accrue to the company that effectively manages vertical integration or close, mutually beneficial relationships with suppliers.

Although vertical integration has generally shown to yield cost reduction, quality adherence, and timely delivery of goods and services, it needs to be pursued with caution. A review of the literature revealed that it appears to work better when an organisation has large market share. For example, Nike (www.nike.com/usa) located in Beaverton, Oregon, is the largest and most profitable sports shoe manufacturer in the world. Its large market size allows Nike to use a network structure of suppliers and manufacturers throughout Southeast Asia with whom Nike has formed strategic alliances (Capowski, 1994). Nike's costs are very low because wages in Southeast Asia are a fraction of what they are in the U.S. and this gives Nike a low cost advantage, and secondly, Nike is able to response to changes in sports shoe fashion very quickly using its global computer communication network systems. *Secondly*, managers of a network system should be aware that *backward integration* may be dangerous for firms in the industries undergoing technological change if management cannot keep abreast of those changes or invest the financial resources necessary for the next wave of technology. Benefits and limitations of vertical integration will be presented later in this section.

Extent of vertical integration: Once the organisation has decided in which direction it wishes to expand (forward/downstream) or backward/upstream), it has to decide how far it wishes to expand. Therefore, it is possible to choose between **full integration** and **taper integration**. A company achieves *full integration* when it produces all of a particular input needed for its processes or when it disposes of all of its output through its own operations. On the other hand, *taper integration* occurs when a company buys from independent suppliers in addition to company-owned suppliers or when it disposes of its output through independent outlets in addition to company-owned outlets.

Balance of capacity: The issue here is whether the organisation should seek to balance capacity so that each stage in the chain only suppliers the next stage, or whether it should let there be excess capacity, which can be used to attack other markets. The advantage of fully balanced networks is that they are simpler to manage and each business can focus on supplying its direct customers.

Benefits and disadvantages of vertical integration:

Benefits: Being vertically integrated means that:

- *Operations can build barriers to new competition*. By vertically integrating backward to gain control over the sources of critical inputs or vertically integrating forward to gain control over distribution channels, an organisation can build barriers to new entry into its industry. To the extent that this strategy is effective, it limits competition in the organisation's industry, thereby enabling the organisation to charge a higher price and make greater profits than it could otherwise.

- *Operations can facilitate investments in efficiency-enhancing specialised assets*: Investing in specialised assets allows operations to lower the costs of value creation and/or to differentiate their products/services offering more effectively from that of competitors, thereby facilitating premium pricing.

- *Operations can protect product/service quality*: By protecting product/service quality, vertical integration enables a company to become a differentiated player in its core business.

- *Operations can improve scheduling*: It is sometimes argued that strategic advantages arise from the easier planning, co-ordinating, and scheduling of adjacent processes made possible in vertically integrated organisations. (Hennart, 1988; Viljoen & Dann, 2000). Advantages of this kind can be particularly important to firms trying to realise the benefits of just-in-time inventory systems.

In summary, being vertically integrated means that organisations are closer to their customers and suppliers. This makes it easier to trace and eliminate the root causes of any quality problems. In terms of speed, vertically integrated companies are better able to synchronise their schedules and, because of their closeness, find forecasting easier. Better forecasts and improved communications lead to more accurate delivery promises and enhanced dependability.

Finally, technological advantages, which can be denied to competitors, can be shared among network members giving better product flexibility. For example, For example, Boeing Australia (www.boeing.com.au), and former Hawker de Havilland (www.hdh.com.au), an aircraft manufacturing company located at Bankstown Airport, Sydney, being a member of a global network namely "GlobeMan 21" (meaning global manufacturing of the 21st century) has shared the latest technology of the KAIZEN philosophy known as Neo-KAIZEN. This new continuous improvement approach which is being recently experimented with by Japanese universities and organisations has enabled Hawker de Havilland's efforts to achieve better product flexibility (Politis, 1999). The costs of research and development, and other support functions, can also be pooled. This reduces the group's cost base.

Some disadvantages: As discussed earlier, although vertical integration might appear an attractive strategic approach, it needs to be pursued with caution. Why?

- Buying into new materials supply or distribution channels is usually a strategy of greater magnitude that might take organisational debt levels beyond acceptable limits.

- An upstream or downstream activity is part of the overall value chain, which means that these types of businesses are not similar to the core activity of the organisation, hence there is little stimulus for businesses to improve the level of service they provide.

- Some believe that vertical integration might actually result in negative synergy for the organisation (Viljoen & Dann, 2000). Retailing electrical products, for example, is a very different type of activity from assembling them; that, in turn, is very different from producing component parts such as microchips. Where each aspect of the value chain is a distinct field of activity, vertical integration may be more trouble than it is worth.

- As discussed earlier, *backward integration* may be dangerous for firms in the industries undergoing technological change if management cannot keep abreast of those changes or invest the financial resources necessary for the next wave of technology.

- Vertical integration commits an organisation very heavily to one particular field of economic activity. This can be very risky unless the field of economic activity is a stable one, which few are.

- Last, but not least, vertical integration results in high **bureaucratic costs**. Bureaucratic costs are those involved in running an organisation, and this case, include costs that stem from bureaucratic inefficiencies and costs associated with the lack of strategic flexibility in times of changing technology, or by uncertain demand.

The disadvantages associated with vertical integration raise the question of whether it is possible to use alternative networks that can yield cost savings for customers and suppliers alike. Some of the variations to vertical integration (middle ground networks) are presented in the following section of this chapter.

Alternative variations to vertical integration

In this section we will discuss some of the newly emerging organisational arrangements used to avoid some of the disadvantages of vertical integration. At the beginning of this chapter we have introduced such arrangements namely *keiretsu*, *Hollow Corporations*, and *Virtual Companies*.

Keiretsu: It is an arrangement whereby organisations and suppliers become members of a coalition (network) and its members are assured long-term relationships and expected to function as partners, providing technical expertise and stable environment to satisfy an ever-changing marketplace. Members of the *keiretsu* can also operate as suppliers further down the chain, making second- and even third-tier suppliers' part of the coalition. A good example is the Mitsubishi Keiretsu, which consists of 28 core members who are bound together not by authority relationships but rather by cross-ownership, long-term business dealings, interlocking directorates, and social ties (many of the senior executives are college classmates). In the Mitsubishi Keiretsu there are three major firms: Mitsubishi Corporation (www.mitsubishi.com), which is a trading company; Mitsubishi Bank (http://www.btm.co.jp), which finances the Keiretsu's operations; and Mitsubishi Heavy Industries (www.mhi.co.jp), which is a leading world-wide manufacturer. In addition to these firms, hundreds of other Mitsubishi related companies contribute to the power of the *keiretsu* (Holstein 1990). But what are the benefits of many organisations joining a *keiretsu* network?

Quite obviously, *keiretsus* are very powerful. Organisations and their suppliers or customers work out ways to add-value, for instance, by implementing just-in-time inventory systems or by co-operating on designs for component parts to improve quality and lower assembly costs. Within this framework, suppliers make substantial investments in specialised assets in order to serve the needs of *keiretsu* members. Thus, *keiretsu* members have been able to capture many of the benefits of vertical integration without having to bear the associated **bureaucratic costs**. Also in the area of research and development (R&D) *keiretsu* members can share information and innovative ideas to improve the quality of products and services. For example, in the U.S. there now more than 250 R&D consortia that are sharing both costs and information. The idea behind the R&D *keiretsu* members is to involve suppliers early in product development and give them greater responsibility for design and production. Out of this approach it is anticipated to compress product development cycle and reduce nonrecurring cost out of product development. Last, but not least, *keiretsu* networks attempt to build long-term co-operative relationships with suppliers.

Virtual Companies or Hollow Corporations: As discussed earlier, *virtual companies* are newly emerging organisational arrangements used to avoid some of the disadvantages of vertical integration. Rather than letting vertical integration lock an organisation into businesses that it may not understand or be able to manage, another approach is to find good flexible suppliers. So organisations form networks in an arrangement whereby they rely on a variety of supplier relationships to provide services on demand. These networks are known as *virtual companies, hollow corporations, network companies*, or *joint partnering*.

Virtual companies have fluid, moving organisational boundaries (i.e., have high degree of flexibility) that allow them to create a unique enterprise to meet changing marker demands. Such flexibility may provide a variety of vendor services that include doing the payroll, hiring personnel, designing products, providing consulting services, manufacturing components, conducting tests, or distributing products. Virtual companies' relationship may be short-term or long-term and may include true partners, collaborators, or simply able suppliers and subcontractors.

The advantages of virtual companies include specialised management expertise, low capital investment, flexibility, and speed. The result is efficiency, and through efficiency to exploit fast-changing opportunities and access to global markets (Morita, 1992). A good example would be IBM (www.ibm.com), Toshiba (www.toshiba.com), and Siemens (www.siemens.com). A contemporary example is the semiconductor industry, exemplified by two California companies, S3 Inc. (www.s3.com) in Santa Clara and Visioneer (www.visioneer.com) in Palo Alto. Both organisations subcontract almost everything. At Visioneer, software is written by several partners, hardware is manufactured by a subcontractor in Silicon Valley, printed circuit boards are made in Singapore, and plastic cases are made in Boston, where units are also tested and packed for delivery.

From research and consulting perspective the *virtual organisation* is composed of people who are linked by computers, faxes, computer-aided design systems, and video teleconferencing and who may rarely if ever see one another face to face. People come and go as and when their services are needed, much as in a matrix structure, but they are not formal members of an organisation, just functional experts who form an alliance with an organisation, fulfil their contractual obligations, and then move on to the next project.

Accenture (www.accenture.com) formerly known as Anderson Consulting (www.andersonconsulting.com), the global management consulting company, is becoming just such a virtual organisation. CEO George Shaheen says the company's headquarters are wherever he happens to be at the time. (it has to be noted that he spends 80% of his time travelling (Andersen's Androids, 1996).) The company's 40,000 consults often work from their homes, travelling to meet the company's clients throughout the world and only rarely stopping in at one of Andersen's branch offices to meet their superiors and colleagues. The benefit of this virtual arrangement is that the consultants all pool their knowledge in a massive internal database that they can easily access through computer and the company's Intranet.

Activity 4.1

Network Consideration

Debate the pros and cons of vertical integration and decide which is the most appropriate network, which will best fit your business unit. What advantages are you anticipating to gain from such a network?

Activity 4.2

Critical Thinking Exercise

What are the cultural impediments to establishing *keiretsu* networks in the United Arab Emirates? What would the United Arab Emirates or GCC countries community's position be on such arrangements? Find an example of an organisation that has a *keiretsu* network in the United Arab Emirates or in the GCC countries and describe its effectiveness?

The location of operations

The location decision involves deciding where the operation should be located. When we see in the news that a company has selected a site for a new plant, or a new store is opening, the announcement can appear trivial. Often it is reported that a particular site was selected from among a number of alternatives, and few reasons are provided, such as good community, customer traffic, or available land. In reality such media reports do not reveal the long, detailed process for selecting a site for a business operation. The process involved in selecting a particular location usually can take several years and the evaluation of dozens or even hundreds of potential sites are considered. But what are the underlying reasons behind such an expensive and lengthy process?

The location of an operation will have an effect on its cost base and the level of service it can provide. The actual impact will depend upon the operation's geographical position relative to its customers, suppliers and the resources it consumes. Locating a value creation operation in the optimal location for that operation can have one or two effects.

- It can lower the costs of the value creation operation, helping the company achieve a low-cost position, or

- It can enable a company to differentiate its products or services offering and charge a premium price.

So the location decision is crucial. The overall objective of the location decision is to achieve a balance between *spatially variable costs*; *service* and *revenue* potential. That is because different locations will have different implications for an operation in terms of:

- Spatially variable costs – cost that change depending on the location

- Service – the level of service the operation is able to provide

- Revenue potential.

The objective of the location decision is to minimise spatial variable cost and maximise the level of service and revenue potential.

Because of the variety of available locations experience has shown that there are various factors that influence the location decision. On the supply side the location decision is influenced by:

- *Labour costs* – wages and non-wage costs (employment taxes, holiday entitlements). These costs are not comparable from region to region. Factors such as productivity and exchange rates also have to be considered.

- *Land costs; energy costs; transportation costs* – in other words it is important to consider how much it will cost to ship products to the market and how much it will cost to bring resources to the operation.

- *Community factors* - local taxation rates, capital movement restrictions, government financial assistance (i.e., research and development tax rebates), government planning assistance, local attitudes towards investment, language, local amenities (i.e., schools, shops, etc) availability of support services, history of labour relations, labour absenteeism and turnover rates, environmental restrictions and waste disposals, and planning procedures and restrictions.

On the demand side the location decision is influenced by: *labour skills*; *convenience for customers*; the *actual site*; and the *image* of the location. In terns of customer convenience for example, it is common practice for McDonald's (www.mcdonalds.com) restaurant to locate their operations on attractive sites such as the University of New South Wales in Kensington, Sydney, Australia or the University of Wollongong in the beach road, Jumeirah, Dubai, United Arab Emirates. Also for service related-businesses it is commonly accepted to be smaller in size and less costly although a hospital can require a huge investment and be very large.

Although the above factors may well serve the location needs within national borders, different location decisions have to be made as companies have begun to locate in foreign countries. Why? Because although China for example offers an extremely attractive potential market because of this huge population, growing economy, and cheap labour force, it has probably the most inefficient transportation and distribution system in Asia, and a morass of government regulations. Ellis and Williams (1995: 319) has quoted, "it can take three weeks to ship finished goods the 1000 km from Shanghai to Beijing".

The immediate question that rises is, in which country or region should an operation be located? The location decisions then have to be made at least at three different levels:

- The location decision has to consider which region or country will be appropriate. Issues that need to be considered at this level include language and political stability.

- The location decision has to consider which area within the region or country will be appropriate. Issues that need to be addressed at this level include land prices, the local labour force, community factors and infrastructural development.

- The location decision has to consider the actual site. Issues that need to be considered at this level include soil composition, future plans for the site, availability of utilities, shape of the site and ease of access. The choice of the actual site if often the most opportunistic decision that has to be made.

Closing up with the location decision chapter, it needs to be addressed that the location decision is largely based on judgement although there are techniques that can be used to facilitate our choice. Two of the most common techniques are the weighted scoring method and the centre-of-gravity method. Both of these methods are presented in detail by Slack et al. (2000: 167-169).

Activity 4.3

Establishing Production Facilities for the Chinese Market

The emergence of China from its previously highly regulated political and economic system has offered many world-wide competitors a major new, but underdeveloped market, which presents huge opportunities for the future. In both world-wide industrial products and branded consumer goods the country is at a very early stage of development.

Since China opened its markets to foreign investment in 1979, world-wide competitors have been attracted by opportunities arising from the country's 1.2 billion population. Many of these companies have established joint ventures with local companies in order to gain access to this huge market. Each of the major companies, which have entered the Chinese market, see the country as a vital element in their attempts to gain global dominance. Unilever (www.unilever.com), for example, expected current sales of $200 million a year in 1995 to rise to $1.5 billion by 2001.

Entering the Chinese market and establishing new production facilities pose considerable problems even for large and well-resourced companies, which have established brands and/or production technology. First, establishing production facilities can be a long drawn-out process. For example, it took Nestle (www.nestle.com) some 13 years before it was able to establish its first joint venture in the production of powdered milk. Secondly, even bringing international brands to China does not stop local producers improving their own products, and competing strongly on price. More important, however, are the problems, which confront world-wide competitors in respect of the country's infrastructure and economic development. Not only does the country's geographical scale pose major logistical problems, but the transportation system is ill fitted to meeting the needs of national distribution. For example, it can take three weeks to ship finished goods the 1000 km from Shanghai to Beijing. Similarly, for television advertising, adverts have to be made abroad and sent to some 300 individual broadcast stations. It can also take up to six months to get a price increase approved by officials.

Given the country's recent emergence from a very different political and economic system, companies also face shortages of manpower, including managerial staff. Overcoming this shortage requires a heavy investment in training and development. Production workers in particular need to become familiar with and able to operate high technology plant very much more advanced than that found in much of Chinese industry.

All of these factors and others mean that companies investing in China do not anticipate much of a return on their investment in the short term. Any monies currently being generated are almost inevitably reabsorbed in further developing operations in the country. Equally, political and economic risks remain in doing business in China. Balanced against this, the potential of the size of the market means that in the long term few companies can risk not having a presence in the country.

Questions:

1. What is the climate for establishing production facilities in China? Is it supportive of foreign investment?

2. What does the current economic climate in China look like? Is it attractive of foreign investment? Explain.

3. What are some current issues facing China? Is it politically stable for establishing production facilities?

4. In terms of infrastructure, is China much different from Europe or United Arab Emirates? What are the potential problems that are likely to emerge for the production facility in China?

Source: Information based on press reports (Ellis & Williams, 1995).

The balance of capacity

After the vertical integration of the operation's network or the alternative networks (i.e., Keiretsu, Hollow Corporations, and Virtual Companies) and the location of its various operations have been decided what typically happens is that organisations that have become accustomed to rapid growth continue to add capacity at rates consistent with past growth. To support an organisation's growth then the next set of important decisions that have to be made will be related to the size or capacity of each part of the network.

During the growth phase when designing operations networks the basic questions that we are trying to address are what physical capacity should each part of the network have at a given point in time and how much it is going to cost. Trying to balance capacity between each part of the network means we should know at least two costs: the *fixed* and *variable costs* of the operation. Fixed costs exist irrespective of how much is produced. Variable costs increase as production volumes increase. Dividing the total output by the total fixed and variable cost gives the cost per unit produced.

Unit costs are lower when all capacity is being used. In other words, one could argue that an operation must have maximum output in a given period. Although this is generally the case, there are some reasons why the statement that 'unit costs are at their lowest when all capacity is being used' is not entirely true. In most operations capacity is effectively infinite. That is because work can be sub-contracted, overtime can be worked, and hence it is impossible to work at maximum (100%) capacity.

Other organisations operate their facilities at a rate less than the capacity. They do so because they have found that they can operate more efficiently when their resources are not stretched to the limit. For example, machines may break down more frequently when being used100%. Instead, they expect to operate at perhaps 90% or 94% of capacity. This concept is called **effective capacity**. Effective capacity is sometimes referred to as **utilisation**.

Effective capacity is simply the percent of design capacity actually expected. It can be calculated from the following formula:

$$\text{Effective capacity} = \frac{\text{Expected capacity}}{\text{Capacity}} \qquad (4.1)$$

Effective capacity is the capacity an operation can *expect* to achieve given its product mix, methods of scheduling, maintenance, and standards of quality. Another dimension, which is considered by organisations, is the **efficiency** of its operation. Depending on how facilities are used and managed, it may be difficult or impossible to reach 100% efficiency. Typically, efficiency is expressed as a percentage of effective capacity. Efficiency is a measure of actual output over effective capacity:

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} \qquad (4.2)$$

Once the effective capacity (utilisation) and efficiency have been determined, the next step is to determine the **rated capacity**. Rated capacity is a measure of the ***maximum usable*** capacity of the particular operation and will always be less than or equal to capacity. The equation used to compute rated capacity is:

$$\text{Rated capacity} = (\text{capacity})\ (\text{effective capacity})\ (\text{efficiency}) \qquad (4.3)$$

So the dimension of rated capacity is a measure that is commonly used by capacity management experts to schedule and maintain their operations, in other words, to develop the capacity plan, which is designed to satisfy future demand. In general, two strategies are taken into account by capacity management to develop the capacity plan, known as: *capacity leading demand* and *capacity lagging demand*. When capacity leads demand the operation should always have enough capacity to cope with demand, therefore revenue is maximised and customers are satisfied. The major problem with this strategy is that the utilisation of the plant is usually low. On the other hand, when capacity lags demand the operation will rarely have sufficient capacity to meet demand and hence the utilisation will be high, but customers will remain unsatisfied.

When there is poor match between the actual demand and the available capacity, in other words, demand exceeds capacity or capacity exceeds demand, capacity management uses various tactics for matching capacity to demand. Internal changes include adjusting the process to a given volume through:

- making staffing changes;

- adjusting equipment and processes, which might include purchasing additional machinery or selling or leasing existing equipment;

- improving methods to increase throughput;
- use spare capacity to build inventory which can be used later; and
- redesigning the product to facilitate more throughput.

Some external changes include influencing the demand by *offloading demand* to a period when there is available capacity by advertising and price cuts. Alternatively, by using the approach of *back ordering during high-demand periods,* or outsourcing.

The above tactics can be used to adjust demand or capacity to existing facilities. The strategic issue, however, is how to have a facility of the correct size that would lead to profitable operation. **Break-even analysis** helps with that decision.

The objective of the break-even analysis is to find the point, in dollars and units, at which costs equal revenue. This point is the break-even point as shown in Figure 4.3 below. As shown, break-even analysis requires an estimation of *fixed costs*, *variable costs*, and *revenue*. **Fixed costs** are costs that continue even if no units are produced i.e., taxes, depreciation, debt, interest, etc). **Variable costs** are those that vary with the volume of units produced, usually known as direct cost (i.e., labour cost, material costs, etc). **Revenue function** is the function in break-even analysis that increases by the selling price of each unit produced.

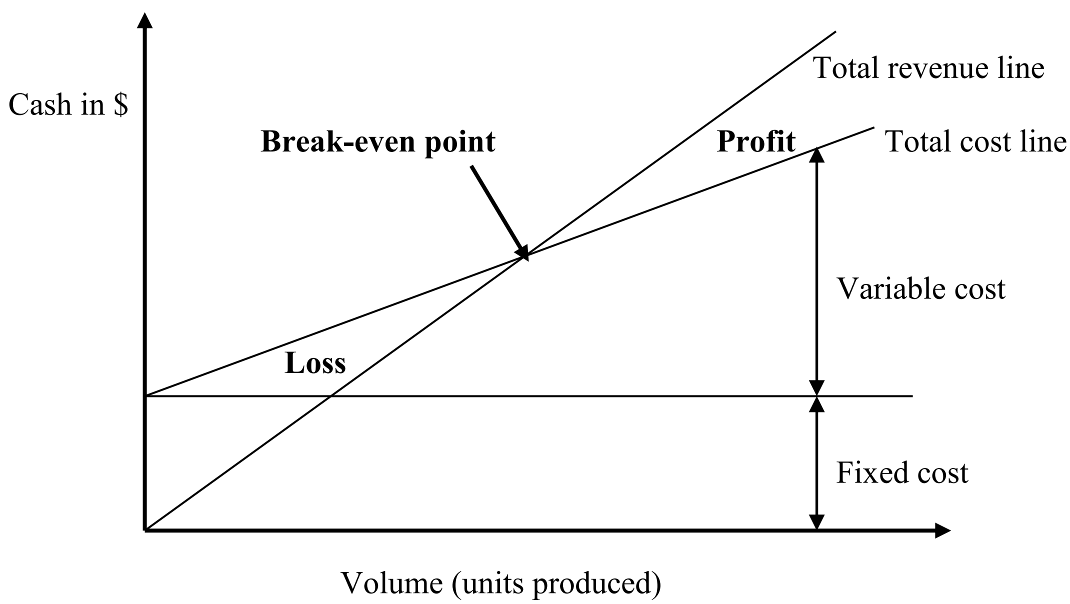


Figure 4.3 **Typical Beak Even Analysis Graph**

As shown in Figure 4.3, to the right of the break-even point, an operation makes profit. How much profit does an operation makes needs to be calculated mathematically? The algebraic approach and the respective formulas for the break-even point are given in any finance or accounting textbook.

Information technology within networks

As discussed in the 'learning objectives' section of this chapter it is essential for managers that work within networks to be familiar and understand the consequences of the more recent systems of SAP and Electronic Data Interchange (EDI). (Note that material related to SAP and EDI are discussed in detail in Chapter 7 from the perspective of electronic-commerce and operations management.)

SAP AG (http://www.sap.com/), a German-based company stands for Systeme, Anwendungen, Produkte in der Datenverarbeitung (Systems, Applications, and Products in Data Processing). It is a system that provides holistic control over supply chain functions. It is very large and versatile system. SAP R/3 system consists of a set of business application software chapters designed for the Client/Server environment. It includes powerful programs for accounting and controlling, production and materials management, quality management and plant maintenance, sales and distribution, human resources management, and project management. Generally SAP R/3 has been designed as an integrated system and gives managers and virtual operators the ability to link business processes with those of its customers and suppliers to create a complete supply network covering the entire chain from supply to delivery. In summary, there are many benefits that can be obtained from implementing the SAP R/3 system. Some of these benefits are listed below:

- The system is designed for all types of business
- The system has a world-wide range
- The system features Flexibility, Open system and Interactive processing
- The system is a fully integrated package and hence promotes Integration within the company and the network
- SAP R/3 system is an end-to-end business solution
- The system supports multiple level organisational structure
- The system supports global networks and accounting practices
- SAP R/3 has a predefined Standardised business process across the organisation and its network

- SAP R/3 provides a complete business solution across all business units of the network that are required for strategic and operational control of any organisation.

Although it was stated that SAP R/3 is designed for all types of business, SAP R/3 is not for everyone. It is very costly and complex, costing clients millions of dollars for implementation, thus making its use practical for only large organisations. Companies annually spend almost $10 billion in computer and networking equipment to run SAP, and a $20 billion support industry of consultants, trainers, and software firms have grown up around SAP and other *Enterprise Resource Planning* (ERP) software companies. SAP is very difficult to install and can cost hundreds of millions of dollars. It took five years and $160 million for Chevron to install SAP (Russell & Taylor III, 2000).

Concluding this chapter it is important to know that information technology has created the global village and the concept of virtual corporations. Networks are making full use of information technology to manage and exchange information across the network. Many networks and organisations use Electronic Data Interchange (EDI) combined with bar codes to provide quick response to customers. EDI is a specialised network (sometimes on the Internet) that companies use to exchange orders and status with their suppliers and customers. By removing the non-value-added time (i.e., the time that elapses in which no value is added to the product or service, such as moving, storing, counting, inspecting, checking, revising, copying, etc) and transmitting purchase orders, invoices, and payments electronically, the time between, say, order entry and order fulfilment decreases, thus improving the level of customer service and network efficiency. EDI links customers and retailers, retailers and distributors, and distributors and producers. These firms form a network and complement one another and hence we are seeing the emergence of “trading partners”.

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. A network encompasses all the facilities, functions, and activities involved in producing and delivering a product or service. **True**

2. EDI provides a secure means for transmitting standardised business forms over private networks. **True**

3. The primary consideration for manufacturing firms involved in location analysis is finding the geographic area with the greatest potential for customer traffic. **False**

4. The basic location criteria for service-oriented firms are the same for manufacturing firms. **False**

5. An important factor in the location decision for companies involved in heavy manufacturing is the cost of transportation for heavy manufactured items. **True**

6. Important factors in the location decision for companies involved in heavy manufacturing include the availability of skilled workers. **False**

7. Retail and service operations generally require the smallest and least costly facilities. **True**

8. The closeness of suppliers and the amount of inventory a firm will be required to keep are directly related. **True**

9. As the distance between a firm and its suppliers increases, the variability of the timing of deliveries increases. **True**

10. It is important when a company builds a new facility to consider soil stability and content. **True**

11. Many networks locate overseas to take advantage of a cheap labour force. **True**

12. V*irtual organisation* is composed of people who are linked by computers, faxes, computer-aided design systems, and video teleconferencing and who may rarely if ever see one another face to face. **True**

MULTIPLE CHOICE QUESTIONS

1. Facilities along the network supply chain include:
   a) plants
   b) warehouses
   c) distribution centres
   d) all of the above

2. The networks are:
   a) changing the fundamental nature of doing business
   b) blurring the traditional roles of manufactures, distributors, and suppliers
   c) breaking down geographical barriers
   d) all of the above

3. Which of the following criteria would a company which produces electronic equipment and components likely consider most important for location analysis?
   a) land and construction costs
   b) availability of skilled workers
   c) transportation costs

d) proximity to raw material

4. A company which is most interested in the availability of skilled labour, access to commercial air travel, and government regulations and zoning requirements is probably part of:
   a) light industry
   b) warehouse and distribution
   c) retail and service
   d) heavy manufacturing

5. In terms of location analysis, which of the following generally requires the smallest and least costly type of facility?
   a) light industry
   b) warehouse and distribution
   c) heavy manufacturing
   d) retail and service

6. Which of the following factors influence the location decision for a service facility?
   a) convenience for customers
   b) availability of skilled labour
   c) energy and transportation costs
   d) all of the above

7. A company making a location decision, which involves factors such as taxes, labour pool, and proximity of suppliers, has most likely narrowed the decision down to what level?
   a) country
   b) region
   c) site
   d) **community**

8. Labour climate, one of the most overall factors in a location decision, is defined as:
   a) the work ethic of the labour population
   b) the possibility of conflict with organised labour
   c) the skill level of the labour pool
   d) all of the above

9. Which of the following might a community do to attract businesses to its area?
   a) ease zoning and environmental regulations
   b) provide tax breaks and low-interest loans
   c) improve and build roads
   d) all of the above

SHORT-ANSWER QUESTIONS

1. What is vertical integration? Give examples of backward and forward integration.

2. Assume that you are going to open a fast-food restaurant in your community. Select three sites. Perform a location analysis for each and select the best site.

3. What kind of companies stand to gain the most from entering into a network with potential competitors? Why?

4. Explain what EDI is and the benefits it can provide.

Summary

This chapter provided an introduction to design of operations network. In particular, it focussed on the nature of operations networks and the concepts of the 'supply-side' and the 'demand-side' parts of the network. The chapter also examined the advantages of taking a network perspective in making strategic design decisions. The chapter also investigated the extent to which an operation chooses to be 'vertically integrated' into the network, and how much of the network an operation should own. Alternative arrangements to vertical integration, such as *Keiretsu* and *Hollow Corporations,* have been investigated and their application to specific cases was justified. Finally, the power of information technology within networks was discussed and the most recent network systems (SAP and EDI) were presented.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to design of the operations network

- ☐ The concept of networks from the competitive advantage perspective
- ☐ The total supply network arrangement
- ☐ The global network approach

The nature and purpose of the operations network

- ☐ The nature of the operations network
    - ☐ The supply-side of the network
    - ☐ The demand-side of the network
    - ☐ The objectives of the total supply network

- ☐ Advantages of taking network perspective
    - ☐ Significant links in the network
    - ☐ Long-term position in the network

- ☐ Direction, extent and balance of vertical integration
    - ☐ Direction of vertical integration
    - ☐ Backward integration
    - ☐ Forward integration
    - ☐ Extent of vertical integration
    - ☐ Balance of capacity
    - ☐ Benefits and disadvantages of vertical integration

- ☐ Alternative variations to vertical integration

- Keiretsu
- Virtual companies or hollow corporation

- The location of operations

- The balance of capacity
  - Effective (utilisation) capacity
  - Efficiency
  - Rated capacity
  - Break-even analysis

- Information technology within networks
  - Systems, Applications, and Products in Data Processing (SAP)
  - Electronic Data Interchange (EDI)

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.
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Chapter 5 The nature of planning and control

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The nature of planning and control

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this chapter, you should be able to:

- understand what is planning and control and what are differences between planning and control.
- provide an overview of the principles and method of planning and control.
- examine how the nature of demand affects planning and control.
- examine the influence of volume and variety on planning and control.
- provide specialist tools to planning and control in project environments.
- become aware of the different aspects of planning and control.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Understand the importance and the advantages of planning and control processes in organisations
- Understand that planning and control is the reconciliation of the operation’s potential to supply products and services with the demands of its customers on the operation
- Understand the degree of uncertainty in demand and its affects in the balance between planning and control
- Examine how efficient and effective are planning and control activities
- Be familiar with the specialist tools and techniques that are available for effective planning and control in project environments

What you will need

Suggested study time	Text Books	5 hours
	Activities and exercises	2 hours
Other resources:	Suggested readings	3 hours
	Total	10 hours

Introduction

The Henry Ford Health System (www.henryford.com) in Southeast Michigan is Michigan's sixth largest employer. It consists of a 900-bed hospital and research facility with more than 16,000 full-time equivalent employees, including 3,000 nurses and more than 4,000 allied health professionals who provide care during more than 2.5 million patient contacts. Henry Ford health care providers perform more than 30,000 ambulatory surgery procedures each year. The hospital houses 30 different nursing units, ranging from an 8-bed neurosurgical intensive care unit to a 44-bed general medicine unit. As more complex medical procedures are performed on an outpatient basis, the overall demand for hospital beds has declined, and many communities have set about to reduce their excess capacity. Combining facilities, closing down facilities, or building new facilities are long-term capacity decisions.

Intermediate-term attempts to control health-care costs have centred on reducing nursing staff resources, which accounts for 40 percent of personnel costs, with the potential to recruit more staff later if demand changes. Henry Ford Health exhibits many of the characteristics that many organisations have to face. Hence, managers have to make critical decisions about the use of resources to more effectively respond to demand, making capacity planning and control a difficult process. Although capacity planning and control appear to be similar in nature, in reality there are differences between them.

A plan is a formalisation of what is intended to happen at some time in the future. Control is the process of coping with changes to the plan and the operation to which it relates. Although planning and control are theoretically separable they are usually treated together. The balance between planning and control changes over time. Planning dominates in the long term and is usually done on an aggregated basis. At the other extreme, in the short term, control usually operates within the resource constraints of the operation but makes intervention into the operation in order to cope with short-term changes in circumstances.

In the case of the Henry Ford Health System in Southeast Michigan, it is recognised that without consideration of planning and control activities, operations would have no indication of what they are supposed to do or when they were supposed to do it, nor could they cope with deviations from what was expected. In other words, capacity planning and control are *essential* and *important* activities for any organisation to meet customer's demands.

If planning and control activities are executed in an efficient and effective manner they should ensure that products and services are produced:

- in the appropriate quantity
- at the appropriate time
- at the appropriate level of quality

Also at Henry Ford Health System the problems of matching resources to demand become apparent when management made a decision to reduce the nursing staff by several positions, and perhaps reopen positions if demand rapidly increases. The issue that arises then is how does the nature of demand affect planning and control? It is obvious that the degree of uncertainty in demand affects the balance between planning and control. The greater the uncertainty, the more difficult it is to plan and greater emphasis must be placed on control. This idea of uncertainty is linked with the concepts of *dependent* and *independent demand*.

By *dependent demand*, we mean that the demand for one item is related to the demand for another item. Consider the BMW 740 series. BMW's (www.bmw.com) demand for auto tires and radiators depends on the production of 740 series. Four tires and one radiator go into each finished BMW 740. Demand for items is *dependent* when the relationship between the items can be determined. Therefore, dependent demand is relatively predictable because it is dependent on some known factor. Once management can make a forecast of the demand for the final product, quantities required for all components can be computed, because all components are dependent items.

On the other hand, *independent demand* relates to the finished goods or other end items that are sold to someone. There is usually no way to determine precisely how many of these items will be demanded during any given time period because demand typically includes an element of randomness. In other words, *independent demand* is less predictable because it depends on the changes of the market or customer behaviour.

The different ways of responding to demand can be characterised by differences in the P:D ratio of the operation. The P:D ratio is the ratio of total throughput time of goods or services to demand time. This ratio of total throughput of goods and services is linked with the concepts of *loading*, *sequencing* and *scheduling*, which are all distinct activities of planning and controlling the volume and timing of the operations.

- **Loading** dictates the amount of work, which is allocated to each part of the operation

- **Sequencing** decides the order that work is tackled within the operation, and

- **Scheduling** determines the detailed timetable of activity and when activities are started and finished.

Control can be classified as push or pull control. Pull control is a system whereby demand is triggered by requests from a work centre (i.e., an internal customer). Push control is a centralised system whereby control (and sometimes planning) decisions are issued to work centers which are then required to perform the task and supply the next work station. In manufacturing 'pull' schedules generally have far lower inventory levels than 'push' schedules.

In a pull system workflow is dictated by "next-step demand". A system can communicate such demand in a variety of ways, including a shout or a wave, but by far the most commonly used device is the *Kanban* card. *Kanban* is a Japanese word meaning "signal" or "visible record" and communicates demand for work or materials from the preceding station.

Finally, the *volume* and *variety position* of an operation has an affect on the nature of its planning and control. Customer responsiveness, planning horizon, the major planning decisions, the control decisions and the robustness of planning and control are especially affected by volume and variety.

What is planning and control?

Basically planning and control seeks to ensure that the operation runs effectively and produces what it should. As discussed in the introductory section of this chapter, good planning and control ensures that the organisation's resources are used effectively and that the right quantity of goods and services is produced at the right point in time and with the right quality. Because planning and control is linked to organisational resources it is intimately linked to the facility design and layout. The design of the operation determines what the operation is capable of doing. Planning and control determines what the operation actually does. For example, it determines whether the resources at the operation's disposal are used in a way that satisfies demand. In fact planning and control is all about matching supply and demand.

As known demand (and here we refer to independent demand) usually fluctuates due to market changes and customer behaviour, it makes the planning and control task very difficult in its execution. In addition to demand changes, planning and control is complicated by a number of other organisational factors such as:

- Due to cost constraints organisations do not have infinite resources. Hence planning and control decisions have to be made about how limited resources should be deployed.

- Physical constraints can also complicate the planning process. Even if an organisation has infinite financial resources, the equipment it needs or the people it wants may not be available when required.

- All products and services have a shelf-life. They have to be delivered while the customer still wants them. Such timing constraints further complicate the planning and control activity.

- Finally, products and services have to be manufactured so that they conform to certain quality standards. These quality constraints often have implications for the planning and control tasks.

Although capacity planning and control are closely linked and they sound to be the same in nature, in reality there are differences between them. A plan describes what is intended to happen, but offers no guarantee that it will happen. Specifically, a plan, like a *production plan* in manufacturing, for example, specifies what is to be made (i.e., a number of finished products or items) and when. It also includes a variety of inputs, including financial plans, customer demand, engineering capabilities, labour availability, and inventory fluctuations, supplier performance, and other consideration. Each of these inputs contributes on its own to the production plan as shown on Figure 5.1.

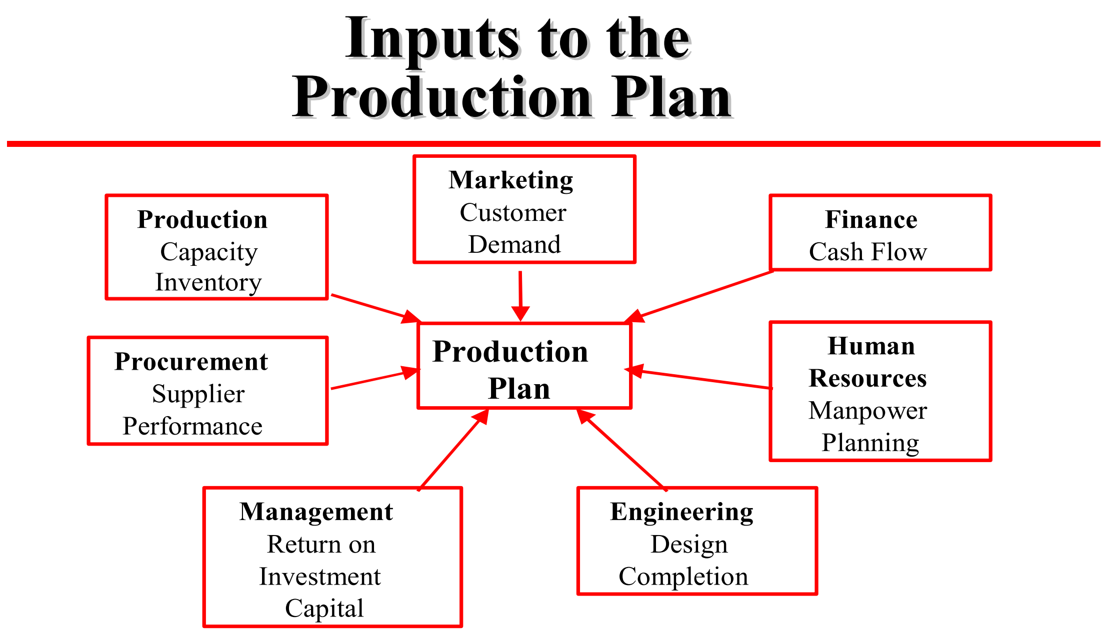

Figure 5.1 Inputs to Production Plan

Adopted from Heizer and Render (1999:539)

Because of the uncertainty of all these inputs, a plan is a set of expectations based on experience, but as implementation proceeds unforeseen circumstances are likely to make it necessary to change the plan.

On the other hand, control is about coping with unforeseen circumstances. It is the process by which plans are modified so operations can still achieve their objectives, even though the assumptions made originally no longer hold. Control makes the necessary adjustments intending to reduce the potential of customer dissatisfaction that may arise because the plan is not being adhered to. Furthermore, control is intended to minimise the disruption to the operation and improve its quality standards.

For example, many organisations have difficulty with scheduling (that is, achieving effective throughput) because they overload the production process. Among other things, this may occur due to the fact that managers do not know the actual performance in the work centers. Effective scheduling depends on matching the schedule to performance. Lack of knowledge about the capacity and performance causes reduced throughput and hence disruption to the operation (that is, the cause of bottlenecks). Consequently, control makes the necessary schedule changes (that is, underloading the work centers), or corrects performance output in order to improve customer service level so that units may be produced on time. In addition, quality may improve because less work-in-progress hides fewer quality problems.

Although modifications to a plan may assist the operations to achieve its objectives, the implications of changing some plans at short notice are just too disruptive to the whole even to be justifiable. Therefore, the planning and control changes should be carefully designed and executed over time without losing customers and draining the company's resources. So, planning and control activity is carried out over *long*, *medium* and *short terms*.

- **Long-term planning** and **control** usually has a financial focus and involves decisions being made at the aggregate level. (In this case aggregate planning determines the capacity resources to meet demand over a long time horizon.) Such decisions often have to be based on forecasts (usually qualitative forecasts) rather than hard data. (Qualitative forecasting techniques may be considered those of jury of *executive opinion*, *sales force composite*, *delphi method*, and *consumer market survey*.) (Heizer & Render, 1999).

- **Medium-term planning** and **control** is done at the partially disaggregate level and often includes 'contingency' planning. In other words, medium-term planning and control is concerned with both, planning in more detail and replanning if necessary.

- **Short-term planning** and **control** is done at the fully disaggregate level. In the short term, time for full evaluation of options is rarely available and hence the focus tends to be on responding quickly to unforeseen variation. In making short-term interventions and changes to plan, operations managers will be attempting to balance the quality, speed, dependability, flexibility, and costs of their operations on an *ad hoc* basis.

Activity 5.1

Planning and Control Time Horizon

1. What are the main differences between **long-term** planning and control and **short-term** planning and control activity in your organisation? How does each approach affect different types of customers?

2. What forecasting techniques are used for the **long-term** planning and control activity in your organisation? Who is responsible for the **short-term** planning and control activity?

The nature of supply and demand

The nature of supply and demand affects the planning and control activity. Uncertain supply or demand, for example, means that contingency plans have to be developed. The starting point of planning and control for management is customer demand. Customers can be inside the organisation, such as a machine operator waiting for a part or partially completed product to work on. Customers can be outside the organisation – for example, an individual purchasing groceries or a new automobile or a student undertaking a course. In either case an essential determinant of effective planning and control is an accurate forecast of demand. For this reason the chapters of forecasting and planning and control are directly interrelated.

As discussed in the introductory section of this chapter, in general the demand for items is either *dependent* or *independent*.

Dependent demand is predictable and it is based on known factors and as such makes forecasting straightforward. Dependent demand items are typically used internally to produce a final product. If an automobile company plans to produce 1,000 new cars per day, then it will need 5,000 wheels and tires, including the spares, per day. The demand for wheels is dependent on the production of cars. Simply, the demand of one item depends on the demand for another item and hence, forecasting is straightforward.

Operations with dependent demand either 'resource to order' or 'make to order'. Operations which resource to order allocate transforming and transformed resources only once the order has been received. A single order consumes a given set of resources and it is the order that triggers production.

Making to order is appropriate when the nature of demand is predictable (i.e., it is known that the order will be for a given type of product), but the timings and volumes are unknown. As with resourcing to order, the trigger which starts production is the receipt of an order.

Independent demand relates to the finished goods or other end items that are sold to someone. Cars are an example of an *independent demand* item. Independent demand is usually external and, thus, is beyond the direct control of the organisation. Therefore, *independent demand* is less predictable because it depends on the changes of the market or customer behaviour. When demand is independent and there is no forward visibility of orders, operations have to forecast what they think future demand is likely to be. In such circumstances operations tend to make to stock. The risk of this strategy is that the operation may make too much, or too little.

In the case of too much, the operation generates unnecessary inventory, and thus, unnecessary cash outlay. Operations managers should be aware that any unnecessary inventory is associated with at least two costs: *carrying*, or *holding costs*; and *ordering costs*.

- **Carrying costs** are the costs of holding an item in inventory
- **Ordering costs** are the costs of replenishing inventory.

In the case of too little inventory, the operation looses income due to shortages of products. Shortages result in permanent loss of sales and can as well cause customer dissatisfaction and loss of goodwill resulting in a permanent loss of customers and future sales. Costs that are associated with shortage are known as *stockout* costs. Therefore, the nature of independent demand planning and control is to make decisions on how many and what types of stock an operation can produce in light of the risks it is prepared to run of being out of stock or ending up with too much stock. An operation makes 'best guesses' concerning future demand, attempting to put the resources in place, which can satisfy this demand. In summary, a planning and control activity is typical of independent demand planning and control.

A different way of responding to demand can be characterised by differences in the P:D ratio of the operation. P is equal to the total throughput time, that is, the time taken to purchase, make and deliver goods and services. On the other hand, D is equal to demand time, that is the time a customer is willing to wait between requesting a particular product or service and receiving it. As discussed in the introductory section of this chapter, the P:D ratio is the ratio of total throughput time of goods or services to demand time. With regards to the P:D ratio we have three scenarios.

- If $P >> D$ the operation has to make to stock
- If $P \cong D$ the operation can afford to resource to order, and
- If $P << D$, and product demanded is fairly standard, the operation can afford to make to order.

The actual P:D ratio is likely to vary from product group to product group, even within a given operation. Finally, the P:D ratio provides an indication of the level of speculation within an operation. Forecasts are rarely perfect, but when $P >> D$, operations are forced to forecast. The greater the P:D ratio, the longer term, and hence the less precise the forecast will be. Reducing the P:D ratio, in effect, is a way of taking some of the risk out of the operations planning and control.

Finite and infinite loading

Planning and control involves reconciling supply and demand. Operations managers should consider three things when reconciling supply and demand: *scheduling*; *sequencing* and *loading*. We will discuss these in the following sections.

Loading involves determining what volume of production the operation can cope with. Loading is the process of assigning work to limited resources. Many times an operation can be performed by various persons, machines, or work centers but with varying efficiencies. If there is enough capacity, each worker should be assigned to the task that he or she performs best, and each job to the machine that can process it most efficiently. In effect, that is what happens when 'capacity requirements planning' (CRP) generates a load profile for each machine centre. The routing file used by CRP lists the machines that can perform the job most efficiently first. If no overloads appear in the load profile, then production control can proceed to the next task of sequencing the work at each centre. However, when resource constrains produce overloads in the load profile, production control must examine the list of jobs initially assigned and decide which jobs to reassign elsewhere. But how can overloads be produced in the load profile?

In theory machines can work for 168 hours per week. In practice, weekends, set-ups and break-downs means that there will be some periods when equipment is idle. Because of practical constraints that an operation has to face, there are two basic types of loading to consider when reconciling supply and demand: *finite loading* and *infinite loading*.

Finite loading is when work is allocated to machines only up to a certain set limit. Finite loading is particularly relevant when:

- it is **possible** to limit the load – for example, the hospital appointment system

- it is **necessary** to limit the load - for safety reasons you cannot have more than a predetermined number of people in an aeroplane, and

- the **cost** of limiting the load is **not prohibitive**.

Finite loading is extremely complex, particularly in a machine shop. Finite loading involves complex calculations and the computing power required often prohibits it in machine shops. Experience has shown that the *assignment method of linear programming* is one of the best methods to allocate jobs to machines or workers to tasks. The *assignment method of linear programming* is a specialised linear programming solution that is much simpler than the 'model formulation', or 'graphical solution method' listed in other textbooks. (The interested reader can refer to Russell & Taylor III, 2000, Chapter 11 supplement.) Other methods such as **Gantt charts** are relatively easy and useful in loading and scheduling. When used in loading, *Gantt charts* show the loading and idle times of several departments, machines, or facilities. They display the relative workloads in the system so that the manager knows what adjustments are appropriate. A typical Gantt Load Chart is shown on Figure 5.2.

Infinite loading is when there is no limit to the work allocated to particular machines. The assumption in infinite loading is that once the work has been loaded a way of coping with it will be found. Infinite loading is particularly relevant when:

- it is **not possible** to limit the load – for example, an accident and emergency departments of a metropolitan hospital

- it is **not necessary** to limit the load – a fast food restaurant, and

- the **cost** of limiting the load is **prohibitive**.

Gantt Load Chart

- Shows relative workload in facility
- Disadvantages
  - Does not account for unexpected events
  - Must be updated regularly

Work Center	S	S	M	T	W
Sheet Metal	Job A			Job F	
Mechanical		Job D		Job G	
Electrical	Job B			Job H	
Painting	Job C		Job E		Job I

Figure 5.2

Adopted from Heizer and Render (1999: 586)
Note that the week reflects the Islamic calendar

Sequencing

As discussed earlier, *sequencing* is one of the three things that operations managers should consider when reconciling supply and demand. When more than one job is assigned to a machine or activity, the operator needs to know the order in which to process the jobs. The process of prioritising jobs is called **sequencing**. If no particular order is specified, the operator would probably process the job that arrived first. This default sequence is called *first-come*, *first-served* (FCFS). Or, if jobs are stacked upon arrival to a machine, it might be easier to process the job first that arrived last and is now on top of the stack. This is called *last-come*, *first-served* (LCFS) sequencing.

Another common approach is to process the jobs first that is due the soonest or the job that has the highest customer priority. These are known as *earliest due date* (DDATA) and *highest customer priority* (CUSTPR) sequencing. Operators may also look through a stack of jobs to find one with similar set-up to the job that is currently being processed (SETUP). That would minimise the downtime of the machine and make the operator's job easier.

A variation on the DDATE rule include *minimum slack* (SLACK) and *smallest critical ratio* (CR). SLACK considers the work remaining to be performed on a job as well as the time remaining (until the due date) to perform that work. Jobs are processed first that have the least difference (or slack) between the two, as follows:

SLACK = (due date – today's date) – (remaining processing time)

The critical ratio uses the same information as SLACK but arranges it in ratio form so that scheduling performance can be easily assessed. Mathematically, the CR is calculated as follows:

$$CR = \frac{\text{Time remaining}}{\text{Work remaining}} = \frac{\text{due date – today's date}}{\text{remaining processing time}}$$

If the work remaining is greater that the time remaining, the critical ratio will be less than 1. If the time remaining is greater than the work remaining, the critical ratio will be greater than 1. If the time remaining equals work remaining, the critical ratio exactly equals 1. In summary then:

If CR > 1, then the job is ahead of schedule

If CR < 1, then the job is behind schedule

If CR = 1, then the job is exactly on schedule.

Other sequencing rules examine processing time at a particular operation and order the work either by shortest processing time (SPT) or *longest processing* (LPT). Sequencing by **longest operation time** first leads to high utilisation of work centers, but can result in low flexibility, longer delivery lead time and poor delivery reliability (Slack et al. 1998). On the other hand, sequencing by **shortest operation time** can be good thing to do if the business is cash constrained as it ensures that quick jobs pass through the system rapidly. The problem with sequencing by shortest operation time first, however, is that productivity may be reduced.

All these sequencing rules for arranging jobs in a certain order for processing seem reasonable. The operations manager, however, should be knowledgeable enough to understand the advantages and disadvantages of each rule. In some cases, for example, it really does not matter which jobs are processed first, thus the rule(s) are not so important.

The reader of this chapter should be also aware that the level of complexity of sequencing is different for sequencing jobs through one process, through two processes, and through any number of processes. As the level of complexity increases the operations manager has to use simulation techniques to simulate hypothetical job shops. Such activity requires high level of expertise that is not the objective of this chapter. (the interested reader can refer to simulation textbooks.)

Scheduling

As discussed earlier, *scheduling* is the third thing that operations managers should consider when reconciling supply and demand. Basically the scheduling activity involves producing a timetable. Scheduling involves deciding start and finish times for tasks, but many jobs may compete simultaneously for the same resources. To help address the difficulties inherent in scheduling, we can categorise scheduling techniques as *forward scheduling* and *backward scheduling*.

Forward scheduling starts the schedule as soon as the job requirements are known. In other words, work is planned to start as soon as possible. Forward scheduling is used in a variety of organisations such as hospitals, clinics, and fine dining restaurants. In these facilities, jobs are performed to customer order, and delivery is often requested as soon as possible. Forward scheduling is usually designed to produce a schedule that can be accomplished even if it means *not* meeting the due date. In the case of the restaurant, for example, forward scheduling means building unnecessary work-in-progress inventory. Although forward scheduling creates work-in-progress inventory, it increases flexibility, and results in high labour utilisation.

Backward scheduling begins with the due date, scheduling the final operation first. In other words, work is planed to start as late as possible. That is, steps in the job are scheduled one at a time, in a reverse order. By subtracting the lead time from each item, the start time is obtained. However, the resources necessary to accomplish the schedule may not exist. Backward scheduling is used in many manufacturing organisations, as well as service companies such as catering for a banquet or scheduling a surgery. In summary, backward scheduling reduces material costs, minimises the operation's exposure and encourages a focus on due dates.

Although both, *forward* and *backward scheduling* offer advantages, they also have disadvantages. In practice, a combination of forward and backward scheduling is often used to find a reasonable trade-off between what can be achieved and what is desired.

As discussed earlier, scheduling activity involves producing a timetable. From this statement it sounds that scheduling is an easy activity and it can be done on the back of the postage stamp. Unfortunately, scheduling is complicated by the fact that it is a factorial problem. Scheduling involves dealing with several different types of resource simultaneously. The number of possible schedules grows rapidly as the number of processing activities increases. The scheduling activity is further complicated by the fact that the schedule has to be *recalculated* when demand changes.

Scheduling can be classified as *infinite* or *finite*. *Infinite scheduling* loads without regard to the capacity, then levels the load and sequences the jobs. To the contrary, *finite scheduling* sequences jobs as part of the loading decision. In this case resources are never loaded beyond capacity. It is obvious that operations use finite scheduling instead of infinite scheduling.

In *finite scheduling* loading and sequencing decisions are made at the same time, so that the first jobs loaded onto a work centre are of highest priority. Any jobs remaining after the capacity of the work centre or resource has been reached are of lower priority and are scheduled for later time periods. Finite scheduling is characterised by the ability of the scheduler to make changes based on up-to-the-minute information. These schedules are often displayed in Gantt chart form similar to one shown on Figure 5.3 below. The scheduler has the flexibility to handle any situation, including order, labour, or machine changes.

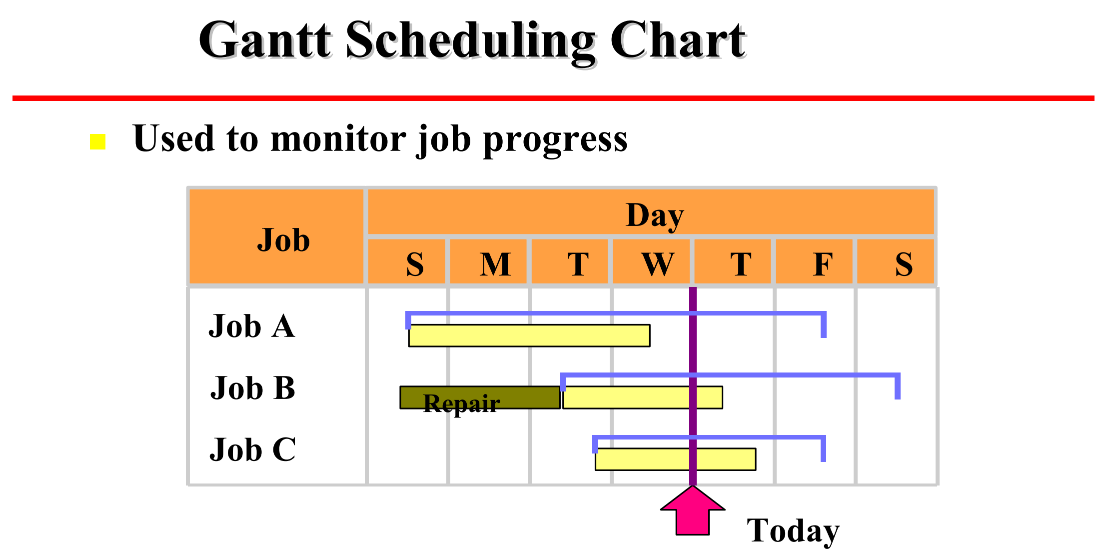

Figure 5.3 Typical Gantt Scheduling Chart
Adopted from Heizer and Render (1999:587)

Finite scheduling allows delivery needs to be balanced against efficiency based on today's conditions and today's orders, not according to some predefined rule. Many of the current finite scheduling computer programs offer resource constraint features, a multitude of rules, and the ability of the scheduler to work interactively with the scheduling system to create a realistic schedule. These systems may also combine an "expert system" and simulation techniques and allow the scheduler to assign costs to various options. Finite scheduling helps but leaves it up to the scheduler to determine what constitutes a "good" schedule (Anard, 1994).

Finally, operations managers need to know that a schedule can be designed to *push* or *pull* work through the operation. **Push schedules** usually rely on a central planning and control system. Each work centre completes all the work it can and *pushes* this work forward to the next work centre. Push schedules dump orders on the next downstream work station regardless of timeliness and resource availability. Push scheduling is the opposite of the *pull scheduling*, often known as *Just-in-Time* (JIT).

Pull schedules rely on the customer (internal or external) to pull work through the operation. When an order is received a product is dispatched from the stores. The 'gap' in the stores is the signal (KANBAN) for the assembly to produce a replacement product. The resultant 'gaps' in assembly are the signals for the machining centres to produce replacement components, and so on. It is now generally accepted that the pull schedules tend to result in less inventory than the push schedules, therefore, pull schedules result in substantial quality improvements.

Activity 5.2

Critical Thinking Exercise

Scheduling people to work the late, or "graveyard", shift is a problem in almost every 24-hours company. An article in *The Wall Street Journal,* titled "Scheduling Workers Who Fall Asleep on the Job Is Not Easy", describes night-shift dilemmas at an oil refinery and at police departments. Scheduling is also difficult for airlines that fly long routes, such as El Al Airline's popular 11-hour non-stop Athens to Singapore.

Exercise:

1. Select five organisations that require night shifts and discuss how each can deal with its staffing requirements.

2. What are the major issues in each which affect morale, productivity, alertness, and safety?

Activity 5.3

Push and Pull Schedules – Group Exercise

Select four types of operations (manufacturing or service) and suggest which type (push or pull) scheduling might be appropriate for each. Why?

Volume-variety influences on planning and control

Finally, the volume-variety characteristics of an operation have an impact on the type of planning and control system that will be appropriate. Operations which produce a high variety of products or services in relatively low volume will clearly have customers who require a different set of factors and use processes which have a different sets of needs to those operations which create standardised products or services in high volume (Slack et al. 2000).

More specifically, in operations with **low volume** and **high variety** the planning and control activity tends to **focus on timing** because:

- There is little, or no product standardisation
- Designs cannot be produced in advance of orders being received
- The time taken to respond to customers requests is usually long
- The requirements of the customer often 'emerge' during consultation
- There is little opportunity for forward planning

In operations with **high volume** and **low variety** the planning and control activity tends to **focus on volume**, because:

- Customers expect fast response
- The planning and control horizon can be long
- Process failure can have a major impact

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. The scheduling function differs by process type. **True**

2. Loading dictates the amount of work, which is allocated to each part of the operation. **True**

3. Scheduling is the last stage of planning before production takes place. **True**

4. One responsibility of the planning and control department is checking the availability of materials, machines and labour. **True**

5. Managers typically have only one objective to consider when planning. **False**

6. If jobs are stacked on top of each other upon arrival to a machine, it will probably be best to use the LCFS rule for processing them. **True**

7. SLACK is a sequencing heuristic that considers the remaining processing time to complete a unit, but disregards its completion date. **False**

8. In using the critical ratio heuristic, if the time remaining equals the work remaining, then CR = 1. **True**

9. Gantt charts map out planned and completed activities against a time scale. **True**

10. Today, Gantt charts are not used frequently. **False**

11. In finite scheduling, loading and sequencing decisions are made separately rather than together as they are in infinite scheduling. **False**

12. With finite scheduling, resources are never loaded beyond capacity. **True**

13. Because software that will do finite scheduling is becoming more popular, it is fairly easy for a company to purchase a software package off the shelf, which can handle the company's particular manufacturing environment. **False**

14. In operations with low volume and high variety the planning and control activity tends to focus on volume. **False**

15. Just-in-Time (JIT) is often known as push scheduling. **False**

MULTIPLE CHOICE QUESTIONS

1. Which of the following refers to the scheduling and monitoring of day-to-day production of a job shop?
   a) shop floor control
   b) production activity control
   c) job shop scheduling
   d) all of the above

2. Which of the following is *not* a responsibility of the planning and control activity?
   a) deciding on which machine a part will be routed for processing
   b) assigning workers to operate machines that process the parts
   c) determining in what order the parts will be processed
   d) all of the above are responsibilities of scheduling

3. Loading and load levelling are part of which of the following planning and control activity?
   a) releasing work orders to the shop
   b) checking the availability of materials, machines, and labour
   c) maintaining process reports
   d) issuing dispatch lists for individual machines

4. If no particular heuristic sequencing rule has been specified, the default sequence is:
   a) FCFS
   b) DDATE
   c) CR
   d) SLACK

5. When an operator looks through a stack of jobs to find ones requiring similar process, which heuristic sequencing rule is being used?
   a) LCFS
   b) CR
   c) SPT
   d) SETUP

6. In using the CR heuristic sequencing rule, if CR > 1 the:
   a) the work remaining is greater than the time remaining
   b) the job is behind schedule
   c) the job is exactly on schedule
   d) the job is ahead of schedule

7. Which of the following heuristics in a one-machine shop will minimise average tardiness and maximum tardiness?
   a) SPT

b) CR
c) FCFS
d) **DDATE**

8. Which of the following statements is true concerning finite scheduling?
   a) finite scheduling assumes that capacity is unlimited
   b) finite scheduling is more difficult than infinite scheduling, but it is more successful
   c) companies can easily implement software off the shelf into their specific service environment
   d) with finite scheduling the first jobs loaded are those with the highest priority

9. Which of the following is *not* a software package for finite scheduling?
   a) CAPOSS
   b) OPT
   c) ISIS
   d) FSS

10. All of the following are considered non-productive activities relating to equipment, *except*
   a) setting up or breaking down a machine
   b) maintaining the machine
   c) waiting for workers or material
   d) machining the 'block' of a car engine.

SHORT-ANSWER QUESTIONS

1. What is planning and control? What are some of the typical inputs that contribute to the production plan?

2. What information is provided by the critical ratio sequencing rule? How does it differ from SLACK?

3. Give examples of four types of operations (manufacturing or service) and suggest which time horizon (long, medium, or short) planning and control might be appropriate for each. Why?

4. What is independent demand? How does it differ from dependent demand? Discuss the financial implications of stockouts.

5. Explain the difference between infinite and finite scheduling. Also explain the advantages and disadvantages of forward and backward scheduling.

Summary

This chapter provided an introduction to planning and control activity. In particular, it focussed on the nature of planning and control and discussed the concepts of 'loading' and 'scheduling'. The chapter also examined the effects of the demand on planning and control activity and the influence of volume and variety on planning and control. The chapter also investigated the types of sequencing, and, the different approaches to scheduling. The difference between push and pull schedules has been investigated and their application to specific cases was examined in a group exercise.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to planning and control

- ☐ The concept of planning and control activity

What is planning and control?

- ☐ The nature of the planning and control
    - ☐ The production plan and its inputs
    - ☐ Long-term planning and control
    - ☐ Medium-term planning and control
    - ☐ Short-term planning and control

- ☐ The nature of supply and demand
    - ☐ Dependent demand
    - ☐ Independent demand

- ☐ Finite and infinite loading
    - ☐ Gantt loading chart

- ☐ Sequencing
    - ☐ SLACK
    - ☐ Critical ratio (CR)

- ☐ Scheduling
    - ☐ Forward scheduling
    - ☐ Backward scheduling
    - ☐ Infinite and finite scheduling

- Push and pull scheduling

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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Chapter 6 Supply chain planning and control

Contents………… .... Page

Supply chain planning and control

Learning outcome

This chapter goes beyond the strategic and structural issues of designing supply networks covered in Chapter 4 and considers the more 'infrastructural' issues of planning and controlling the 'strands' in the supply network. By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- understand the basic principles of supply chain planning and control.
- understand what the differences between purchasing, physical distribution, logistics, materials management and supply chain management are.
- understand the purpose and objective of purchasing management.
- understand the purpose of and objectives of physical distribution management.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Be familiar with the definitions of purchasing, physical distribution management, logistics, materials management and supply chain management
- Examine the benefits of the purchasing function and supplier development
- Understand that supply chain management involves managing the entire supply chain
- Understand the dynamics that exist in supply chains
- Understand that logistics is the co-ordinated movement of materials, information and finished products
- Examine how efficient and effective the integration of organisations through supply chain management is

What you will need

Suggested study time	Text Books	6 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	3 hours
	Total	12 hours

Introduction

In chapter 4 we explored how the operations, which are linked via a network, can provide the supply of goods and services to an operation, which is responsible for the delivery of its goods and services to the end customers. In this chapter we are dealing with the flow of goods and services through this network along individual channels or strands of the network (Slack et al. 2000). This chapter considers the more 'infrastructural' issues of planning and controlling the 'strands' in the supply network. The terminology behind supply chain planning and control will be discussed and the difference between the terms of *purchasing*, *physical distribution, logistics*, *materials management* and *supply management* will be investigated. More specifically:

In the supply chain network **purchasing** is concerned with the supply-side activities of an organisation. **Physical distribution management** is the management of the (often multi-echelon) inventory and transportation systems which link the operation with the customer. **Logistics** includes the demand side physical distribution of goods often beyond the immediate customers, through the supply chain to the end customer. **Materials management** is an integrated concept, which includes both purchasing activities as well as physical distribution activities. Finally, **supply chain management** is a broader concept, which includes the management of the entire supply chain from the supplier of raw material to the end customer. Some of the terms used to describe the management of the different parts of the supply chain are shown in Figure 6.1 on the following page.

Because purchasing is the most costly activity in most organisations (historically purchased materials account for about 50% of the manufacturing costs (Russell & Taylor III, 2000)), efficient purchasing could enhance the competitiveness (i.e., high quality, low cost, and speed-to-market) of an operation. The objective of *purchasing management* includes the formal preparation of requests to suppliers for a quotation, the evaluation of suppliers, the issuing of formal purchase orders, and the monitoring of delivery. The purchasing function attempts to obtain goods and services at the right price, for delivery at the right time, with the right quality, in the right quantity, from the right source. The effect of saving on the bought-in materials bill in most organisations has a disproportionate effect on profitability. The greater the proportion of their costs which are devoted to bought-in materials, the greater the saving for a given reduction in bought-in material costs.

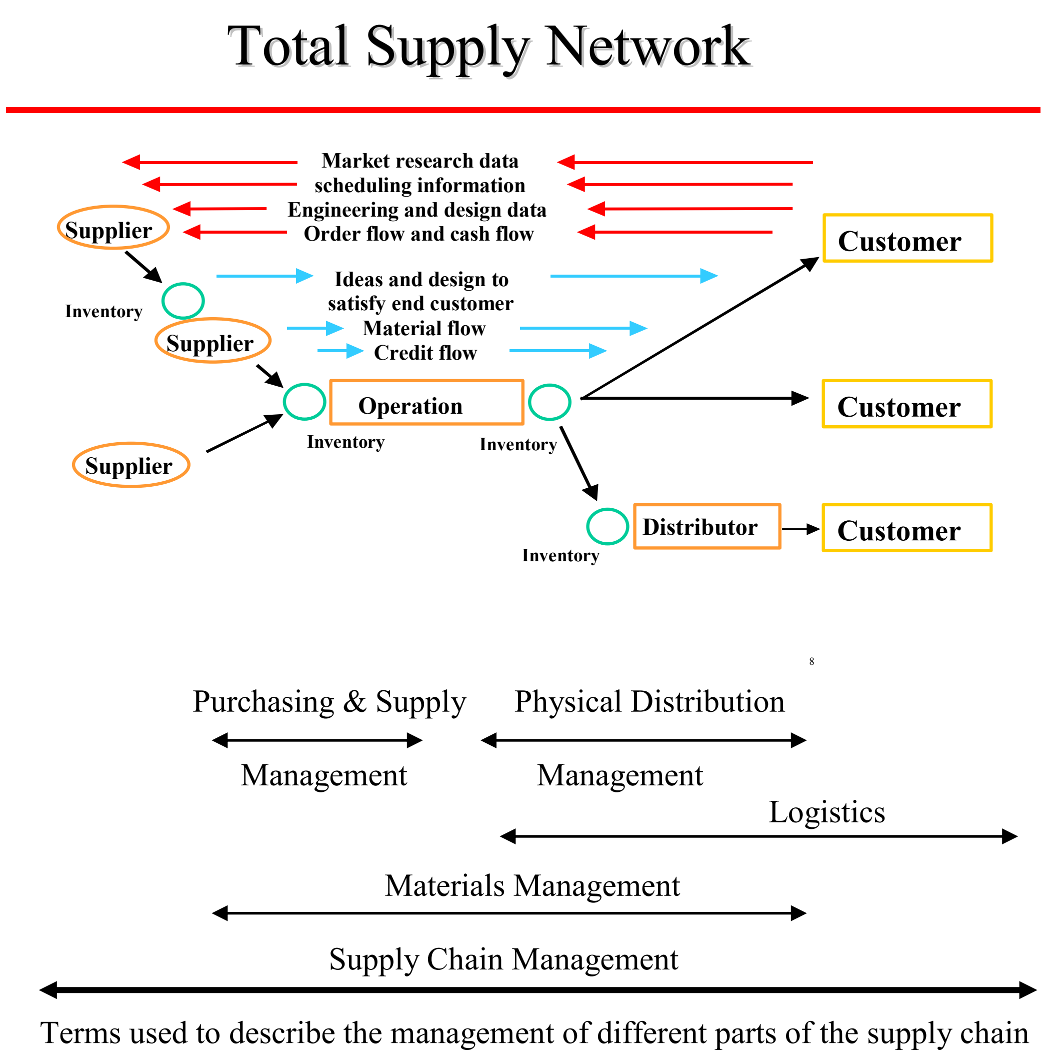

Figure 6.1 Typical Total Supply Network

Similarly, the objective of *physical distribution management* is speed, that is, to reduce the distribution time and get products to customers as fast as possible. Physical distribution management decisions include the number and position of warehouses in the system and the mode of physical transport, which needs to be adopted. This area also includes the decision as to which contract terms buyers and suppliers agree. The choice of contract defines the responsibility and risk relating to who pays for transportation. There are internationally recognised terms, which define the balance of risks and costs. These include such terms as ex-works, free alongside, free on board, cost and freight, cost insurance and freight and delivery.

Finally, operations managers should recognise that *supply chain management* is a more strategic concept, which includes the strategic and long-term consideration of supply management issues as well as the shorter-term control of flow through the supply chain. The term includes developing an understanding of the dynamic effects (sometimes called the

Forrester effect (Forrester (1961)) which governs the amplification of demand changes as they affect upstream operations within the supply chain.

Finally, supply chain management also includes developing appropriate relationships between individual links within the supply chain. These relationship types (which range from integrated hierarchies through to short-term trading commitments) imply different exchange relationships between suppliers and customers.

Definitions of purchasing and related concepts

As discussed in the previous chapters of this course, operations have networks of suppliers. A supply chain is a strand in the supply network along which a set of goods or services flows and some of the terms used to describe the management of the different parts of the supply chain were shown earlier in Figure 6.1.

Purchasing or **supply management** is the function, which manages the operation's interface with its suppliers. Strictly speaking, "purchasing is the acquisition of goods and services" (Heizer & Render, 1999: 419) and a **purchasing agent** is a person with legal authority to execute purchasing contracts on the behalf of an organisation. Kraljic (1983) suggests that supply management is concerned with the long-term availability of high-dollar or critical purchases; that is, future reliable suppliers are critical to the success of the enterprise.

Physical distribution management is the function that manages the operation's interface with its customers. Distribution may not only include sending products on their way to the store. Some retailers may want products to be packed, ready for the shelf, while other retailer stores may require products to be placed on their own shelf.

Logistics is an extension of physical distribution management. Logistics is concerned with the management of information and materials flow from the business. Strictly speaking, logistics refers to "the movement of materials within a production facility and to incoming and outgoing shipments of goods and materials" (Stevenson, 1999:706). Under Stevenson's definition, materials include all of the physical items used in the production process. In addition to raw materials, there are support items such as fuels, equipment, parts, tools, lubricants, office suppliers, etc. Logistics is described as an extension of physical distribution management because it considers the operation's end customers as well as its immediate customers (see Figure 6.1).

As shown in Figure 6.1, **materials management** is concerned with purchasing and supply management as well as physical distribution management. In other words, material management is concerned with the management of the flow of materials and information through the operation's immediate supply chain. Materials management includes activities such as:

- Purchasing
- Inventory management

- Stores management
- Operations planning and control
- Physical distribution management

Finally, **supply chain management** is important because it can be strategically advantageous for all the operations in a given supply chain that work together to ensure that the end customer is satisfied. According to Heizer and Render (1999:416) supply chain management is the "integration of the activities that procure materials, transforms them into intermediate goods and final products, and delivers them to customers". Heizer and Render's definition is reinforced by Figure 6.1, which shows that supply chain management is by far a broad concept. Supply chain management is a holistic approach to managing across organisational boundaries. Operations managers should be aware that as the organisational integration increases the emphasis switches from 'purchasing' to 'supply chain management'.

Purchasing and supplier development

As discussed earlier, statistics show that organisations are spending about 50% of their sales dollars on purchases (Heizer & Render, 1999), thus, the purchasing or procurement function plays a crucial role in supply chain management. Because the cost and quality of goods and services sold is directly related to the cost and quality of goods and services purchased, organisations must examine a number of strategies for effective purchasing. The need for a purchasing strategy and its accomplishment leads to the creation of a purchasing function aiming at:

- Helping to identify the products and services that can be obtained externally
- Developing, evaluating, and determining the best supplier, price, and delivery for those product and services
- Agreeing contracts with suppliers (the contract specifies the transforming and transformed resources which the supplier is to provide)
- Linking the operation and its suppliers (for purchasing to be effective the requirements of the operation's processes and the capabilities of the operation's suppliers must be understood).

The purchasing activity can be described as a process. As a process function, purchasing has interfaces with a number of other functional areas within the organisation as well as with outside suppliers. Purchasing is the traditional connecting link between the organisation and its suppliers. In this capacity, it exchanges information with suppliers and functional areas. The interactions between purchasing and these other areas are briefly summarised in the following paragraphs:

Operating units constitute the main source of requests for purchased materials and services, and close co-operation between these units and the purchasing departments is vital if quality, quantity, and delivery goals are to be met. Cancellations, changes in specifications, or changes in quantity or delivery times must be communicated immediately for purchasing to be effective.

The purchasing department may require the assistance of the *legal* department in contract negotiations, in drawing up bid specifications for non-routine purchases, and to help interpret legislation on pricing, product liability, and contracts with suppliers.

Accounting is responsible for handling payments to suppliers and must be notified promptly when goods are received in order to take advantage of possible discounts. In many organisations, *data processing* is handled by the accounting department, which keeps inventory records, checks invoices, and monitors vendor specifications. Thus, purchasing department must communicate immediately any information that is related to purchasing transactions for accounting to be effective.

Design and *engineering* usually prepare material specifications, which must be communicated to purchasing. Because of its contracts with suppliers, purchasing is often in a position to pass information about new products and materials improvements on to design personnel. Also, design and purchasing people may work closely to determine whether changes in specifications, design, or materials can reduce the cost of purchased items (see following section on value analysis).

Receiving checks incoming shipments of purchased items to determine whether quality, quantity, and timing objectives have been met, and move the goods to temporary storage. Purchasing must be notified when shipments are late; accounting must be notified when shipments are received so that payments can be organised; and both purchasing and accounting must be apprised of current information on continuing vendor evaluation.

Suppliers or *vendors* work closely with purchasing to learn what materials will be purchased and what kinds of specifications will be required in terms of quality, quantity, and deliveries. Purchasing must rate vendors on cost, reliability, and so on. Good supplier relations can pay dividends on rush orders and change, and vendors provide a good source of information on product and material improvements.

In general, purchasing involves:

- Operations requesting a product or service. Purchasing must make sure that the parts and materials required by the product specifications are of the desired quality and are delivered on time.

- Purchasing formally asks potential suppliers to submit quotations, which specify how much they would charge if they were asked to provide the product or service.

- Purchasing reviews the quotations and identifies a preferred supplier.

- Purchasing prepares the necessary purchase agreements – purchasing gets involved with the legal contracts. The operation function often needs to be involved in this stage of the process.

- Purchasing closing the loop. It is the purchasing's responsibility to check that the products or services arrive on time and that they are in a satisfactory condition when they arrive.

Figure 6.2 summarises the purchasing interfaces.

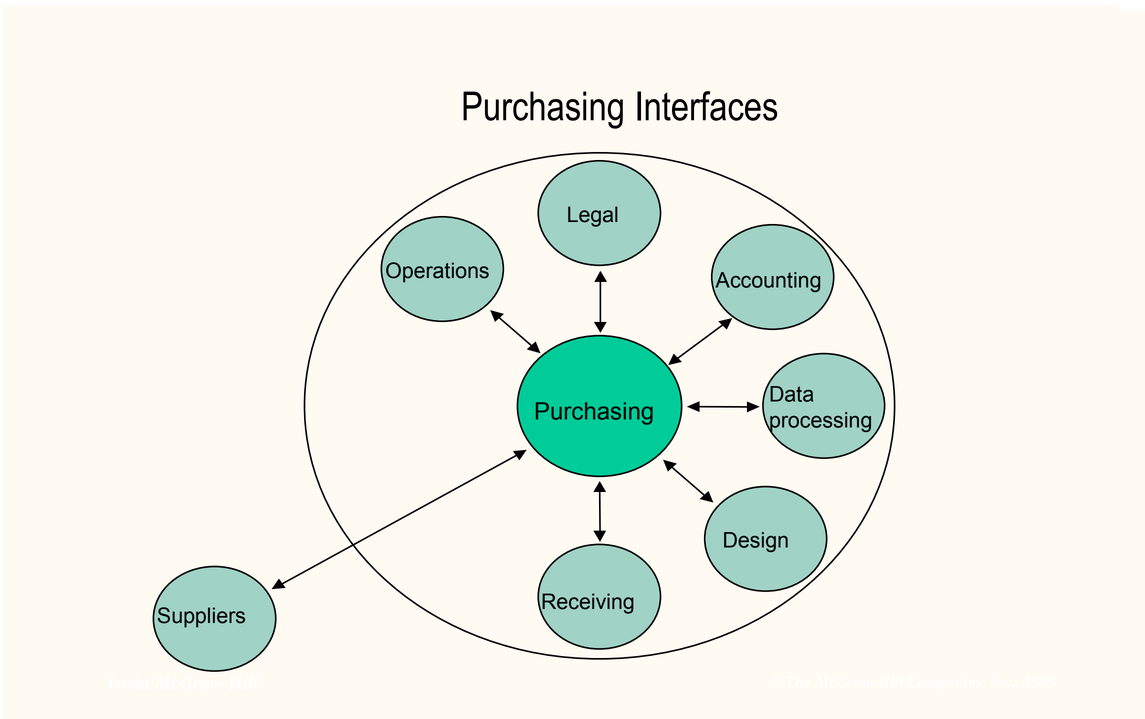

Figure 6.2 Typical Purchasing Interfaces

Adopted from Stevenson (1999: 696)

The above steps lead to the **purchasing cycle.** The cycle begins with a request from within the organisation to purchase material, equipment, suppliers, services, or other items from outside the organisation, and the cycle ends when the purchasing department or purchasing team is notified that a shipment has been received in satisfactory condition. That is:

- Purchasing receives the requisition

- Purchasing selects a supplier

- Purchasing places the order with the vendor

- Purchasing monitors the orders, and

- Purchasing receives the orders and closes the cycle by evaluating the vendor and keeping records.

Activity 6.1

Purchasing Interfaces

1. Briefly describe how purchasing interacts with other functional areas (such as operating units, accounting) within your organisation and the outside suppliers.

2. Should the supplier of your organisation with the high quality – lowest price combination always be selected over others? Debate.

The objectives of purchasing - value analysis

Most operations buy in a wide variety of goods and services and in many operations the amount being bought in is increasing. Therefore, goods and services have to be bought in:

- At the right price – purchasing can have a major impact on profitability. Purchasing staff are usually skilled negotiators.
- At the right quality – traditionally good and services were inspected after delivery. Increasingly suppliers are inspecting their own goods and services prior to dispatch.
- At the right time and in the right quantity – delivery, speed, delivery reliability and flexibility can be reduced if too few goods come in or if the right number of goods arrives too late.
- From the right source – the right source is not necessarily the one that can offer the best short-term deal in terms of price, quality and delivery. Other factors, including the rate at which the supplier is improving his product/services, need to be considered.

The above mentioned purchasing objectives may be achieved using **value analysis**. Value analysis refers to an examination of the *function* of purchased parts and materials in an effort to reduce the cost and/or improve the performance of those items (Stevenson, 1999). Typical questions that would be asked as part of the analysis include:

- Could a cheaper part, component or service be bought?
- Is the function necessary?
- Can the function of two or more parts or components be performed by a single part for a lower cost?
- Can a part or service be simplified?
- Could product specifications be relaxed, and would this result in a lower price?
- Could standard parts be substituted for non-standard parts?

Naturally, purchasing cannot perform an investigation each time materials or services are ordered. However, it should conduct *value analysis* periodically on large dollar-volume items or services because of the potential savings. Although purchasing does not have the authority to implement changes on the basis of value analysis, it can make suggestions to operating units, which may lead to improved performance of purchased goods and services. A typical outcome of a value analysis may be the issue of whether an operation should look for a single or multiple sources, or whether to manufacture in house or buy from outside.

Choosing products and services that can be advantageously obtained externally as opposed to produced internally is known as the **make-buy decision**. Therefore, an essential purchasing decision is the make-buy decision. As known, a wholesaler or retailer buys everything that it sells: an operation however hardly ever does. Manufacturers and restaurants for example, buy items and components that go into final products. The purchasing department's role is to evaluate alternative suppliers and provide current, accurate, and complete data relevant to the buy alternative. The make-buy decision is often based on cost. If the item under consideration can be made cheaper in-house, it will be made in-house. If it cannot, it will be sub-contracted or outsourced.

Experience, however, has shown that the make-buy decision *should not* be based *solely* on *cost*. Other issues to be considered include the risks that are associated with outsourcing or whether a particular product or service is core, i.e., whether it provides competitive advantage?

Outsourcing refers to buying goods and services from outside sources instead of making the goods or providing the services within the organisation. Although outsourcing can be promising, certainly it carries risks. Prior to outsourcing an organisation should consider the following factors:

- cost to do it in-house versus cost to buy, including start-up costs, versus cost to outsource
- stability of demand and possible seasonality
- quality available from suppliers compared with a firm's own quality capabilities
- the desire to maintain close control over operations
- idle capacity available within the organisation
- lead times for each alternative
- who has patents, expertise, and so on, if these are factors
- stability of technology (if a technology is changing, it may be better to use a supplier), and
- the degree to which the necessary operations are consistent with, or in conflict with, current operations.

Physical distribution management - logistics

As discussed in the introductory section of this chapter, physical distribution management is the function that manages the operation's interface with its customers. Moreover, as demonstrated in Figure 6.1, on the demand side of the operation, the goods and services produced have to be physically distributed. This can be complex and costly, especially in multi-echelon systems. An operation with three factories and six customers for example, has to 'manage' eighteen (3 x 6 = 18) distribution channels.

Due to the complexity of physical distribution, warehouses are often used to eliminate some of the problems of physical distribution management. Warehouses are buildings used to receive, handle, store, and ship products or materials. If factories supply warehouses and customers request goods or services from warehouses, the number of distribution channels that have to be managed is reduced. Some retail companies that have begun to operate on the Internet sometimes function almost exclusively out of a warehouse-type environment. For example, Amazon.com (www.amazon.com) books trades books on-line out of a group of offices furnished with desks and computers on the fourth floor of an old building in Seattle, supplemented by a 46,000 square-foot warehouse.

As physical distribution gets complex, it becomes costly. Statistics has shown that the distribution of goods to and from their facilities can represent as much as 25% of the cost of products (Heizer & Render, 1999). Because of this high cost, organisations constantly evaluate their methods of distribution. Based on the situation (and the type of operation) one of the major modes or a combination of different distribution modes is employed. Such modes of distribution include *trucking*, *rail*, *airfreight*, *waterways* and even *pipeline*. The different modes of distribution have different characteristics and these affect their suitability for different operations. The decision as to which mode of distribution is to be employed would be influenced by issues such as:

- Delivery speed
- Delivery reliability
- Product deterioration, and
- Transportation cost.

For example, pipelines are the best forms of transporting crude oil, natural gas, and other petroleum and chemical products. (it has been quoted that 90% of the state of Alaska's budget is delivered from the 1.5 million barrels of oil pumped daily through the pipeline at Prudhoe Bay (Heizer & Render, 1999.))

The mode of transport chosen has implications for the operations, because it will affect, or will be affected by, the operation's location. It will also determine the size of the batches that can be transported. For example, an automobile manufacturer should be close to materials, parts suppliers and a skilled labour force. A hydroelectric power supply unit should be located close to waterfalls and close to its major customers.

As discussed earlier, **logistics** is an extension of physical distribution management. Logistics is concerned with the management of information and materials flow from the business. Strictly speaking, logistics refers to "the movement of materials within a production facility and to incoming and outgoing shipments of goods and materials" (Stevenson, 1999:706). Figure 6.3 shows the many steps that materials move through a production facility. These steps are presented below.

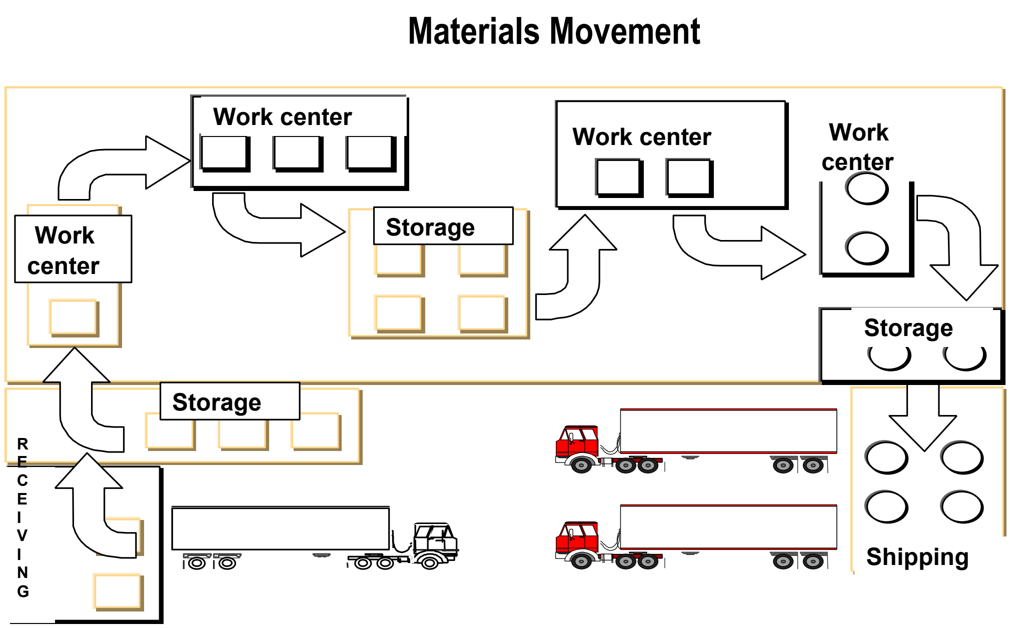

Figure 6.3 Typical Materials Movement Graph

Adopted from Stevenson (1999: 707)

The steps that materials move within a production facility include:

- from incoming vehicles to receiving
- from receiving to storage
- from storage to the point of use (i.e., work centre)
- from one work centre to the next, or to temporary storage
- from the last operation to final storage

- from storage to packaging or shipping, and
- from shipping to outgoing vehicle.

The responsibility of the logistics function is to move materials at the appropriate destinations at appropriate time. Care should be taken against lost or damage during movement.

Contract terms

In any supply transaction the organisation buying and the supplier supplying products and services have to take responsibility for the risks and the payments for the transportation. So the contract agreed between the supplier and customer needs to specify who will be responsible for what. There are various classes of contracts that are internationally recognised, and each satisfies the specific needs and requirements of an operation. The most common are:

- Ex-works contracts – the purchaser is responsible for all the costs of transporting the goods from the supplier's location. These costs would include transportation, insurance, documentation, loading and customs.
- Free alongside (FAS) – the supplier is responsible for the costs associated with transporting and insuring the goods until they reach a specified port. The customer is responsible for all the costs thereafter (loading and unloading, insurance, customs).
- Free on board (FOB) – the supplier pays for everything up to, and including, loading on to the outbound transportation. The customer is responsible thereafter.
- Cost and freight (C&F) – the supplier pays for transportation to an agreed place. The customer is responsible for the costs of customs documentation, insurance once the goods have been loaded, and all costs once the goods have been unloaded.
- Cost, insurance and freight (CIF) – this is exactly the same as cost and freight except that the supplier pays for the insurance.
- Delivered – the supplier is responsible for all costs.

Finally, as international trade barriers fall, more companies are expanding global operations and international distribution is costly and can be risky. Managing a global supply chain that may have far flung customers and/or suppliers magnifies some of the challenges compared to managing a domestic supply chain. Obviously, distances and lead times become more critical as the supply chain becomes more stretched out. So, too, does the possibility of having to deal with language and cultural differences. Currency differences and monetary fluctuations are other factors that must be dealt with when dealing with international distribution.

Integration of the organisation's function

As discussed earlier, both material and information flow through the supply chain. Information flows in the form of orders from the purchaser to the supplier. On the other hand, materials, in the form of goods or services, flow from the supplier to the purchaser. This section considers the various ways in which these flows of information and materials can be managed. The various ways to manage the flow of information and materials include: *materials management*, *merchandising*, *logistics*, and *supply chain management*.

Materials management – the concept of materials management was originated in the 1970s and its main objective is to integrate the management of the materials flow and its associated information flow. The rationale underpinning materials management is that costs should be reduced if the flow of materials can be integrated.

Integrated, in this context, means a single function has the responsibility for purchasing, expediting, inventory management, stores, physical distribution management, and product planning and control. Experience has shown that if a single function owns all of these activities that function should be able to co-ordinate them, thereby eliminating local optimisation and hence reducing costs. This rationale is further justified because separate functional management of the materials flow often creates long lead-time, hence, high levels of inventory. As known, long lead-times mean that the materials and services have to be purchased much earlier to ensure the availability at the start of production, resulting in high costs. So, allowing the co-ordination to be done from a single source and even removing some intermediate inventories should lead to cost reduction.

Merchandising – merchandising is usually associated with retail operations. A merchandiser typically has the responsibility for organising sales to retail customers, the layout of the shop floor, inventory management, and purchasing (Slack et al. 2000). In other words, merchandising involves combining the purchasing activity with sales and physical distribution management. Because daily trends of sales in some retail shops can vary enormously, the replenishment of stocked items has to be fast to avoid stockout. Such replenishment can be successfully obtained using key technologies such as bar-coding and electronic point-of-sale systems.

Logistics – as discussed in the previous section of this chapter, logistics is an extension of physical distribution management. Strictly speaking, logistics refers to "the movement of materials within a production facility and to incoming and outgoing shipments of goods and materials" (Stevenson, 1999:706). It also refers as the co-ordinated movement of materials, information and finished products.

Supply chain management - as discussed earlier and shown on Figure 6.1, supply chain management involves managing the entire supply from raw inputs to finished products and services. The end customer is the only customer with any 'real' money. Strictly speaking, everyone else in the supply chain simply shares this money. Hence, the rationale underpinning supply chain management is that everyone in a given supply chain should:

- Focus on satisfying the end customer

- Identify and implement strategies aimed at capturing and retaining end-customer business

- Manage the supply chain *effectively* and *efficiently*. Due to the wide range of activities that have to be co-ordinated, managing the entire supply chain opens up many opportunities for improvement. Identifying these opportunities on the supply chain network can reveal the sources of cost and potential cost saving.

However, supply chain management *does not* come without problems and/or barriers. Some of the barriers that will prevent its effective and efficient execution are:

- The businesses in a given supply chain are usually owned by different people and this makes it difficult to co-ordinate the activities that are associated with the supply chain management system.

- Supply chains usually branch. A given supply chain can serve different markets with different needs which require different, and most likely conflicting strategies.

Therefore, there is certain volatility in the supply chain because of the supply chain dynamics and time lags. Fluctuations of the production levels along the supply chain due to small changes in the end-customer demand can cause such dynamics. Forrester (1961) has demonstrated that supply chain dynamics exist between organisations in the supply chain and can cause errors, inaccuracies and volatility, and that these increase for operations further upstream in the supply chain. (for detail discussion of the 'Forrester effect' the interested reader should refer to Slack et al. 1998: 495- 498.)

Integration through supply chain management

A key question every organisation has to address is how much of the supply chain should it seek to own? Ownership is not the only method of supply chain integration. In fact the options vary from 'vertically integrated hierarchy' through to 'short-term trading commitment', as shown on Figure 6.4.

Integrated hierarchy – integrated hierarchy is the term used to describe a fully vertically integrated organisation. A fully vertically integrated organisation is one that houses all activities, from raw material sourcing through to dispatch to the end customer, on a single site. The major advantages of a fully vertically integrated organisation is that it has no need to manage the exchange of information, orders or material with outside agencies.

Increasing Degrees of Integration

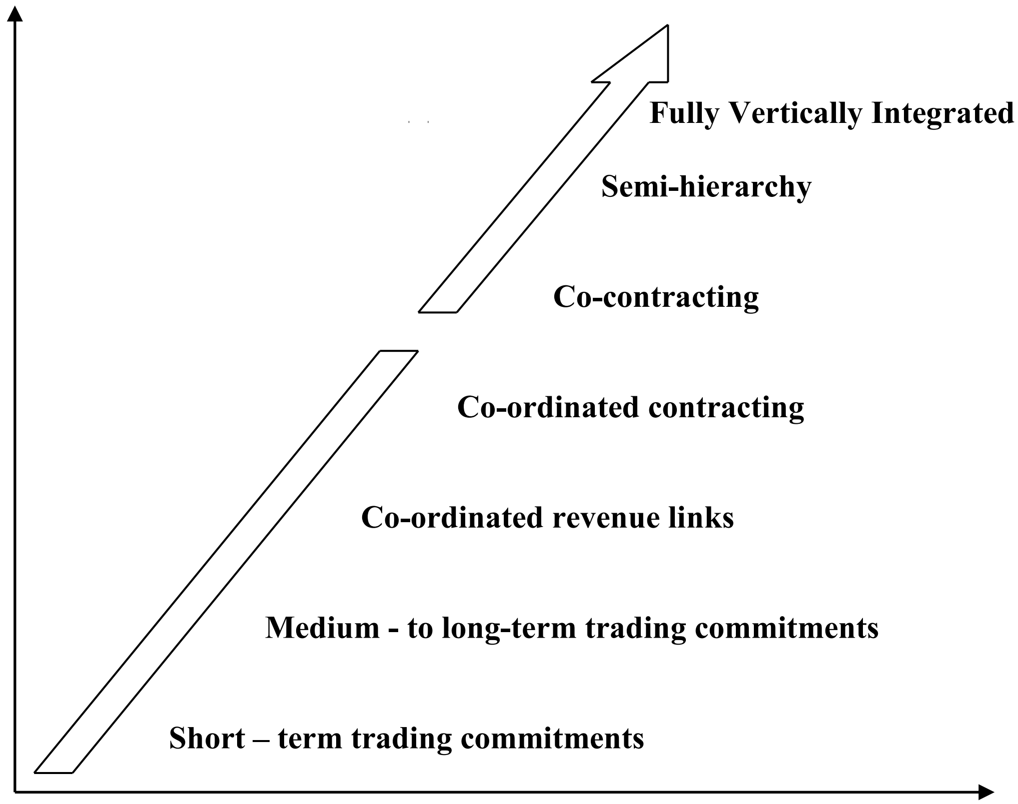

Figure 6.4 Supply Chain Management Integration

Semi–hierarchies – semi–hierarchies exist when the organisations in a given supply chain are owned by the same group. The advantages of semi–hierarchies are that they can:

- Centralise purchasing which can lead to volume discounts
- Operate common systems and technologies, and
- Easily transfer people, materials and even money.

Co-contracting – co-contracting involves long-term alliances rather than mergers. Usually long-term alliances are based on a transfer of equity, as well as people, technologies, goods and services. Co-contracting, which includes partnerships, can reduce an individual operation's freedom of action, but at least allows the individual operations to retain their own legal identities, cultures and strategies.

Co-ordinated-contracting - co-ordinated-contracting involves prime contractors who employ sub-contractors. Co-ordinated-contracting is usually carried out on a job-by-job basis. The prime contractors will win the business and employ the sub-contractors who provide their own tools and equipment. The formal relationship between the prime contractor and sub-contractors terminates at the end of the job.

Co-ordinated revenue links - co-ordinated revenue links are used in licensing or franchising. Co-ordinated revenue links transfer ownership of a given operation but guarantees income for the licensor or franchiser. According to Rugman and Hodgetts (1995) licensing is an arrangement whereby a firm is prepared to transfer to the overseas entity for a defined period the right to use its commercial/industrial property, for some loyalty payment. Franchising involves the right to use a business format in the overseas market in return for the franchiser receiving some form of payment.

Medium-to long-term trading commitments - medium-to long-term trading commitments are established when businesses agree to trade with each other for extended periods without formal contracts.

Short-term trading commitments - short-term trading commitments are entered into on a transaction-by-transaction basis. Short-term trading commitments usually involve a competitive tendering process. One problem with this is that it does not necessarily lead to the lowest life cycle cost.

Activity 6.2

Increasing Degrees of Integration

Select four types of operations (manufacturing or service) and suggest which type of integration might be appropriate for each. Why?

Activity 6.3

Structure of Supply Chain - Group Exercise

Sketch what you think might be the structure of the supply chain for Federal Express (www.fedex.com).

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. Supply chain planning and control considers the 'strands' in the supply network. **True**

2. Supply chain management includes only the management of the physical distribution activities. **False**

3. Logistics is an extension of physical distribution management. **True**

4. One responsibility of supply chain planning and control is checking the availability of materials, machines and labour. **False**

5. Helping to identify the products and services that can be obtained externally is the responsibility of the logistics department. **False**

6. Value analysis assists supply chain managers in the make-buy decision process. **True**

7. An operation that has many factories and many customers is perceived to have easy logistics structure. **False**

8. C & F contracts are exactly the same as the CIF contracts. **False**

9. Merchandising is associated with the manufacturing of products in a foreign country. **False**

10. Vertically integrated organisations retain their own legal identities and strategies. **False**

SHORT-ANSWER QUESTIONS

1. What is supply chain planning and control? Describe the various parts of supply chain management.

2. List at least 5 purchasing interfaces within the framework of supply chain management.

3. Describe the benefits of outsourcing and discuss the considerations that a manager must take before implementing any form of outsourcing.

4. How do we distinguish between supplier management, supply chain management, purchasing, and materials management.

5. Why is information so important to the smooth operation of an organisation's logistics system?

Summary

This chapter provided an introduction to supply chain planning and control. In particular, it focussed on the nature of supply chain planning and control and discussed the concepts of purchasing, physical distribution, logistics, materials management and supply chain management. The chapter also examined the power of value analysis in the framework of purchasing and the issues that are associated with the *make-buy* decision. The chapter also investigated the various classes of contracts that are internationally recognised and explored the challenges of managing a global supply chain. Integration through supply chain management and the degrees of integration were presented. Finally, the structure of the supply chain of a specific organisation (www.fedex.com) was examined in a group exercise.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel that you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to supply chain planning and control

- ☐ Terms used to describe supply chain planning and control

- ☐ Definitions of purchasing and related concepts
  - ☐ Purchasing or supply management
  - ☐ Physical distribution management
  - ☐ Logistics
  - ☐ Materials management
  - ☐ Supply chain management

- ☐ Purchasing and supplier development
  - ☐ Purchasing interfaces
  - ☐ Purchasing cycle

- ☐ The objective of purchasing – *value analysis*
  - ☐ Make-buy decision
  - ☐ Outsourcing

- ☐ Physical distribution management – logistics

- ☐ Contract terms
  - ☐ Ex-works
  - ☐ FAS
  - ☐ FOB
  - ☐ C & F

- CIF
- Delivered

- Integration of the organisation's functions
  - Materials management
  - Merchandising
  - Logistics
  - Supply chain management

- Integration through supply chain management
  - Fully integrated hierarchy
  - Semi- hierarchy
  - Co-contracting
  - Co-ordinated contracting
  - Co-ordinated revenue links
  - Medium-to long-term trading commitments
  - Short-term trading commitments

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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Chapter 7 E-Commerce and Operations Management

Contents ... **Page**

E-Commerce and Operations Management

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this chapter, you should be able to:

- develop an understanding of the basic principles of *both* electronic commerce (e-commerce) and Business-to-Business (B2B) processes.
- understand the importance of security in e-commerce environment.
- understand the impact of the Internet on operations management and the role of electronic technology in the electronic-procurement.
- understand the responsibility that operations managers have in the e-commerce environment and find out how Enterprise Resource Planning (ERP) systems can be used to support operation’s management transactions (i.e., inventory tracking).

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Understand what is the nature and purpose of e-commerce and electronic business
- Understand the economics of e-commerce from operations management perspective
- Understand that in the e-commerce environment security is of paramount importance
- Understand and accept the role of electronic technology in operations management
- Acknowledge that purchasing in an e-commerce environment can be executed electronically
- Be familiar with the Enterprise Resource Planning (ERP) systems
- Examine the capabilities of the SAP’s R/3 commercial Enterprise Resource Planning (ERP) system.

What you will need

Suggested study time	Text Books	9 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	4 hours
	Total:	16 hours

Introduction

> "Technology is reshaping this economy and transforming businesses and consumers. This is done more than e-commerce, or e-mail, or e-trades, or e-files. It is about the "e" in economic opportunity"
>
> - William Daley, U.S. Commerce Secretary

An electronic ordering system connected to over 800 suppliers helps global toy retailer Toys "R" Us (http://inc.toysrus.com) to ensure that the right toy is on the right self at the right time. Moreover, companies such as Chrysler (www.chrysler.com), Baxter International (www.baxter.com), Eastman Kodak (www.kodak.com), Cisco Systems (www.cisco.com), Travelcity (www.travelcity.com), and Wal-Mart (www.walmart.com) have created a new (an electronic) way of conducting business both inside and outside the firm. Computers and networks function like electronic middlemen, with lowered costs for typical marketplace transactions such as selecting suppliers, establishing prices, ordering goods, and paying the bills (Malone, Yates, and Benjamin, 1987). Buyers and sellers can complete purchase and sales transactions digitally, regardless of their location. Increasingly, the Internet is providing the underlying technology for buying, and selling products, services and information. In 1995, in *The Road Ahead*, Bill Gates used the term *friction-free capitalism* to describe how the Internet was helping to create Adam Smith's ideal marketplace, in which buyers and sellers can easily find one another without taking much time or spending much money. Organisations such as Travelcity among others are succeeding because at the Travelcity Web site (see Figure 7.1) where visitors can obtain information on airlines, hotels and other travel and leisure topics, and they can make airline and hotel reservations on-line. The World Wide Web is fuelling the growth of what is known as *electronic commerce* or *e-commerce*.

Figure 7.1 Travelcity Web site

Electronic commerce (e-commerce) is becoming one of the most common business terms of the new millennium. The U.S. Department of Commerce, Bureau of Census (2001) has shown that retail e-commerce sales has increased by 60 percent between quarter one 2000 and quarter four 2000 (see Figure 7.2). Of course the result of such e-commerce sales is a great range of fast, low cost electronic services, which stems from using an advanced information technology. Information technology (hardware, software, databases, and telecommunications) is crucial to operations management for achieving dramatic increases of market growth.

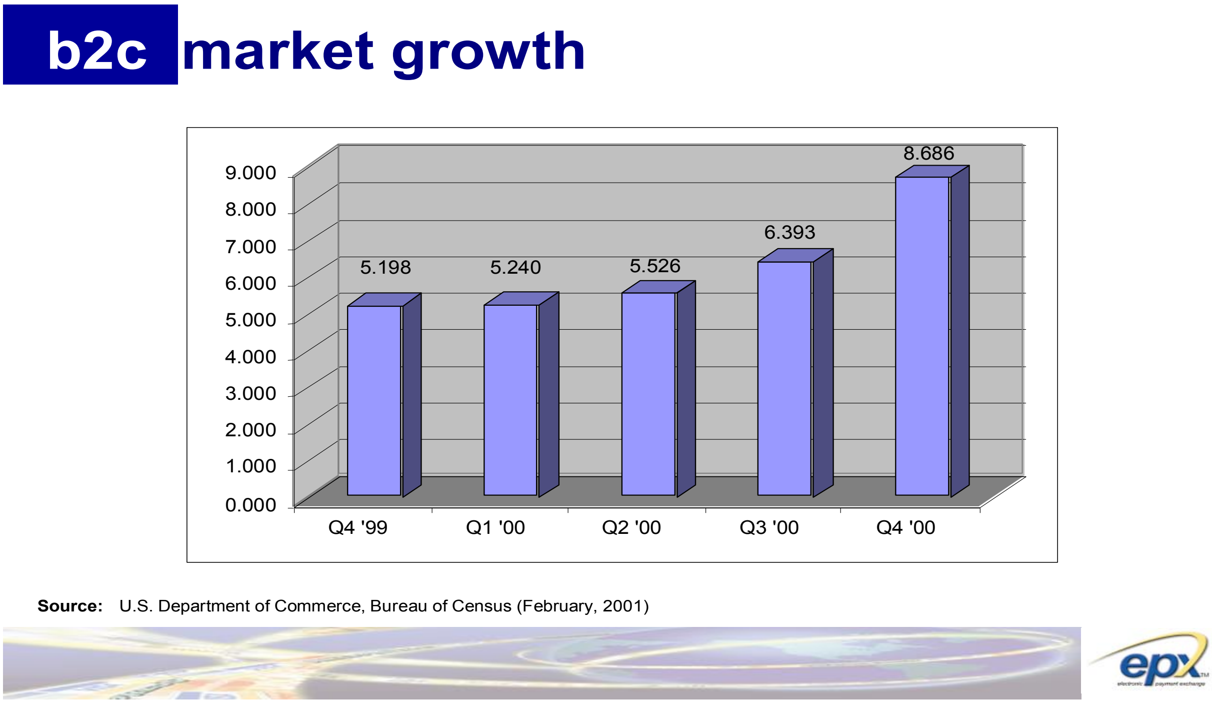

Figure 7.2 Quarterly U.S. Retail E-commerce Sales

But as operations expand, their transactions on the Internet with new suppliers, as opposed to partners with whom they have had longstanding relationships, and the integrity and security of the systems must be re-evaluated. According to National Computer Security Association (www.ncsa.com) (1996) in the U.S. security is about protecting three operational attributes:

- Confidentiality;
- Integrity; and
- Availability of data.

Protecting these attributes is the biggest challenge operations managers have yet faced. A detail discussion on security issues and electronic systems' security follow in a later section of this chapter.

In operations management the chain of activities that takes place electronically involves taking information as raw material and producing added-value information-based products and services out of the original raw information. So, e-commerce refers to an online process owned by intermediaries. Producers of information interact with services and other processed information, such as purchasing, scheduling and logistics, orders, and payments or instructions.

At a more detailed level, e-commerce covers any form of business or administrative transaction or information exchange that is executed using any information and communication technology (ICT). E-commerce embraces:

- business-to-business (i.e., Extranet);
- business-to-consumer (i.e., Internet);
- business-to-employee (i.e., Intranet); and
- government-to-nation (both businesses and the citizen; i.e., Internet).

Finally, research and practitioners argue that e-commerce has emerged as an important tool to give organisations the leading edge to lower their supply chain costs, shorten lead times, minimise stock, improve product and service quality, provide exceptional customer service levels and efficiently co-ordinate global demand, supply and production (Fawzy, 1999).

The nature and purpose of electronic commerce and electronic business

As discussed in the introductory section of this chapter, the global availability of the Internet for the exchange of transactions between buyers and sellers is fuelling the growth of *electronic commerce*. Electronic commerce is the process of buying and selling goods and services electronically with computerised operations transactions using the Internet, networks, and other digital technologies. By replacing manual and paper based operations management procedures with electronic alternatives, *e-commerce* has accelerated ordering, delivering, and payments for goods and services while reducing companies' operating and inventory costs.

E-commerce is applied to facilitate the management of employee personnel policies, reviewing account balances and production plans, scheduling plant repairs and maintenance, and revising design documents. Organisations are taking advantages of the connectivity and ease use on Internet technology to create internal corporate networks called *Intranets*. (Intranet is an internal network based on Internet and World Wide Web technology and standards.) The use of Intranets for the management and co-ordination of organisations' communication and business processes is known as *electronic business (e-business)*. IBM's chairman, Louis Gerstner, prefers the use of *e-business* term because it is "… all about cycle time, globalisation, enhanced productivity, reaching new customers, and sharing knowledge across institutions for competitive advantage" (Turban, Lee, King & Chung, 2000:5).

By distributing information through electronic networks, *e-business* extends the reach of existing operations management to e-mail, Web documents, and work-group software to effectively communicate with thousands of employees in operations, and to even manage far-flung task forces and teams. As known from past experience these tasks would be impossible in face-to-face traditional operations. Table 7.1 shows some examples of *e-commerce* and *e-business*.

Table 7.1 Examples of *e-commerce* and *e-business*.

e-commerce	***e-business***
Amazon.com (www.amazon.com) operates a virtual storefront on the Internet offering more than 3 million book titles for sale. Customers can input their orders via Amazon. Com's Web site and have the books shipped to them.	Roche Bioscience (http://216.205.119.117/job/roche.html) scientists worldwide use an intranet to share research results and discuss findings. The intranet also provides a company telephone directory and newsletter.
Mobil Corporation (www.mobil.com) creates a private network based on Internet technology that allows its 300 lubricant distributors to submit purchase on-line.	Dream Works SKG (http://www.dreamworks.com) uses an intranet to check the daily status of projects, including animation objects, and to co-ordinate movie scenes.
Travelcity (www.travelcity.com) provides a Web site (see Figure 7.1) where visitors can obtain information on airlines, hotels and other travel and leisure topics, and they can make airline and hotel reservations on-line.	Higher Colleges of Technology (www.hct.ac.ae) uses an intranet to share course outlines, on-line teaching material, employment opportunities, e-mail communication and videoconferencing. The intranet reduces paperwork and enhances the quality of faculty services by providing immediate information.

Both *e-commerce* and *e-business* can fundamentally change the way business is conducted because organisations can redefine their business models, reinvent business processes, change corporate culture, and create much closer relationships with customers and suppliers.

Business-to-business (B2B)

Within the popular term of e-commerce four definitions are often used by organisations (Heizer & Render, 2001), namely, *business-to-business (B2B), business-to-consumer (B2C), consumer-to-consumer (C2C)*, and *consumer-to-business (C2B)*.

Business-to-business (B2B): This implies that both sides of the transaction are businesses, non-profit organisations, or government;

Business-to-consumer (B2C): These are e-commerce transactions in which buyers are individual consumers;

Consumer-to-consumer (C2C): Here consumers sell directly to each other by electronic classified advertisements or auction sites; and

Consumer-to-business (C2B): In this category individuals sell services or goods to business.

From the operations management perspective the focus is on the *business-to-business (B2B)* e-commerce. Recent statistics (Forrester Research, 1999: 64) has shown that the B2B segment of *e-commerce* is expected to grow to $1.3 trillion in the U.S. alone by 2003 and to constitute about 80 per cent of the e-commerce market, followed by similar trends in the European Community. In relation to operations management, Handfield and Nichols (1999) listed the data that we anticipate to find in B2B applications that will be crucial for the success of operations.

- **Product** – drawings, specifications, video, or simulation demonstrations, and prices;

- **Production processes** – capacities, commitments, and product plans;
- **Transportation** – carriers, lead time and costs;
- **Inventory** – inventory tracking, inventory levels, inventory costs, and location;
- **Suppliers** – product catalogue, quality history, lead times, terms and conditions;
- **Supply chain alliances** – key contact personnel, partner's roles and responsibilities, and schedules;
- **Supply chain process and performance** – process descriptions, performance measures such as quality and delivery;
- **Competitor** – benchmarking information, competitive product offering, and market share;
- **Sales and marketing** – point of sale (POS) data entry, promotions, pricing and discounts; and
- **Customer** – sales history and forecasts.

Moreover, from the operations point of view the term **business-to-employee (B2E)** is often used enabling organisations to centralise information; organise information; improve and share information; speed up development and distribution of applications; and decrease costs and increase efficiency. The benefits of *e-business* and the use of *Intranet* have been acknowledged by various authors. For example, Fawzy (1999) has listed eight advantages of using the Intranet in operations:

- Elimination of duplication of information and of confusion over which is the latest version of a document;
- Wider ownership of information is encouraged and there is greater pressure to make it accurate;
- Better customer service because the operations function is less 'departmentalised' and more integrated;
- More efficient transfer at lower cost;
- Improved team-working and collaboration on projects because the Intranet provides a common working and reporting base;
- Increased potential for innovation and development because of the sources of contacts;
- Improved product and service design because the operation is closer with customers' views; and
- Faster response time from employees, suppliers and customers, which can lead to increased speed to market.

Although computers and Internet are the enablers of *e-commerce,* Gaither (1996) has cautioned operations managers that attempting an ambitious automation, such as *e-commerce* of their operations, is far more difficult and complex that is anticipated because it takes longer and it usually costs more than originally expected. Thereby, he suggested eight key factors which are necessary to manage the changes from traditional operating systems to automated (i.e., e-commerce) technology:

- Have a master plan for implementing automation (i.e., e-commerce);
- Recognise the risks in automating traditional operations;
- Establish a new technology department that will disseminate information and advocate new technology;
- Allow plenty of time for the completion of an e-commerce project;
- Do not try to automate everything at once;
- People are the key variable for making automation projects (i.e., e-commerce) successful;
- If companies move too slowly in adopting new technology, the e-commerce project may be left behind, meaning that it will be beaten by the competition; and
- Consider the amount of capital required. If capital is in short supply, as it almost is, this factor can be the predominant consideration in automation decisions.

Finally, as organisations begin to expand transactions on the Internet, the biggest challenge that operations managers are facing is the security of the electronic (on-line) transfer of the various elements of the information discussed earlier in this section. This means electronic transfers of supply chain, such as purchases, sales orders and payments need to be assessed for reliability and integrity.

Security in the e-commerce environment

Security is of paramount importance in organisations where information systems make extensive use of networks. Networks present end-users, hackers, and thieves with many points of access and opportunities to steal or modify data in networks. Since *e-business* is about distributing information through electronic networks, security in the *e-commerce* environment is about safeguarding at least three operational attributes (National Computer Security Association, 1996), namely:

- The confidentiality;
- Integrity; and
- Availability of data.

Protecting these attributes demands that operations managers improve systems' integrity while monitoring, reviewing, and auditing these real time systems (Greenstein & Feinman, 2000).

While operations managers have lots of experience in safeguarding assets, *e-commerce* poses some new risks and challenges. The challenges often arise from the fact that operations managers do not have the knowledge nor the training to deal with *e-commerce* security problems. Documents over the Internet are perceived to be vulnerable to being intercepted and or even altered by unauthorised individuals. This concern is magnified when the documents hold critical information such as the payment instructions contained in financial enterprise resource planning (ERP). Schneier (1996) classified Intranet security attacks as follows:

- Attacks against cryptographic designs;
- Attacks against implementations;
- Attacks against passwords;
- Attacks against hardware;
- Attacks against trust models;
- Attacks on the users;
- Attacks against failure recovery;
- Attack prevention versus attack detection; and
- Attacks against the cryptography.

But what is *cryptography*? Cryptography is a composite word made out of two Greek words: '*crypto*' (hidden or enigmatic) and '*graphy*' (writing). Therefore, organisations rely on cryptography (*enigmatic writing*) to protect sensitive information transmitted over networks. A message can be encrypted by applying a secret numerical code called an encryption key so that it is transmitted as a scrambled set of characters. (The key consists of a large group of letters, numbers, and symbols.) In order to be read, the message must be decrypted (unscrambled) with a matching key. The most commonly used method of encryption is the "*public key*" encryption illustrated in Figure 7.3.

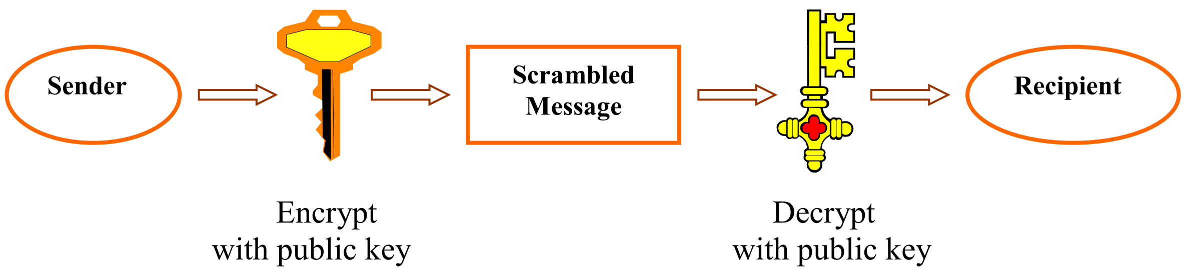

Figure 7.3 Public Key Encryption

According to Laudon and Laudon (2000), a public key encryption system can be viewed as a series of public and private keys that lock data when they are transmitted and unlock the data when they are received. The sender locates the recipient's public key in a directory and uses it to encrypt a message. The message is sent in encrypted form over the Internet or a private network. When the encrypted message arrives, the recipient uses his or her private key to decrypt the data and read the message.

Although methods such as the "*public key*" encryption can ensure the security of information that travels through networks, there is a high level of scepticism and concern among operations mangers as to what information producers can do to guarantee the integrity of information. Operations managers worry about bills of material, records being changed, and that company policy might be misrepresented. Their concern is quite justifiable because a recent study conducted by the Information Week (1998), found that

> "…of 1600 information technology professionals from 50 countries, 73 per cent of the companies reported some breach of corporate security during the past 12 months. However, companies doing business through their Web sites or implementing electronic supply chains and Enterprise Resource Planning applications were significantly more likely to be victims of security loss that affected their revenues and corporate data".

In other words, organisations that engage in *e-commerce* have been victims of greater information loss, theft of data, and lost of revenue than firms that do not use the Internet as a vehicle for business transactions. Thus, when addressing the issue of information security, operations managers do not only face the question: "what security do we need in an Enterprise Resource Planning (ERP) system?" but also "which ERP system is secure that would enable the business to continue to use the information as efficiently as possible?" When implementing a secure ERP system, this availability translates into speed of operation of the secure ERP system, its reliability, and its ease of use. We should discuss a commercial ERP system in more detail in a later section of this chapter.

Moreover, in relation to security of information that travels through networks, McCarthy (1997) cited that the Open Recommended Solutions (ORS) consortium has identified nine basic threats to Internet based application shown in Table 7.2.

Table 7.2 The Nine Basic Threats to Internet Web Sites

	Threat Type	**Explanation**
1	Data destruction	Loss of data on a Web site (through accident or malice) and the interception of traffic (unencrypted or encrypted) going to or coming from the web
2	Interference	The intentional re-routing of traffic or the flooding of a local Web server with inappropriate traffic in an attempt to cripple or crash the server
3	Modification/ replacement	Altering of data on either the send or receive side of the Web transmission. The changes, whether they are accidental or not, can be difficult to detect in large transmissions
4	Misrepresentation/ false use of data	Offering false credentials, passwords, or other data. Also included is a person's posting of a bogus or counterfeit home page to intercept or attract traffic away from the intended destination
5	Repudiation	An after-the-fact denial that an on-line order or transaction took place
6	Inadvertent misuse	Accidental but inappropriate actions by approved users
7	Unauthorised altering/ downloading	Any writing, updating, copying, etc. performed by a person that has not being granted permission to conduct such activity
8	Unauthorised transaction	Any use by a non-approved party

9	Unauthorised disclosure	Viewing of Web information by an individual not given explicit permission to have access to this information

Based on McCarthy's Intranet Security Stories from the Trenches (i.e., nine threats) one could question whether we can safely place commercially confidential information on computer networks. Then, the single greatest aversion to conducting business on-line is trust.

Securing users' trust

Reliability and security are two of the most important elements of successful *e-commerce* programs. But how do we secure users' trust when choosing to place on computer networks confidential information? By combining biometric identification methods such as fingerprints and iris scanning with digital certificates, transactions can be biometrically secured, protected and guaranteed from end-to-end (Laudon & Laudon, 2000). This process can dramatically reduce fraud, cut costs, and increase confidence in doing business electronically. Critical installation components and interfaces must be completed to ensure security on the Internet. To solve security issues from management, organisational and technological perspective, communications security implementation requires:

- *Authorisation*: ensuring authorised users of systems and performance of business functions by authorised users only;
- *Authentication*: establishing that parties to an electronic transaction or communication are who they claim they are (i.e., digital certificate);
- *Integrity*: ensuring that data on the host system or in transmission is not intercepted, modified or deleted illicitly;
- *Confidentiality*: warranting that data is only revealed to parties who have a legitimate need;
- *Availability*: ensuring that legitimate access to information and services is provided:
- *Non-repudiation*: if a party to some transaction or communication later denies that it has ever happened, some mechanism is in place to facilitate dispute resolution (i.e., digital certification);
- *Privacy*: ensuring that customers' personal data collected from their electronic transactions are protected from indecent and/or unauthorised disclosure;
- *Encryption*: data encryption scrambles data to prevent it from being read or tampered with during transit. Only those with the right key can read it;
- *Firewalls*: perimeter security can be achieved by using firewalls (for commercial transaction protection); and
- *SSL (Secure Socket Layer)*: is a channel-based security, which secures the channel, being used.

Economics of e-commerce

E-commerce is revolutionising operations management because it reduces costs so effectively. It reduces costs by improving communication and disseminating economically valuable information. The new middleman driving down transaction costs is the *e-commerce* provider. This middleman is cheaper and faster than the traditional broker. E-commerce increases economic efficiencies by matching buyers and sellers. It also facilitates the exchange of information, goods, services and payments. Electronic payment (*e-payment*) systems for example, use technologies such as electronic funds transfer, credit cards, smart cards, debit cards, and new Internet-based payment systems for *business-to-business (B2B)* to pay for products and services electronically. Global *e-payment* networks (see Figure 7.4) are being used by individuals to purchase goods and services electronically from on-line retails, who in turn can use *e-commerce* technologies to link directly to their suppliers or distributors, who in turn are linked electronically to their manufacturers or service providers.

e-Payments

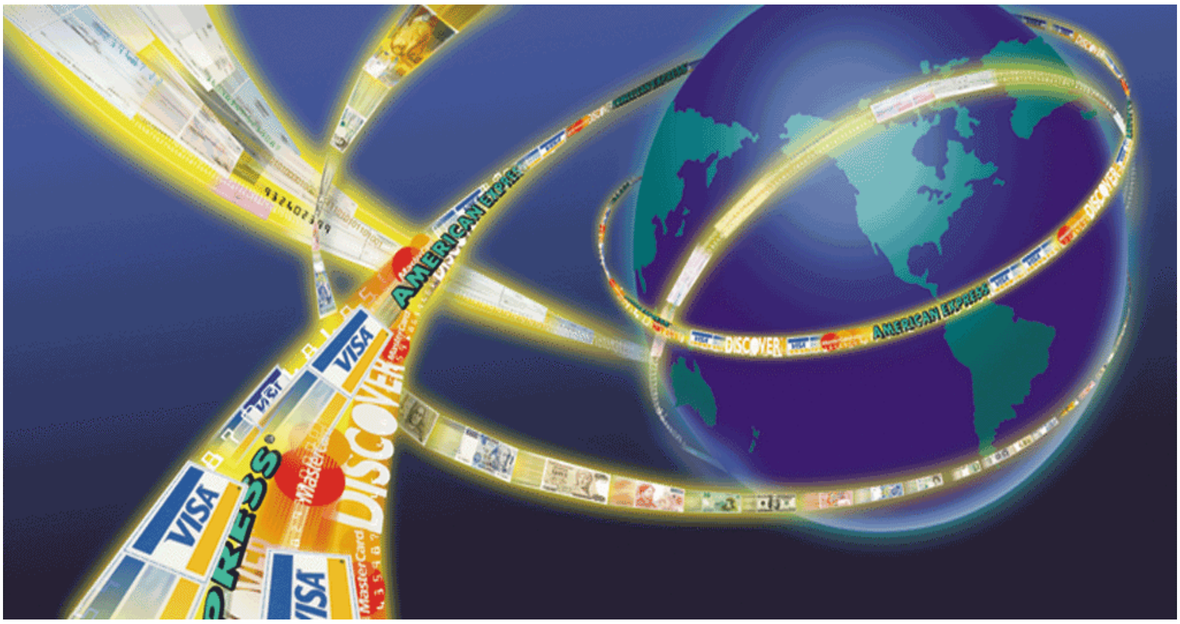

Figure 7.4 Global e-Payment Networks

Although *e-payment* systems are used in both *B2C* and *B2B e-commerce*, recent statistics have shown that the *B2B e-commerce* performed more *e-payment* transactions than *B2C e-commerce*. McKinsey and Company (www.mckinsey.com) has shown that in the year 2000, $ 5.5 trillion U.S. dollars were transacted between *B2B*, followed by $ 4.8 trillion U.S. dollars by *B2C*. This trend is expected to grow because businesses are finding more and more benefits coming from applications that lower agency and coordination costs. In addition, e-commerce opens both large and small organisations to economies not previously available. Perfect information is a big contributor to operational efficiency, and e-commerce is moving us a bit closer to what economists call perfect markets. Moreover, the time constraints inherent in many transactions all but disappear. E-payments for example between customers and providers have never been easier or cheaper. Although e-commerce is promising many benefits to organisations, it has its limitations. Turban, et al. (2000) have listed some of the benefits and limitations of e-commerce.

Benefits of e-commerce:

- Improved, lower-cost information that makes buyers and sellers more knowledgeable has an inherent power to drive down costs;
- Lower entry costs increase information sharing;
- Available 24 hours per day, virtually any place in the world, enabling convenient transactions for those concerned;
- Availability expands the market for both buyers and sellers;
- Decreases the cost of creating, processing, distributing, storing, and retrieving paper-based information;
- Reduces the cost of communication (i.e., electronic meetings, etc);
- Richer communication than traditional paper and telephone communication because of video clips, voice, and demonstrations;
- Faster delivery of digitised products such as drawings, documents, and software;
- Better and faster execution of *global concurrent engineering* (i.e., product development);
- Increased flexibility of locations. (That is, it allows some processes to be located anywhere because an electronic communication can be established, and allows people to shop and work from home –telecommuting.)

Limitations of e-commerce:

- Lack of system security, reliability, and standards;
- Lack of privacy. (That is, the ability to track who is on the other end of a transaction is still rather easy.)
- Insufficient band width; some transactions are still rather slow;
- Integrating e-commerce software with existing software and databases is still a challenge;
- Lack of trust in:
  - Unknowns at the other end of a transaction;
  - Integrity of the transaction itself; and
  - Electronic money that is only bits and bytes.

(Security issues from management, organisational and technological perspective, were discussed earlier in securing users' trust section.)

The meaning and role of electronic technology in operations management

For the purposes of this chapter, we define technology to be the know-how, physical things, and operational procedures used to produce products and services. Know-how is the knowledge and judgement of how, when, and why to employ equipment and operational procedures. Craftsmanship and experience are embodied in this knowledge and often cannot be written into manuals. Physical things are the equipment and tools. Operational procedures are the rules and techniques for operating the equipment and performing the work. In today's operational competitive environment all these components work together with the support of electronic technology. Operations managers use electronic technology (e-technology) to acquire, process, and transmit information from operations to the other functional areas (i.e., engineering, finance, human resources, accounting, research and development, marketing, and management information systems) of the organisation. E-technology is accelerating time-based competition through collaboration in product/service and process design using virtual teams. Members of product/service teams in different locations can easily share knowledge at low cost and at no time at all. In product development for example, Davenport (1993: 56-58) has addressed at least five key applications of e-technology.

- **Automated design** (decreases the speed of design and prototyping): e-technology supports rapid design and prototyping processes, for both service and manufacturing enterprises. It is possible to combine automated process design with *expert systems* that evaluate alternative designs and select those that best meet customer criteria;
- **Simulation systems** (improves the simulation process performance): e-technology enables operational process designers to simulate the execution of designs in increasingly realistic and complex settings. In process design, the implications of resource constraints and the ability of processes to run faster and to handle increased volume can be interactively simulated. Emerging 'virtual reality' capabilities will provide a realistic, almost lifelike simulation of process environments. Information systems process prototyping and screen-painting systems enable process designers to explore what it is like to use a process before implementing it;
- **Tracking systems** (improves the tracking product status): In complex operational process, operational managers must be able to track continuously the status of particular products or projects in the development stage and during operations cycles. Project management and 'parts tracking' electronic systems can be used to track the names of individuals working on particular product/service; current and cumulative resources expended on a product or service and the dependency relationship among these resources; problems associated with a product's or service's development or eventual manufacture and use; and market feedback about product's or service's prospects. E-technology can provide operations managers an early warnings of resources constraints enabling them to make quick operational decisions.
- **Inter-organisation communication** (co-ordinates product design information across components and products): Process designers need to be able to exchange ideas for new products and day-to-day messages about progress of the actual operations. At one level inter-organisational communication involves common application for electronic messaging and conferencing between different operational departments. At a less technological level, key issues in exchanging design information often revolve around information and data management. That is, establishing common component numbers and product information standards throughout an organisation, building databases of product designs and information, and securing adherence to design and technology standards.
- **Decision analysis systems** (assist in quick decision making of resource allocation and marker rollout). Deciding when to apply additional resources, when to send a product to market and when to cancel a product or service from operations are key operational issues in operational processes. A decision analysis system that calculates likely financial returns from operational investments at various stages of the product /service life cycle can inform operations managers.

On the whole, Davenport (1993: 200-217) has suggested that e-technology can play an important facilitating role in:

- Identifying and selecting processes for redesigning the operations;
- Identifying enablers for new process design;
- Defining operations strategy and process vision;
- Understanding the structure and flow of current (existing) process;
- Measuring the performance of the current process;

- Designing the new process;
- Prototyping the new process;
- Implementing and operationalising the process and associated systems;
- Communicating ongoing results of the effort; and
- Building commitment toward the solution at each process continuous improvement step.

Furthermore, Hammer (1996) also pointed out that operations management can benefit from using e-technology in a variety of ways, such as:

- Sharing databases means sharing information can appear simultaneously in as many places as it is needed;
- Expert systems which are electronically driven can do the work of an expert;
- Telecommunications networks facilitate operations, and to a larger extent business, to reap the benefits of centralisation and decentralisation;
- Beside the operations managers, everyone can and is involved in decision-making with the help of decision support tools;
- Wireless data communication and portable computers, and field personnel can send and receive information wherever they are;
- Allowing the detailed tracking of status, inputs and outputs;
- Being able to connect two operational parties within the process that would otherwise communicate through intermediaries; and
- High performance computing enables plans to be revised instantaneously.

All in all, the focus of e-technology is to constantly re-engineer the operational processes. Thereby, procedures can become more and more responsive to customers and competition. Advanced e-technology often employed by operations in order to achieve a competitive edge that would keep the company in business. Such technology is known as Computer-Integrated Manufacturing (CIM). CIM is the total integration of design, manufacture, and delivery through the use of computer technology.

As shown in Figure 7.5, CIM is made up from **numerical control** (NC) machines, **computer numerical control** (CNC) machines, **direct numerical control** (DNC) machines, **flexible manufacturing systems** (FMS), **robots**, and automated material handling systems, such as **automated guided vehicles** (AGVS) and **automated storage and retrieval systems** (ASRS). Form the process perspective, CIM is supported from **computer-aided design** (CAD) and **computer-aided manufacturing** (CAM), **computer-aided process planning** (CAPP), **manufacturing automation protocol** (MAP), **standard for the exchange of product model data** (STEP), and **cellular manufacturing**. As far as the systems management is concerned, CIM is being supported from **total quality management** (TQM), **electronic data interchange** (EDI), **electronics fund transfer** (EFT), **manufacturing resource planning** (MPR II), **enterprise resource planning** (ERP), **just-in-time** (JIT), **decision support systems** (DSS), **expert systems** (ES), **artificial intelligence** (AI), **local area networks** (LAN), **technical and office protocol** (TOP), **internet**, **intranet** and **satellites** technology. Finally, from the product design perspective, CIM is supported from **computer-aided design** (CAD), **computer-aided engineering** (CAE), **group technology** (GT), **design for manufacture** (DFM), **initial graphics exchange specification** (IGES), **product data exchange specification** (PDES), and **dimensional measuring interface specification** (DMIS).

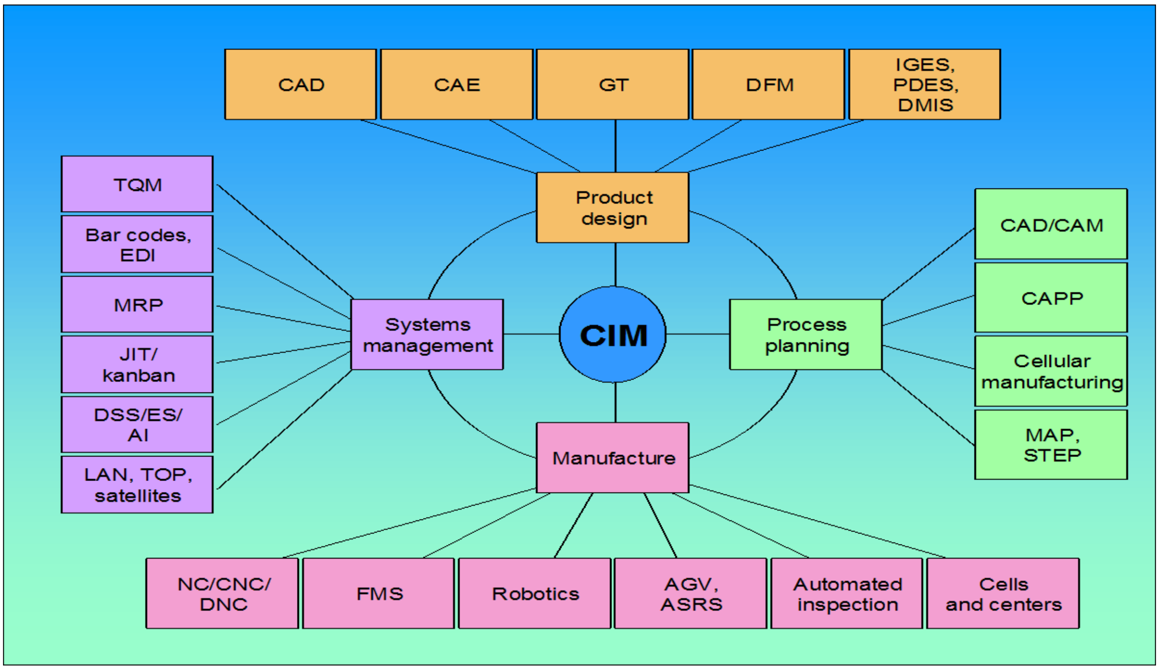

Figure 7.5 Components of Computer-Integrated Manufacturing

Adopted from Russell & Taylor, 2000: 267)

Companies like Cook Specialty Co (www.cookspecialty.thomasregister.com) are engaged with CIM to build a competitive edge that would keep the company in business. Cook invested heavily in CIM technology enabling the exchange of CAD parts drawings with customers and sends instructions for finalised designs to CNC machines for exact manufacture. Robots can handle welding and other repetitive tasks. Quality is being assured with the aid of digital probes of co-ordinated measuring machines (McWilliams, 1996). The idea of using CIM technology is to improve communication between the parties involved in the operational processes. Furthermore, CIM provides accurate data to suppliers and subcontractors resulting in strategic partnership in the globalise extended supply chain.

The application of e-technology cannot be underestimated in services. For example, we have all experienced payments of our bill from the hotel room via a channel on the room's television set. The resulting labour savings at the registration desk and enhanced service for the customer are currently demonstrated at most hotels. Although there are hundreds of service examples that are linked to electronic technology, Table 7.3 shows some applications of e-technology in services.

Table 7.3 Examples of e-technology in services

	Service Industry	**Example**
1	Financial services	Debit cards, electronic funds transfer, automated teller machines, internet stock trading, internet banking
2	Education	Multimedia presentations, electronic bulletin boards, internet library cataloguing system, internet researching and e-learning: In the e-learning environment we have: • synchronous classes • asynchronous classes

		• streamed educational audio and video • online degree and certificate programs • free online tutorial • online seminars
3	Utilities and government	Automated one-man garbage trucks, optical mail scanners, airborne warning and control systems, e-business applications and government approvals, e-police fine payments, and all e-government utilities
4	Restaurants and foods	Optical checkout scanners, wireless orders from waiters to the kitchen, robot butchering
5	Communications	Electronic publishing, interactive TV, voice mail, e-mail, 'notepad' computers, cellular phones
6	Hotels	Electronic check in and check out systems, electronic key/lock systems, electronic billing
7	Wholesale and retail trade	Point-of-sale electronic terminals, e-commerce, electronic communication between store and suppliers, bar-coded data, inventory tracking, electronic procurement and payment, automated security systems
8	Transportation	Automatic toll booths, satellite-directed navigation systems, electronic 'smart' traffic lights
9	Health care	Sonograms, patient-monitoring systems, on-line medical information systems
10	Airlines	Ticketless travel, computer scheduling, internet booking, electronic boarding check

The examples shown in Table 7.3 emphasise that operations managers in services, as in manufacturing, must be able to evaluate the impact of e-technology in their organisation. This ability requires particular skill when evaluating reliability, investment analysis, human resource requirement, and maintenance/service. This new breed of operations managers are known as e-technology – enabled managers.

Impact of the Internet on operations management

The Internet is the largest single source of information in the world today. In other words, the information superhighway or the Internet is one of the most important developments in the history of information systems (IS) and it is also one of the hottest topics in today's business word. The Internet, or '*network of networks*' has become the major business medium for operational enterprises. "Companies of all shapes and sizes are finding that the Internet provides new opportunities for competitive advantages" (Cronin, 1996). Many operations, large and small, are using the Internet-based e-commerce to gain an edge in an increasingly competitive dynamic business environment, both nationally and globally (Quelch & Klein, 1996).

According to Youssef (1992a), one of the most important factors impending on business operations management today is the reality of Global Competition. A key impact of that factor on operations managers is that a country's borders no longer provide protection from foreign imports. Time-based competition has become intense and is increasing. Today, globalisation and global competition, computers and advanced production technology, and social responsibility issues are providing challenges for operations management and are shaping the nature of operations systems for the future (Youssef, 1992b). In order to succeed in global competition, organisations through their operations must make a commitment to customer responsiveness and continuous improvement toward the goal of quickly developing innovative products/services that have the optimal combination of exceptional quality, fast and on-time delivery, low prices and costs, and flexibility (Youssef, 1992a; 1992b), which will be realised with Internet-based e-commerce.

Operations find themselves competing in a race where the road signs and rules keep changing, where there is no finish line and no permanent win. Basically, geographical and cultural distances have shrunk significantly with the advent of jet aeroplanes, fax machines, global computer and telephone link-ups, world television satellite broadcasting and, now-days, the use of the Information Superhighway or, as widely accepted the Information Age-the Internet (Gates, 1999).

During the last two decades, many operations adopted the Electronic Data Interchange (EDI) technology to enter into paperless economy. With the passage of time this has changed and now experts are debating whether businesses will abandon the well structured, and planned EDI processes in favour of e-commerce. Many business choose EDI because it is fast, inexpensive (when compared to ordinary mail) and a safe method of sending purchase orders, invoices, shipping notices and other frequently used business documents. Naturally, a set of questions is raised about the usefulness of the Internet for operations management. Some of these questions are:

- If it is generally agreed that the characteristics of electronic and physical markets are fundamentally different, are operations managers adapting to the new environment and adopting new strategies to compete digitally?
- Are operations managers using the Internet merely as an efficient communication medium to reach out to their stakeholders (customers, shareholders, suppliers and business partners) or is the Internet used as a new value delivery system to create new products, new services and new solutions for the operating environment?
- Are operations managers building new competence and capabilities in the new digital economy by amalgamating place-based competence with space-based attributes or are strategies pursued in a disparate and disconnected fashion?
- To what degree have operations managers redefined the rules of conducting their business? How far have operations managers gone to rethink their business and value propositions?
- What are the drivers and enablers that change the digital economy?
- What organisational attributes do operational managers need to adapt and align for e-business transformation?

Although over the years EDI has provided many tangible and intangible benefits to businesses, many operations all around the world are beginning to move inevitably from traditional methods to Internet-based electronic commerce. Internet-based e-commerce started to attract large attention, especially over the last eight years from banking to operations management because of its promise of reducing the cost of operations and just-in-time (JIT) applications (Cronin, 1996; Heizer & Render 2001). Internet-based e-commerce is rapidly emerging as an entirely new method of conducting business and interacts with customers, suppliers and partners.

Internet browsers, with their Hyper Text Mark-up Language (HTML), are easy to adapt to many types of information exchange as compared to EDI standards which are very structured and rigid. Internet is very easy to use while EDI requires a group of consultants to operate it. There are similarities between Internet and the EDI, however, the differences are explained by Sawabini (1995). Sawabini indicated that the Internet format is not as standard as the EDI format. However, the EDI does not need any human interface while the Internet does. The following table (Table 7.4) summarises the fundamental differences between traditional e-commerce (EDI) and the Internet-based e-commerce.

Table 7.4 Traditional (EDI) and Internet-based e-commerce

Factors	Traditional (EDI)	Internet-based e-commerce
Implementation dynamics	Proposition is biased towards a predetermined relationship, otherwise the transaction cannot happen	Customers decide and indicate the request to buy in a one-to-many relationship
Business case	Users develop transaction capabilities only after they know there is a market or willingness to use the channel	Users develop content and make it ready for a critical mass of buyers to get connected
Financial transactions	Financial transactions can take place over existing networks	Internet gateways to financial networks, new instruments and micro-payments
Effects on business processes	Any transaction done has a direct effect on internal business processes	Transactions mirror reality and should dramatically simplify business processes
Frequency of transactions	Smaller frequency, by higher dollar value for transaction	Mass market, infrequent usage and lower cost per transaction are acceptable
Choice of products	Comparison-shopping is excluded	Comparison-shopping is essential
Level of trust	High	Low to medium
Duration of relationship	Long	Low to medium
Cost	Higher	Lower
Reliability	Higher	Lower (but getting better)
Flexibility	Lower	Higher
Effect on distribution	No conflict of distribution channel due to primary focus on uniqueness of transactions	Channel conflict on line, as transactions become the "back end", and consumer interface becomes the "front end"

Adopted from Soliman (1999: 280)

Examining the factors of Table 7.4 it is evident that both approaches (i.e., the traditional (EDI) and Internet-based e-commerce) offer direct and indirect benefits. As a result, some experts are in a state of uncertainty and are reluctant to give a firm view of the future of operations management in an Internet environment. However, all experts agree that the Internet has a huge potential and can be a useful tool for operation managers.

According to Mougayar (1998), there are various types of key measurements that must be made prior to embarking on a full implementation of Internet-based e-commerce. Some of the important key elements to measure operations value are:

- **Reducing costs**: The most basic cost reductions could be related to publishing costs, which include the cost of production, printing and distribution. Furthermore, marketing and selling costs are also lower in an electronically enabled commerce environment.
- **Process simplification**: Instead of using paper, using the World Wide Web (WWW) simplifies and speeds the approval process.
- **Improving customer service**: Providing customers self-access to their accounts, transactions and orders, is a valuable service. The level of satisfaction for those customers (internal and/or external) interacting electronically will undoubtedly rise.
- **Generating new revenue**: The new Internet-based Electronic Marketplace generates new revenue by selling new products and services specifically designed for the electronic marketplace. Existing product or service can also be sold on the Internet.
- **Making faster decisions**: By receiving information about competition through an Internet information retrieval database, it would be possible to develop a competitive strategy much faster than otherwise.

The major benefits from the Internet include improved internal and external communications. The Web has specifically brought a new marketing medium and enhanced information resources. Innovative applications are starting to appear that allow for sales and database interrogation. Other benefits include e-mail and file transfer functionality. Web utilisation has given operations management '*Internet presence*' and provided them with opportunities to develop and expand new products and services.

Traditionally, in operational settings, design engineering, procurement and production departments communicate with each other using paper-based methods. In today's operations environment the use of the Internet-based e-commerce and its superiority over traditional EDI are adding new dimensions to reducing the running costs of the operation.

As discussed earlier in this chapter, the Internet-based e-commerce can be used to interconnect companies without any of the standard structure of EDI. The latest approach is to adopt the text of a purchase order in the body of a simple e-mail message which brings us to the topic of electronic purchasing or e-procurement.

Electronic purchasing (e-procurement)

As discussed earlier, electronic communication between store and suppliers assisted with bar-coded data systems results in accurate electronic procurement and payment. The advent of electronic purchasing has changed the traditional image of purchasing as a paper-shuffling function. Since the early of 1970s organisations have been using EDI, a computer-to-computer exchange, over telephone lines or direct leased lines, of routine business documents having a standard format. Special communications software translates documents into and out of a generic form, allowing operations to exchange information even if they have different hardware and software components. Invoices, purchase orders, and payments are some of the routine documents that EDI can handle. More recently however, organisations such as Wal-Mart (www.walmart.com), GM (www.gm.com) and Baxter International (www.baxter.com) have perfected their EDI purchasing operations, which is now conducted on a company's private mainframe computer system resulting to the known Internet-based e-commerce or e-commerce approach. Internet-based e-commerce is aiming at creating a *virtual marketplace* where purchases and order releases communicated over the Internet or to approved vendor on-line catalogues.

In this modern procurement approach, known as e-procurement, on-line catalogues are information about products/services in electronic form via the Internet that was traditionally presented in paper catalogues. They are quickly improving cost comparison and bidding processes. These electronic catalogues can enhance traditional catalogues by incorporating voice and video clips. On line catalogues are available in three versions: those provided by:

- Vendors
- Buyers, and
- Intermediaries.

Whichever version of a catalogue is being used, the bottom line is that operations managers benefit in variety of ways. For example:

- Operations personnel find the on-line catalogue easier to use and available whenever they need it.
- There is significantly less cost involved than traditional faxes, telephone calls and purchase orders.
- On-line catalogues are virtually available on every employee's desktop computer assisting the concept of teamwork.
- Cost of items purchased is often lower because of improved information and because the costs of the vendor are lower.
- The cost of preparing Request for Quotes (RFQs) can be substantially reduced, because there is less paper-shuffling.
- The number of employees working in purchasing departments can be substantially decrease resulting operational overhead cost reduction.

Last but not least, e-procurement has assisted operations management with on-line auctions. Operations managers find on-line auctions a productive way of disposing of excess raw material and discontinued or excess inventory.

Because e-procurement offers new challenges to operations management, operations managers have found that these challenges will require new skills and staffing in the purchase area. With that in mind it is recommended to students to undertake the on-line cookbook activity shown below. What needs to be done in this Internet activity is self-explanatory.

Internet Activity 7.1

Visit http://hepg.aw.com/

On the right side of the webpage you will find "Find Our Book Websites: Select keyword or Author name here: In the window of 'Find Your Keyword' find the key word

OM5

Enter, then click
Internet Activities

Select Chapter 11

Go to Internet Activity 11.2

Destination:
http://www.campbellsoup.com/

Instructions: To support these measures, Campbell drastically improved its marketing efforts to the customer. For instance, Campbell has instituted many innovative marketing directives on its website. One example is an on-line cookbook in which you can input the type of soup you have. The program will then list all of the possible recipes you can use in preparing a meal. For an illustration, go to: http://www.campbellsoup.com/, scroll down and click the "Campbell's creative kitchen" icon. You may then click on the "featured winter recipes" to see general recipes or you may click on the "custom recipe search" icon. With the custom recipe search, you may then input the ingredients you want to use and/or the Campbell product you would like to use. Once you are done, you can click the "begin search" icon and will receive a list of possible recipes.

Another innovative function on Campbell's website is the "Menu Scan" program. This program is designed to give you nutritional information of your typical diet. For an illustration, go to: http://www.campbellsoup.com/, scroll down and click the "Menu Scan" icon. After reading the instructions, you may then click the "Begin Menu Scan" icon. You then may start entering your information and then "Submit it" After you finish submitting your typical menu, you will get a nutritional breakdown of your typical diet.

Source: http://www.prenhall.com/divisions/bp/app/krajewski/5e/activities/ch11.htm

Inventory tracking and Enterprise Resource Planning (ERP)

E-commerce has brought about a new role for organisations such as FedEx (www.fedex.com). Instead of being just the package delivery service of the past, FedEx now provides distribution warehouses to companies such as Dell Computer (www.dell.com) and National Semiconductor (www.national.com). As FedEx customer you can now track items from source to destination. Millions of documents can be tracked each day worldwide. But where did it all start?

The focus of manufacturing systems in the 1960s was on Inventory control. Most of the software packages then (usually customised) were designed to handle inventory based on traditional inventory concepts. In the 1970s the focus shifted to Material Requirement Planning (MRP) systems which translated the Master Schedule for the end items into time-phased net requirements for the sub-assemblies, components and raw materials planning and procurement.

In the 1980s the concept of MRP-II (Manufacturing Resource Planning) evolved which was an extension of MRP to shop floor and distribution management activities. In the early 1990s, MRP-II was further extended to cover areas like Engineering, Finance, Human Resources

Management, Projects Management etc, i.e., the complete gamut of activities within any business enterprise. Hence, the term Enterprise Resource Planning (ERP) was coined.
With regards to operations management, ERP systems can radically transform the operational processes of an organisation. An ERP provides the operations manager with a fast and efficient system that is capable of doing the operation's transactions (i.e., inventory tracking). An ERP system can be used to support operations management by providing a sophisticated, on-line, performance system. Critical to business is the concept of aligning the operations management processes with customer satisfaction, a matter that can be handled easily using an ERP system.

In addition, an ERP system can share databases and it can also provide a total integration of business units (see Figure 7.6). The use of shared databases and extensive telecommunication has allowed operations managers to have and view the same information that floor operators and front line worker, have and use, thus providing them with a wealth of information to make informed decisions about allocating the organisational resources. The ability to perform many functions on-line and away from a regional office and overseas locations was made easier with ERP systems.

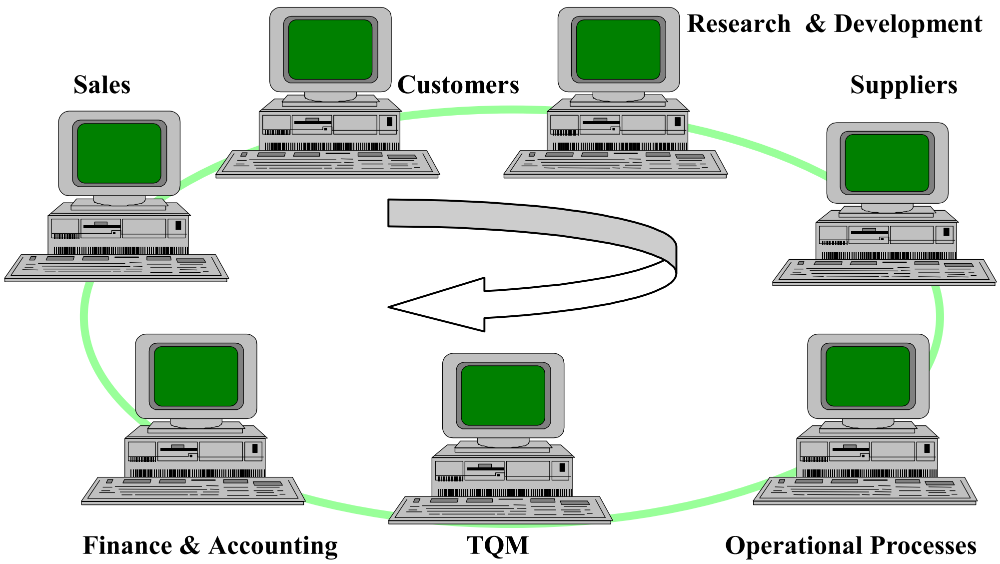

Figure 7.6 ERP - Total Integration of Business Enterprise

In terms of performance improvement and quality it is generally agreed that in a typical process flow, quality is measured at two checkpoints. These are known as incoming and outgoing quality inspections (input part and the output part). Deming's Total Quality Management (TQM) method has a different perspective that emphasises quality improvement at three different checkpoints. The goal of the *first checkpoint is to work with upstream suppliers and vendors* (both inside and outside the operations) to manage inputs to the 'real' requirement, and to include timeliness, cost, quality and performance. At the *second checkpoin*t, *the goal is to assure that internal processes are effective and efficient*, and meet or exceed customer's quality, cost, quantity, performance and other expectations. Finally, the goal of the *third checkpoint is customer service*; making sure that customer's expectations are being met. Deming states that if an organisation through its operations directs its time, energy and money to these checkpoints, it follows that:

- Total quality will increase dramatically;
- Total quality costs will decrease significantly; and
- The organisation will dominate the marketplace.

It is suggested that an ERP system provides an approach where productivity improvements are realised from concentrating on product development cycle time, market responsiveness, customer-focused operations and service quality (Gaither, 1996; Russell & Taylor III, 2000). These principles are fundamentally different from the historic cost and control mode of operations. An ERP system simply automates manual processes with minimal investigation into doing things in new and different ways. It has basically automated pre-existing operations processes thought the use of:

- Simulation modelling;
- Front end data collection;
- Knowledge-based systems;
- Electronic data interchange (EDI); and
- Internet based e-commerce.

It is clear that computer tools are essential for the rapid prototyping, simulation and delivery of goods and services.

Introduction to commercial ERP systems: SAP R/3

We have come to realise in this chapter that Information Systems are now a line management tool capable of being used well or being misused. Some will ignore or misunderstand its power. Those who succeed in the twenty-first century will be the companies that recognise the power of integrating business strategy, information systems, and the potential of the individual employee within the teamwork environment using ERP systems.

There are may Enterprise Resources Planning Packages on the market. The most commonly used commercial package in medium to large organisations is SAP R/3. This is clearly demonstrated by recent increase in a number of companies adopting SAP R/3 system to fill niche needs as advantaged planning or product data management.

SAP A.G. (http://www.sap.com/), the parent company, was founded in 1972, and is based in Walldorff, Germany. SAP is one of the leaders in the Client/Server software market worldwide and is the fourth largest independent software supplier in the world. SAP R/3 is currently one of the hottest Enterprise Resource Planning (ERP) software package in the computer industry. SAP stands for *Systems, Applications and Products* in data processing. Its main competitors in the applications of business are Oracle (http://www.oracle.com/) and Baan (http://www.baan.com/).

The SAP R/3 System is very large and versatile. The system consists of a set of business application software modules designed for the Client/Server environment. All the system's modules are integrated, and cover almost all functions found in a major corporation. These functions include manufacturing, finance, sales and distribution, and human resources. The system can be configured to cover all business situations through 8000 tables that manage all possible hierarchies of most companies. These tables are easy to use and do encompass everything from corporate structure to pricing discounts. All sounds good, but what is SAP R/3 Systems?

SAP R/3 is an enterprise-wide system. It consists of 12 modules, which are integrated, in 'real time', to support all of a company's business transactions. All application modules have a common interface and architecture (i.e., the same looks of the SAP windows and navigation). Due to integration of the various modules the changes made to the data in one application module will be automatically reflected in other application modules involved. The system's 12 Application Modules are:

- Financial Accounting (FI)
- Controlling (CO)
- Asset Management (AM)
- Project System (PS)
- Workflow (WF)
- Industry Solution (IS)
- Human Resources (HR)
- Plant Maintenance (PM)
- Quality Management (QM)
- Production Planning (PP)
- Materials Management (MM), and
- Sales and Distribution (SD)

All of the 12 application modules can be classified under four main processes, namely: Accountancy, Logistics, Human Resources and Common Systems. Each of the processes is explained hereunder:

Accountancy includes the four modules, which are relevant to the accountancy process: Financial Accounting (FA), Asset Management (AM), Controlling (CO), and Project System (PS).

Logistics includes the functions that are most commonly required in organisations, namely: Materials Management (MM), Production Planning (PP), Plant Maintenance (PM), Sales and Distribution (SD), and Quality Management (QM).

Human Resources is covered in the module of "Human Resources (HR)".

Common Systems: In addition, other activities within organisations would require the modules of Workflow (WF) and Industry Solution (IS).

The 12 modules of R/3 system mentioned earlier can be integrated to provide real time enterprise-wide information system processing. The system provides two types of integration, namely: Application Integration and Technical Integration.

Application integration: One point of data entry. In the R/3 system, the data is entered at one particular point, which reduces the change of duplication of data. The change of data in one application module is automatically carried through the other modules involved.

Technical integration: this involves data integrity and elimination of redundant data. As discussed earlier, all the modules have a common architecture and user interface, which maintains data integrity. The system offers on-line, interactive edit and updates to database.

The updates to the database are asynchronously as the database is managed by SAP R/3 system. The two types of integration of R/3 are shown in Figure 7.7.

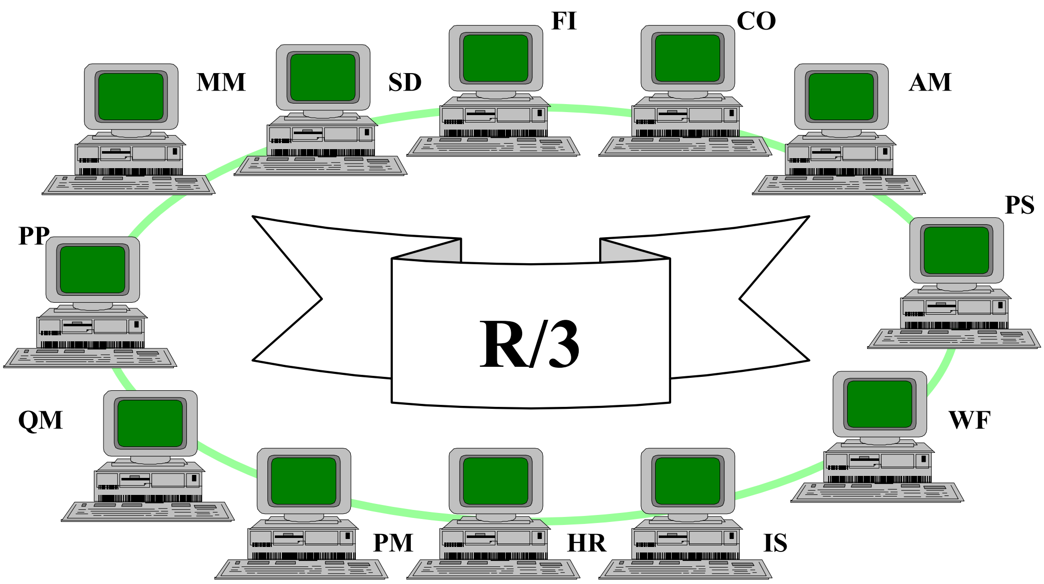

Figure 7.7 SAP R/3 Integrated Application Modules

The SAP R/3 architecture ensures that all the application modules of Figure 7.7 are integrated and platform-independent. The SAP R/3 architecture includes:

- Client/Server architecture;
- Application architecture; and
- System communication.

Client/Server Architecture: SAP R/3 architecture is based on three-tier client/server principles:

- *Presentation layer*: It makes a request to the server, gets the result data and processes the screen displaying it to the user as defined. It is a mere presentation tool supported by SAPGUI (SAP Graphical User Interface).
- *Application layer*: It receives user's requests, processes concerned SAP programs, interacts with the database as and when needed and gets back the result to the Presentation layer.
- *Database*: Database is a storage device where all data is stored. It receives statements from the application layer, processes the statement and modifies the database accordingly.

Application Architecture: SAP R/3 system is platform-independent that means SAP applications can run on different hardware and platforms without sacrificing performance. The R/3 system is highly portable.

System Communication: The SAP R/3 system can communicate with various communication modes, hence ruling out the need of a total reinvestment when the SAP system is implemented. The communication modes includes:

- *Remote Function Calls (RFC)* which help the communication and processing of applications between the R/3 and other systems.
- *Electronic Data Interchange (EDI)* discussed earlier in this chapter.
- *Object Linking and Embedding (OLE).*

Over the years it has been realised that SAP R/3 represents a number of challenges unique to the information system world. Companies that implemented R/3 report difficulty regarding the technical configuration and functionality of the system (Soliman, 1999). Successful implementation requires business process Re-Engineering, a Client/Server environment, the ability to manage the system's flexibility, and the ability to cope with high complexity levels. Although it is being recognised that the SAP R/3 System is a good choice for most companies, the system is not a silver bullet, nor would it implement itself. There are aspects of managing technological change that must be resolved before R/3 can be of optimum use.

Regardless of the difficulties that are related to the technical configuration and the functionality of the system, there are many benefits that can be obtained from implementing the SAP R/3 system. Some of the benefits that the system has delivered are listed below:

- The system is designed for all types of business.
- The system has a world-wide usage.
- The system features Flexibility, Open system and Interactive Processing.
- The system is a fully integrated package and hence promotes integration within the company.
- SAP R/3 System is an end-to-end business structure.
- The system supports multiple level organisational structure.
- The system supports global business and accounting practices.
- The R/3 System has Predefined Standardised business processes across the organisation.
- The system tailors processes for individual business units, and
- Provides a complete business solution across all business functions that are required for strategic and operational control of any organisation.

Activity 7.2

Identify and discuss how the 12 modules of SAP R/3 can be integrated into your organisation. Discuss the role of product or service operations managers in implementing an Integrated Enterprise System such as R/3?

Activity 7.3

The SAP R/3 Systems assist the operations management from the Sales and Operations Plans through the work centres until the work orders are settled. Provide a graphical illustration of the processes as represented in the R/3 System and briefly discuss the interrelationship between the applications of Operations Planning and Execution.

Complete the following questions

TRUE/FALSE QUESTIONS

1. *Friction-free* capitalism is the product of the Internet. **True**

2. The use of Information Technology is not crucial to operations managers. **False**

3. E-commerce and e-business have no differences in operations management application. **False**

4. Operations management is often inclined to use C2C application. **False**

5. E-business is about enhanced productivity, globalisation, and reaching new customers. **True**

6. E-commerce applications pose security problems. **True**

7. In the language of the Internet, Cryptography stands for scrambled message. **False**

8. The Internet is known as '*network of networks*'. **True**

9. There are no differences between EDI and Internet-based e-commerce. **False**

10. Enterprise Resource Planning (ERP) does not offer an integrated approach to business enterprise. **False**

MULTIPLE CHOICE QUESTIONS

1. Which of the following is not an operational attribute in the e-commerce environment?
   a) confidentiality
   b) integrity
   c) availability of data
   d) cluster chart

2. _________ refers to e-commerce transactions in which buyers are individual customers.
   a) CAD/CAM
   b) B2C
   c) C2B
   d) C2C

3. The following are examples of e-procurement available to managers *except*:
   a) EDI
   b) ERP
   c) SAP R/3
   d) CAE (Computer-Aided Engineering)

4. E-commerce embraces:
   a) B2B
   b) B2C
   c) B2E
   d) all of the above

5. Security in the e-commerce environment requires:
   a) Authentication
   b) Confidentiality
   c) Encryption
   d) all of the above

6. The key applications of e-technology in operations management are:
   a) inter-organisational communication
   b) tracking systems
   c) decision analysis systems
   d) all of the above

7. Full implementation of Internet-based e-commerce can be measured by
   a) reducing costs
   b) making faster decisions
   c) improving customer service
   d) **all of the above**

8. The idea of Enterprise Resource Planning (ERP) systems begins with
   a) MRP
   b) MRP-II
   c) SAP R/3
   d) TQM

9. Which of the following provides a total integration of design, manufacture, and delivery through the use of computer technology
   a) CIM
   b) CAD/CAM
   c) EDI
   d) all of the above

10. SAP R/3 can
    a) Provide a common mode of communication.
    b) Provide client/server architecture.
    c) Be used to customise ERP software.
    d) all of the above.

SHORT-ANSWER QUESTIONS

1. Explain the difference between B2B, B2C, C2C, and C2B e-commerce. Provide an example of each.

2. What is the value of on-line auctions in e-commerce?

3. Explain how FedEx uses the Internet to meet requirements for quick and accurate delivery.

4. List the advantages and limitations of e-commerce.

Summary

This chapter provided an introduction to e-commerce from the operations management perspective. In particular, it focussed on the nature and purpose of electronic commerce and electronic business and how e-commerce can assist operations management to succeed. The chapter also examined the security problems in the e-commerce environment with particular emphasis on the threats to Internet based applications. The chapter also investigated the benefits and limitations of e-commerce and addressed the key applications of e-technology in relation to operations management. The impact of the Internet on operations management and the concept of e-purchasing were also addressed in the chapter. Finally, the chapter provided an introduction to Enterprise Resource Planning (ERP), and in particular it focussed on the commercial ERP system SAP R/3.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to e-commerce and e-business

- ☐ The nature of e-commerce and e-business
- ☐ The nature of Information Technology in operations management

The nature and purpose of e-commerce and e-business

- ☐ The nature of B2B
- ☐ The nature of B2E
- ☐ Security in the e-commerce environment
  - ☐ The threats to Internet based application
  - ☐ Securing user's trust

- ☐ Economics of e-commerce
  - ☐ E-payments
  - ☐ Benefits of e-commerce
  - ☐ Limitations of e-commerce

- ☐ The meaning and role of e-technology in operations management
  - ☐ Applications of e-technology
  - ☐ Computer Integrated Manufacturing (CIM)
  - ☐ E-technology and service operations

- ☐ Impact of the Internet on operations management
  - ☐ Electronic Data Interchange (EDI)
  - ☐ Internet-based e-commerce
  - ☐ Electronic purchasing

- Inventory tracking and Enterprise Resource Planning (ERP)

- Commercial Enterprise Resource Planning (ERP) systems: SAP R/3

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

……………………………………………………………………………
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Chapter 8 Operations Improvement

Contents………………………………………………………………….. Page

Operations improvement

Learning outcomes

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- understand how managers can make their operations perform better, how they can stop it failing, and how they can bring their improvements together.
- understand how operations can measure their performance in terms of the five performance objectives – quality, speed, dependability, flexibility and cost.
- examine how can operations managers prioritise improvement of performance objectives.
- understand the principles and stages of benchmarking and how benchmarking fits into the improvement framework.
- understand the way in which operations managers can quantify the importance of their significant competitive factors and their achieved performance using the importance-performance matrix.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcomes stated above.

- Understand the importance and the advantages of measuring the performance of an operation
- Understand the broad approaches to managing the rate of improvement
- Understand where business process re-engineering (BPR) fits into the improvement activity
- Be familiar with the improvement techniques such as scatter diagrams, cause-effect diagrams and Pareto charts.

What you will need

Suggested study time	Text Book	5 hours
	Activities and exercises	2 hours
Other resources:	Suggested readings	3 hours
	Total	10 hours

Introduction

Do managers and organisations that measure performance outperform those that do not? Intuitively, you would expect the answer to be a resounding ‘yes’. Reviews of performance in organisations that plan and measure performance are generally positive, but we should not take that as a blanket endorsement of formal performance measurement. We cannot say that organisations with formal plan of performance measures outperform those that do not. What we measure is probably more critical to the control process than how we measure it. The selection of the wrong criteria can result in serious dysfunctional consequences. Besides, what we measure determines, to a great extent, what people in the organisation will attempt to excel at (Kerr, 1975).

It is unlikely that for any operation a single measure of performance will adequately reflect the whole of a performance objective. Usually operations have to collect a whole bundle of partial measures of performance. The five performance measures discussed in the previous chapters (i.e., quality, speed, dependability, flexibility and cost) are usually “composites of many other smaller measures” (Slack et al. 2000: 599). Each of these partial measures then has to be compared against some time in the past. There are four types of performance standard commonly used:

- Historical standards which compare performance now against some time in the past.
- Target performance standards, which compare performance against some desired level of performance.
- Competitive performance standards, which compare performance against competitors’ performance.
- Absolute performance standards, which compare performance against its theoretically perfect state.

One approach often used by some organisations to compare their operations with those of other companies is known as **benchmarking**. Benchmarking is used as a means of obtaining competitor performance standards. We should discuss the principles and types of benchmarking and how benchmarking fits into the improvement activity in a later section of this chapter.

In chapter 2 we have identified that the performance and activities of the competitors and the needs and preferences of customers influence operations manager to prioritise improvement of performance objectives. (In other words an operation decides which performance objective requires particular attention.) Improvement priorities can be determined by bringing together the relative importance of each performance objective or competitive factor as judged by customers, with the performance which the operation achieves as compared against competitors. The operation’s judgement about both importance and performance can be consolidated on an ‘importance-performance’ matrix (Slack et al. 2000). Different areas on this matrix represent different relative degrees of importance for customers.

Once the priority of improvement has been determined, an operation should consider the approach it wishes to take to the improvement process. An organisation's approach to improving its operation can be characterised as lying somewhere between the two extremes of '*pure*' *breakthrough improvement* and '*pure*' *continuous improvement*.

Breakthrough improvement, which is sometimes called innovation-based improvement, sees the rate of improvement as occurring in a few infrequent but major and dramatic changes. Although such changes can be abrupt and volatile they often incorporate radical new concepts or technologies which can shift the performance of the operation significantly. Researchers and practitioners concur that the process of **reengineering** can result in a breakthrough (dramatic) improvement in process performance (Besterfield et al. 1999). Reengineering is the total redesign of a process (Russell & Taylor, 2000). The process of reengineering is usually called **Business Process Re-engineering** (BPR), which will be discussed in a later section of this chapter.

Continuous improvement assumes a series of never-ending but smaller incremental improvement steps. This type of improvement is sometimes called ***Kaizen*** improvement. The Japanese used the word *Kaizen* to describe an ongoing process of unending improvement – the setting and achieving of ever-higher goals. In Japan, Europe, and the U.S.A., **Total Quality Management** (TQM), **zero defects**, and **six-sigma** are used to describe such efforts. Whatever word or phrase is used, continuous improvement is gradual and constant and often utilises collective group-based problem solving. It does not focus on radical changes but rather attempts to develop an ingrained momentum of improvement. A typical approach of continuous improvement is the one described by Deming's **plan-do-study-act** (PDSA) cycle.

Obviously, with regard to the needs and preferences of customers, both, breakthrough and continuous improvement approaches offer advantages and disadvantages. It is claimed, however, that compromises between these two types of improvement philosophy are possible. Organisations can improve by having occasional radical breakthroughs but utilising a more incremental approach in between the major changes.

Finally, in this chapter we consider the improvement techniques that are known as "statistical process control" (SPC). These are:

- **Input-output analysis**, which attempts to clarify the nature of transformation in processes
- **Flow charts**, which attempt to describe the nature of information flow and decision making within operations
- **Scatter diagrams**, which attempt to identify relationships and influences within the process
- **Cause-effect diagrams**, which structure the brainstorming which can help to reveal the root causes of problems

- **Pareto diagrams**, which attempt to sort out the 'important few' causes from the 'trivial many' causes.

How operations can measure their performance?

As discussed in earlier chapters of this course, before devising an improvement strategy, managers need to know where they are with their current performance. Improvement priorities are determined partly by whether current performance is judged to be good, bad, or indifferent. Performance measures are therefore a prerequisite to improvement.

A review of the literature revealed that performance measurement is the process of *quantifying action,* where measurement means the process of quantification and the performance of the operation is assumed to derive from actions taken by its members (Neely, 1993). For the purpose of this course, performance is defined as "the degree to which an operation fulfils the five performance objectives at any point in time, in order to satisfy its customers (Slack et al. 2000). Often polar diagrams, as shown in Figure 8.1, are used to illustrate whether customers' needs and preferences are satisfied. The five performance measures discussed in the previous chapters (i.e., quality, speed, dependability, flexibility and cost) are usually used to measure performance, and often shown on a polar diagram.

Experience has shown that market needs and expectations vary, as will the extent to which an operation meets these needs. As shown on Figure 8.1, customers' needs and the operation's performance might both change over a period of time. As it can be seen after a period of time the operation has improved its speed, and cost to match market requirements, but its flexibility no longer matches market needs.

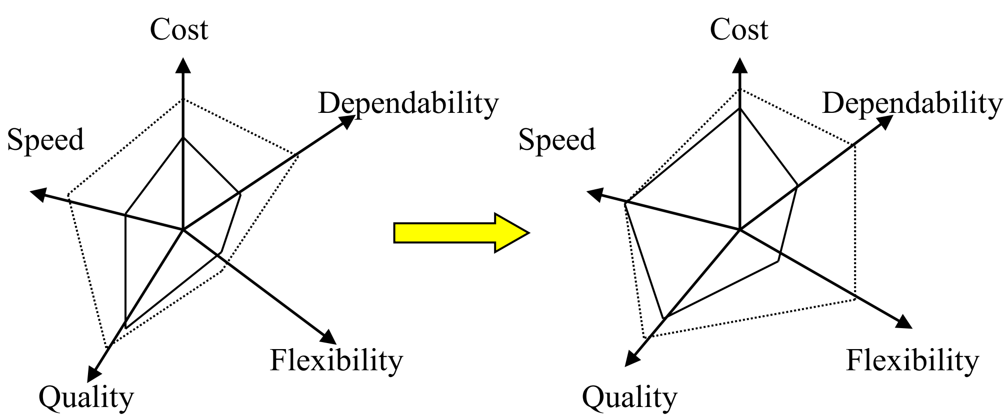

Figure 8.1 Typical Polar Diagram of Performance Measure

Note: Solid line denotes performance of the operation,
Dotted line denotes requirements of the customers

Adopted from Slack et al. (2000: 598)

Although the above figure (Figure 8.1) represents a text book example of polar diagram, W.I. Carr Malaysia, which is a Malaysian operation of a specialist South East Asian stock-broking business headquartered in Hong Kong, has used this diagram. W.I. Carr Malaysia has successfully used the polar diagram shown in Figure 8.2, to illustrate areas of service shortfalls against industry importance.

The pink checked areas represent areas of service shortfall against industry importance. The larger the area, the more critical the shortfall. What should be of particular concern to WI Carr is that although they meet or exceed most industry requirements for Qualifiers (see Chapter 2), there are significant shortfalls evident on order Winners, most noticeably on Access to senior level corporate management and the recommendation track record (Russell, 2000). This polar diagram can be also used in conjunction with the importance-performance matrix (see Figure 8.3) below.

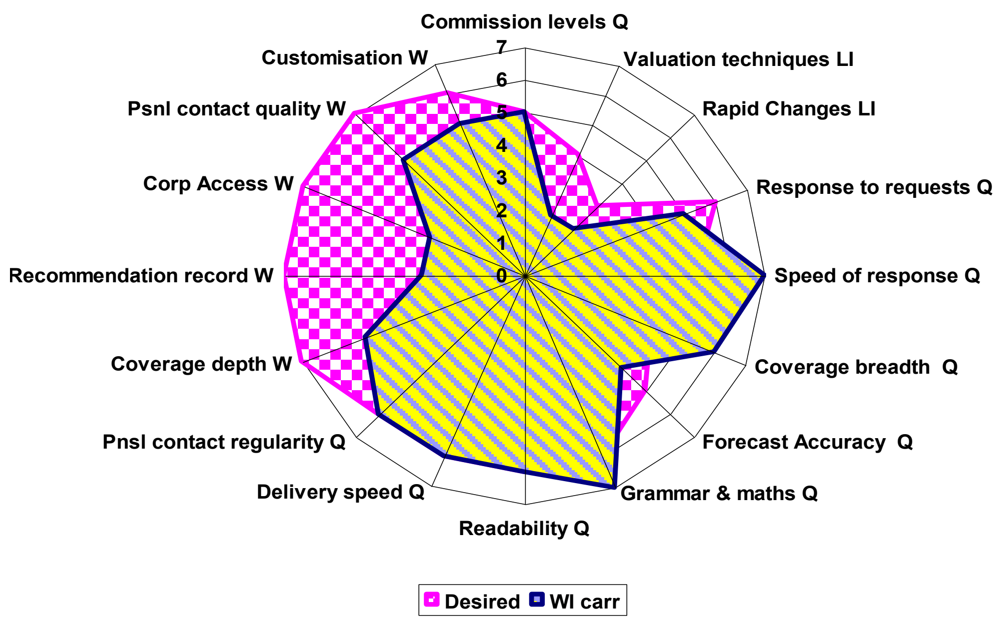

Figure 8.2 Service Shortfalls against Industry Importance

Adopted from Russell (2000)

After an operation has measured its performance by using the five performance indicators (partial measures), operations managers need to assess whether performance is good, bad, or indifferent by comparing the current performance with some standards. As discussed in the introductory section of this chapter, there are four types of performance standard commonly used by organisations:

- **Historical standards**; this type of standard compares current and past performance. These show whether the organisation is getting better or worse, but give no indication of whether performance should be regarded as satisfactory.

- **Target performance standards**; which are set arbitrarily to reflect some level of performance, which is regarded as appropriate.

- **Competitive performance standards**; which compare performance against competitors' performance. The advantage of competitor performance standards is that they relate performance directly to competitive ability.

- **Absolute performance standards**; which compare performance against its theoretically perfect state. Although the target level may never be achieved it can provide motivation and direction.

Although using the above standards has been proven to work in practice for the majority of the organisations, some organisations compare their operations with those of other companies using the approach of *benchmarking*.

The principles and stages of benchmarking

Xerox Corporation (www.xerox.com) used in 1979 the term '*competitive benchmarking'* to describe a process used by the manufacturing function to revitalise itself by comparing the features, assemblies and components of its products with those of competitors (Camp, 1989). Since Xerox first used the term it has broadened in meaning. Benchmarking is no longer:

- restricted to the manufacturing function – its applicability to other functional areas is now recognised (i.e., purchasing, maintenance, etc)

- confirmed only to manufacturing organisations – it has been used in services (i.e., American Express (www.americanexpress.com), Disney World (www.disney.com), etc)

- practised only by experts and consultants – benchmarking exercises often involve a variety of staff (i.e., marketing, engineering, sales, etc)

For example, Federal Express's (www.fedex.com) slogan is "People, Service, Profits", and its treatment of employees, including its no layoff policy, is viewed as a TQM model or **benchmark** (standard) that other companies try to copy (Russell & Taylor, 2000).

But what is benchmarking? For Stevenson (1999), benchmarking is "the process of measuring an organisation's performance on a key customer requirement against the best in the industry, or against the best in any industry" (p. 509). For Russell and Taylor (2000), benchmarking is "comparing a product or process against the best-in-class product" (p. 190), or is "measuring current performance against where a company wants performance to be" (p. 374). Simply stating it, the idea of benchmarking is to develop a target at which to shoot and then develop a standard or benchmark against which to compare your performance. Although Xerox's benchmarking process is more accurate and involves five phases and 10 steps (see Slack et al. 2000: 603), through which benchmarking can be achieved, the steps for developing benchmarking are generally five. These are:

- Determine what to benchmark
- Form a benchmark team
- Identify benchmarking partners
- Collect and analyse benchmarking information, and
- Take action to match or exceed the benchmark.

In the ideal situation, you find one or more similar organisations that are leaders in the particular areas you want to study. Then you compare yourself against them. The company need not be in your industry. Indeed, to establish world-class standards, it may be best to look outside your industry. If one industry has learned how to compare via rapid product development for example, while yours has not, it does no good to study your industry. Benchmarks often take the form of "best practices" found in other organisations. Benchmarks can and should be established in a variety of areas and according to Slack et al. (2000) there are various types of benchmarking.

Internal benchmarking: is the comparison between operations or parts of operations, which are within the same total organisation.

External benchmarking: is the comparison between operations, which are parts of different organisations.

Non-competitive benchmarking: is a comparison against operations, which are not direct competitors.

Competitive benchmarking: is a comparison against operations, which are direct competitors.

Performance benchmarking: is a comparison between the levels of achieved performance in different operations.

Practice benchmarking: is a comparison between an organisation's operations practices, and way of doing things, and those adopted by another operation.

In general, the objective of the various types of benchmarking is usually to investigate whether something can be learned from other organisations or from within the same total organisation. More specifically, however, there are three basic reasons why companies do perform benchmarks. These are:

- partly to determine how well an organisation is performing
- partly to help set performance standards, and
- partly to help identify new ways of doing things (new practices)

Activity 8.1

The 5W2H approach

Asking questions about the current performance can lead to important insights about why the current performance isn't meeting standards as well as it could, as well as potential ways to improve it. One approach to investigate poor performance is named the **5W2H** (5 "w" words and 2 "h" words) approach.

The 5 "w" words are: What? Why? Where? When? And Who? and the 2 "h" words are: How? And How much?

In your department use the **5W2H** approach to improve performance for at least *two key performance indicators*.

Source: Robinson (1991:246)

The importance-performance matrix

In chapter 2 we have introduced the idea of *order-winning* and *order-qualifying* factors. For the purpose of illustrating the importance-performance matrix we have also to be aware of the *less important competitive* factors. **Less important competitive** factors are those, which are relatively unimportant compared to the other two.

In terms of customer needs and preferences discussed in the introductory section of this chapter, it is often useful to categorise performance objectives according to whether they are:

- Order-winning criteria: those factors which directly win business for the operation

- Order-qualifying criteria: those factors that are may not win extra business for the operation, but can cause the operation to lose business if performance falls below a certain level.

- Less-important factors: those factors, which are relatively unimportant to the business.

Extra discrimination can be achieved by breaking these down into three, three-point scales, representing strong, medium and weak positions.

In terms of the performance and activities of competitors, if an operation is *not* as good as, or better than its competitors, it will not win business. Hence, achieved performance can be assessed using a three-point scale – better than, the same as, or worse than. Again more discrimination can be introduced by breaking each of these three categories down into three sub-categories.

Having determined the customer needs and preferences and the performance and activities of competitors, the priority for improvement, which each competitive factor should be given can be assessed from a comparison of their importance and performance (Slack et al. 2000). This can be illustrated on an importance-performance matrix, as shown in Figure 8.3.

As shown in Figure 8.3, the importance-performance matrix is divided into zones of improvement priority. The straight line (line AB) is the '*lower bound of acceptability'*. This is the boundary between acceptable and unacceptable performance. Below the line the performance is unacceptable and there is clearly need for improvement. Above this line there is no immediate urgency for any improvement. If performance falls into the *urgent action* zone, there is clearly need for urgent action otherwise the operation (organisation) will not win business. If performance falls in the *excess zone* it is clear evidence that the operation is overperforming on competitive factors that are less important to customers resulting in not winning business. (Note that resources are wasted if the performance falls into the *excess zone.*)

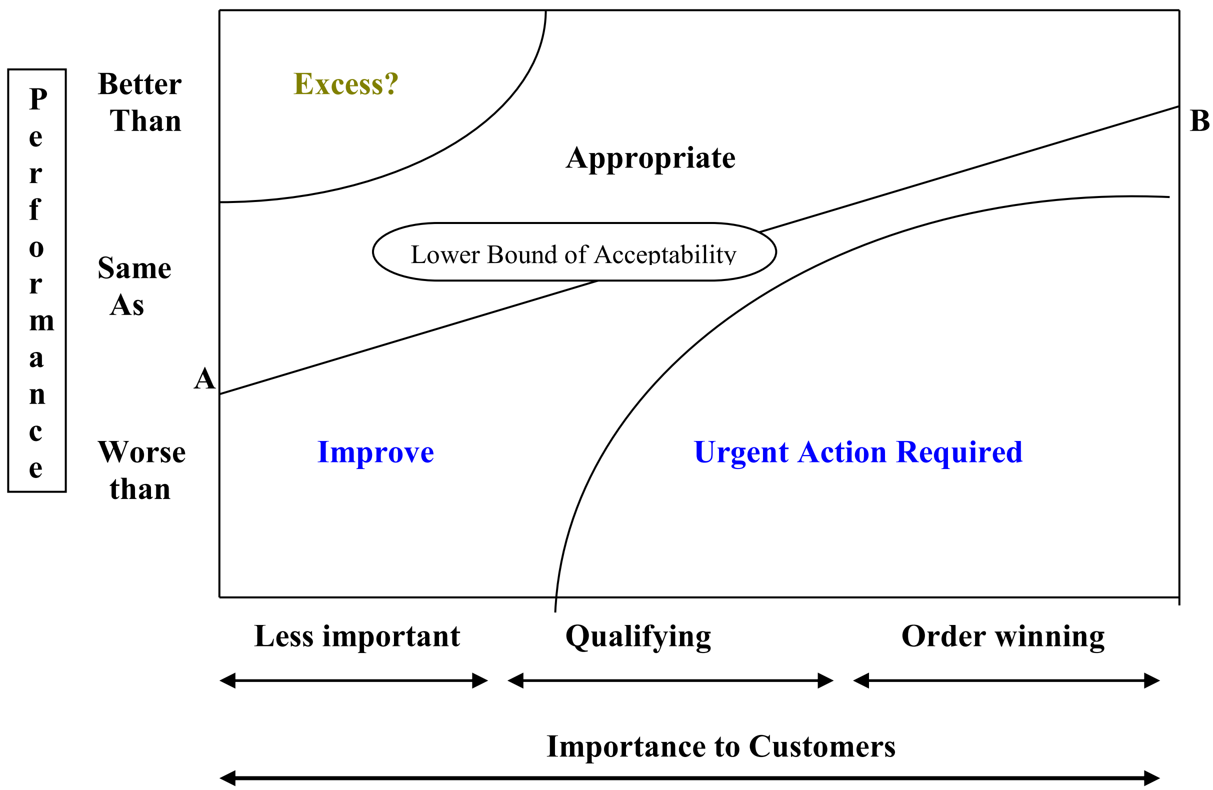

Figure 8.3 Importance-Performance Matrix

It is clear from the importance-performance matrix that the matrix helps identify:

- whether performance is satisfactory (the appropriate zone)
- whether performance needs improving (the improve zone)
- whether performance needs improving quickly (the urgent action zone), and
- whether performance is better than necessary (the excess zone).

Concluding, the importance-performance matrix is a valuable tool for two reasons: (i) It helps to discriminate between many factors, which may be in need of improvement. (helps to determine priorities of improvement.), and (ii) the exercise gives purpose and structure to the debate on the improvement priorities.

Once the priority of improvement has been determined, an operation should consider the approach it wishes to take to the improvement process. An organisation's approach to improving its operation can be characterised as lying somewhere between the two extremes of '*pure*' *breakthrough improvement* and '*pure*' *continuous improvement*.

Continuous and 'breakthrough' improvement strategies

There are two basic improvement strategies namely *continuous* and *breakthrough*.
For many years, the U.S.A. ***Malcolm Baldrige National Quality Award*** has defined continuous improvement as referring to both **continuous improvement** and **'breakthrough' improvement.**

Continuous improvement

Continuous improvement is a philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs.

The major advantage of this philosophy is that small step can follow small step after small step. It is the "go, go, go" approach to improvement as shown on Figure 8.4. The size of the step is not important. What matters is that **kaizen** (often used for continuous improvement) is an ongoing process, hence maintaining momentum is the key.

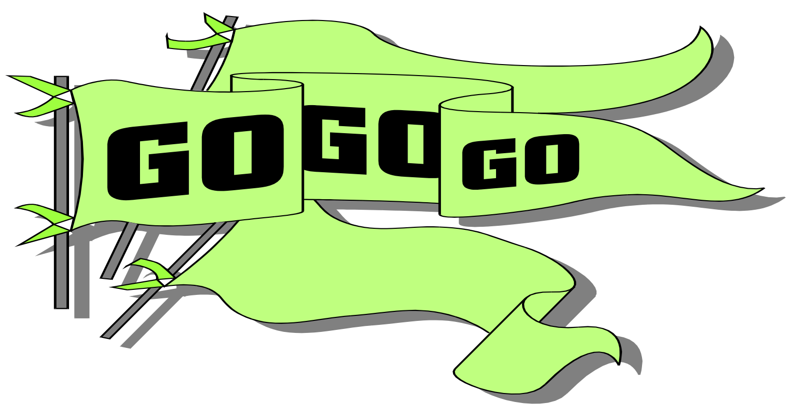

Figure 8.4 'Go, Go, Go'Approach to Improvement

As discussed earlier in the introductory part of this chapter, the Japanese use the word *Kaizen* to describe an ongoing process of unending improvement – the setting and achieving of ever-higher goals. In the U.S.A., **Total Quality Management** (TQM), **zero defects**, and **six-sigma** are used to describe such efforts. Whatever word or phrase is used, continuous improvement is gradual and constant and often utilises collective group-based problem solving. It does not focus on radical changes but rather attempts to develop an ingrained momentum of improvement. A typical process of continuous improvement is the one described by Deming **plan-do-study-act** (PDSA) cycle (Slack et al. 1998). This process is shown in Figure 8.5. The stages of the PDSA process are described below.

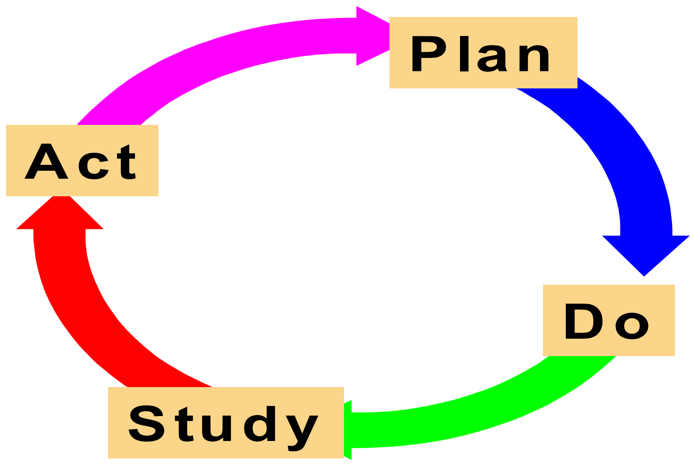

Figure 8.5 The Deming Wheel, or PDSA Cycle

Plan – In this first stage of the Deming Wheel, a process or situation is studied, identifying problems and planning how to solve them. This is where customer expectations are determined and goals to measure quality improvement are established.

Do – In this stage, the plan is implemented on a test basis, improvement is measured, and the results are documented.

Study – This stage was originally called the "check" stage, which is why the cycle sometimes is called the **plan-do-check-act**. Deming changed this to "study" in 1990 to reflect a more thorough analysis of the plan than a simple check. In this stage, the plan is assessed to see if it is achieving the goals established in stage 1, and to see if in the mean time any new problems have developed.

Act – In the final stage, the plan is implemented and the quality improvement is made part of the normal operation. The process then returns to stage 1 to start the cycle over again to identify new quality problems and develop plans to solve them. In reality, continuous improvement is a commitment to a quality management program.

Breakthrough improvement

On the other hand, **breakthrough** (innovation-based) improvement involves major changes in the way the operations work. As discussed in the introductory section of this chapter, researchers and practitioners agree that a 'breakthrough' improvement can be implemented using the process of **reengineering**, which focuses on the **radical redesign** of the business processes to achieve **dramatic** improvements in **critical measures** of process performance (Besterfield et al. 1999). Reengineering is the total redesign of a process (Russell & Taylor, 2000). The process of reengineering is usually called **Business Process Re-engineering** (BPR). BPR is most successful in organisations that can articulate a clear vision and strategic motivation for change, listen without bias to their customers, view their system as a set of processes overlapping functional areas, and rethink and simplify how value is provided to their customers.

The business process re-engineering approach

Business process re-engineering (BPR) means **dramatic change** in the way an organisation works and does things. A term coined by Hammer & Champy (1994), BPR is a "*Fundamental Rethinking and radical redesign of business processes to achieve dramatic improvements in critical measures of performance (cost, quality, capital, service and speed).*

Business Process Re-Engineering is not a one off change which the organisation implements and then forgets about. *"Re-Engineering is like fighting a war against an organisation's antibodies. The only way to win the war is to wear the enemy out. You have to keep beating the drum. The moment you ease up you have lost the battle. Re-Engineering is about trying and trying once again. It often takes a couple of trials to succeed."* (MIS Quarterly, September, 1994).

The basic principles of BPR:

- Rethink business processes in a cross-functional manner, which organises work around the natural flow of information (or materials or customers). This means organising around outcomes of a process rather than the tasks, which go into it.

- Strive for dynamic improvements in the performance by radically rethinking and redesigning the process.

- Have those who use the output from a process to perform the process. Check to see if all internal customers can be their own suppliers rather than depending on another function in the business to supply them.

- Put decision points where the work is performed. Do not separate those who do the work from those who control and manage the work.

Although it has been recognised that BPR is essential for radical business improvements, BPR is not without its critics. Four criticisms in particular appear to have some validity (Slack et al. 2000).

- By its nature, BPR looks only at work activities rather than at the people who perform the work. Because of this, people become 'cogs in a machine'. BPR merely 'oils the wheels' of this destructive machine.

- BPR is often treated as the latest management fad by some managers and as a cure-all for every problem. It is like, say the critics, attempting major surgery on every ailment even those which would cure themselves naturally with some simple physiotherapy.

- BPR is merely an excuse for getting rid of staff. Companies wishing to 'down-size' (that is, reduce numbers of staff within an operation) are using BPR as an excuse. This puts the short-term interests of the shareholders of the company above either their longer-term interests or the interests of the company's employees.

- A combination of radical redesign together with downsizing can mean that the essential core of experience is lost from the operation. This leaves it vulnerable to any environmental changes since it no longer has the knowledge and experience of how to cope with unexpected changes.

Finally, continuous improvement and BPR are not mutually exclusive and it is possible to combine the two within a single operation. Therefore, operations managers should be aware that there are differences between them. Table 8.1 summarises these differences.

Table 8.1 The Difference between Breakthrough and Continuous Improvement

	Continuous Improvement	BPR Innovations
Level of Change	Incremental	Radical
Starting Point	Existing Process	Clean Slate
Frequency of Change	One-time/Continuous	One-time
Time Required	Short	Long
Participation	Bottom-Up	Top-Down
Typical Scope	Narrow, within functions	Broad, cross-functional
Risk	Moderate	High
Primary Enabler	Statistical Control	Information Technology
Type of Change	Cultural	Cultural/Structural

As Table 8.1 shows, continuous improvement is less ambitious, at least in the short time. It stresses adaptability, teamwork and attention to detail. It is not radical, rather it builds upon the wealth of accumulated experience within the operation itself, often relying on the people in the operation to improve it.

On the other hand, BPR (breakthrough improvement) places high value on creative solutions. It encourages free thinking and individualism. It fosters an approach, which does not accept constraints on what is possible.

Activity 8.2

Dramatic Process and Quality Improvement Group Exercise

A stock-broking business headquartered in Athens, Greece, experiences quality ratings that are both deplorable and dropping. Indeed, it is worse than any of the company's other operations. To complicate matters, labour relations are difficult and moral low, resulting in high turnover and absenteeism. The new manager, who has been sent in to straighten things out, believes that the business will be closed unless dramatic process and quality improvements are made. Quality has become too important a factor in the stock-broking industry.

How can the manager turn this business around, build a quality process, and instil quality into the workforce? Discuss in about 150 words.

Common techniques for process improvement

All the techniques described in this chapter can be regarded as 'improvement' techniques because they attempt to improve some aspects of the performance of an operation. As discussed in the introductory section of this chapter, there are various tools and techniques that are particularly useful for improving an operation generally (Slack et al. 1998). Some of the most popular tools and techniques for identifying the cause of quality problems and improving the operation are **input-output analysis**, **flow charts**, **scatter diagrams**, **cause-effect diagrams**, **pareto diagrams**, and **why-why analysis**.

Input-output analysis: the purpose of the input-output analysis is to reach an agreed understanding of the operations function of whichever part of the organisation the problem is set in. It is not intended that input-output graphs give any specific answers to a problem, but it provides a useful 'way in' to improvement.

Three tasks have to be completed to build an input/output model:

- the input to and outputs from the process have to be identified
- the source of the inputs and the destination of the outputs have to be identified, and
- the requirements of the internal customers who are served by the outputs of the process have to be identified.

Flow charts: a flow chart or process diagram is a diagram of the steps in a job, operation, or process. It enables everyone involved in identifying and solving quality problems to have a clear picture of how a specific operation works and a common frame of reference. It also enables a process improvement team to understand the interrelations of the departments and functions that constitute a process. This helps focus on where problems might occur and if the process itself needs fixing. Development of the flowchart can help identify quality problems by helping the problem solvers better understand the process and hence improve performance. A typical process flow chart is shown in Figure 8.6 below.

Process Flow Chart Example

SUBJECT: Request tool purchase			
Dist (ft)	**Time (min)**	**Symbol**	**Description**
		● ⇨ □ D ▽	Write order
		○ ⇨ □ ◆▽	On desk
75		○ ➔ □ D ▽	To buyer
		○ ⇨ ■ D ▽	Examine

O = Operation; ⇨ = Transport; □ = Inspect;
D = Delay; ▽ = Storage

Figure 8.6 Typical Process Flow Chart

Adopted from Adapted from Heizer & Render (1999)

Scatter diagrams: Scatter diagrams are quick and simple method of identifying whether there appears to be a connection between two sets of data (i.e., correlation). (Note that the higher the correlation between two variables, the less scatter in the points; the points will tend to line up. Conversely, if there were little or no relationship between two variables, the points would be completely scattered.) It is important to note that scatter diagrams only indicate that there may be some connection, they do not demonstrate cause and effect. The cause and effect diagrams can distinguish the cause and effect of any connection.

Cause-effect diagrams: A typical cause and effect diagram is shown in Figure 8.7. A cause and effect diagram offers a structural approach to the search for the possible cause(s) of a problem. It is also known as a **fishbone diagram** because of its shape, or an *Ishikawa diagram*, after the Japanese professor who developed the approach to aid workers overwhelmed in problem solving by the number of possible sources of the problem.

This tool helps to organise problem-solving efforts by identifying *categories* of factors that might be causing problems. Often this tool is used after brainstorming session by asking what, when, where, how and why type questions.

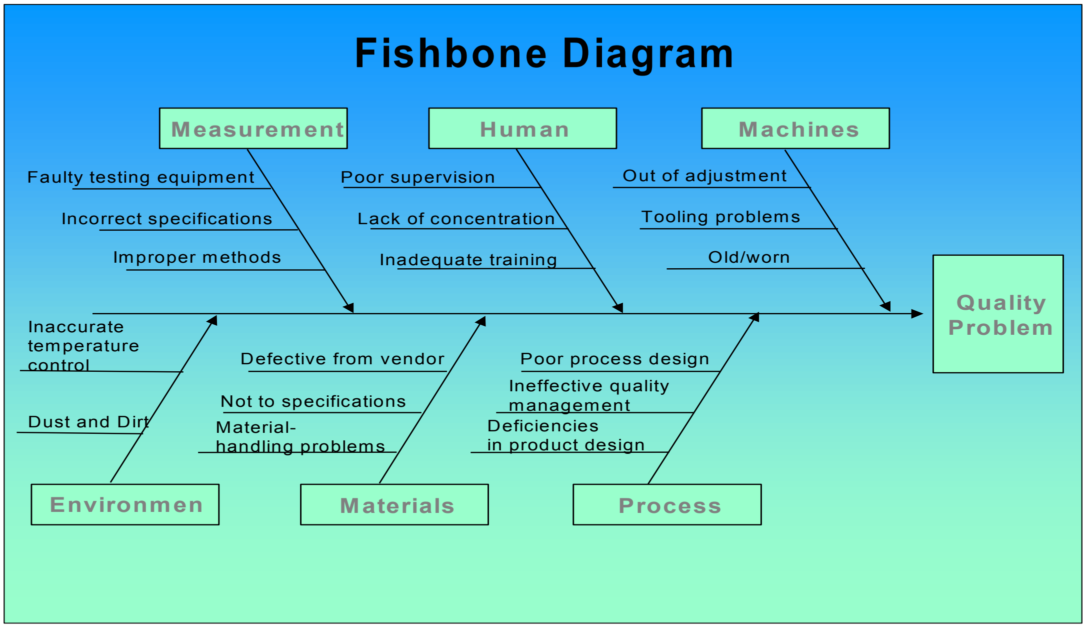

Figure 8.7 Typical Cause-effect diagrams

Adopted from Russell & Taylor, III (2000: 115)

Pareto diagrams: the quality expert Joseph Juran devised Pareto diagrams in the early 1950s. He named this tool after a nineteenth century Italian economist, Vilfredo Pareto, who determined that a small percentage of the people accounted for most of the wealth. Pareto analysis can be applied by tallying the number of defects for each of the different possible causes of poor quality in a product or service and then developing a frequency distribution from the data. The frequency distribution, referred to as a Pareto diagram, is a useful way of distinguishing between what is important and what is less important. They focus on identifying which problem occurs frequently. Experts usually say that 80% of the problems may be attributed to 20% of the causes. A typical Pareto diagram is shown in Figure 8.8 below.

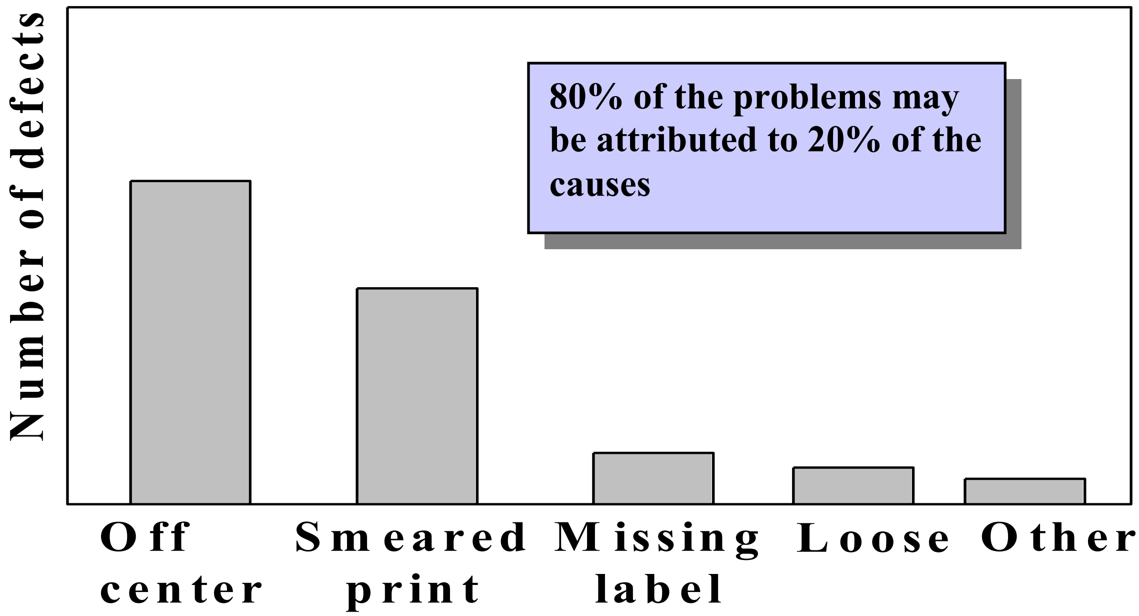

Figure 8.8 Typical Pareto Diagram

Adopted from Heizer & Render (1999)

Why-why analysis: Why-why analysis is a simple questioning technique designed to help identify what is at the root of an issue. The technique starts by stating the problem and asking **why** that problem has occurred. Basically the process involved asking why, until no more "whys" can be asked.

Activity 8.3

Techniques for Process Improvement

Your are the manager of a Pizza Hut takeaway/home delivery service in the CBD area of Dubai, United Arab Emirates and you often receive complaints centred on four defects: a missing item, spills/mixed items, unacceptable taste, and improperly sealed packages. Which technique(s) should you employ to improve the quality of service? Explain in about 150 words.

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. Pareto charts graphically show the relationship between two variables. **False**

2. Of the techniques for process improvement, the one, which gives a clear picture of how a specific process works is called a process flowchart. **True**

3. Reengineering is something new and untested. **True**

4. Reengineering is the total redesign of a process. **True**

5. The six process improvement tools presented in this chapter are also known as the “magnificent six”. **False**

6. The three-stage process referred to as the Deming Wheel consists of the following stages: Plant, Study, Act. **False**

7. Reengineering is typically chartered in response to a break-through goal. **True**

8. Continuous process improvement focuses on functions rather than business processes. **False**

9. Benchmarking refers to the procedure of dismantling and inspecting a competitor’s product or service to improve one’s own product or service. **False**

10. The importance-performance matrix helps to discriminate between many factors, which may be in need of improvement. **True**

11. The needs and preferences of customers are not taken into account by the importance-performance matrix. **False**

12. The fishbone diagram that graphically depicts different categories of problem causes is called a process control chart. **False**

MULTIPLE CHOICE QUESTIONS

1. Which of the following refers to comparing a product or process against the best-in-class product?
   a) cluster charting
   b) business process reengineering
   c) reverse engineering
   d) benchmarking

2. A document that makes use of circles, squares, triangles, and arrows to designate activities is known as a(n)
   a) assembly chart
   b) operations process chart
   c) bill of materials
   d) process flowchart

3. The man who named the Pareto diagrams was
   a) Walter Shewhart
   b) Joseph Juran
   c) Phillip Crosby
   d) W. Edwards Deming

4. The man who developed the plan-do-study-act (PDSA) cycle was:
   a) Walter Shewhart
   b) Joseph Juran
   c) Phillip Crosby
   d) W. Edwards Deming

5. Which of the following was not a factor in Japan's success in the 1970s?
   a) Japans concept of value
   b) growing media attention on quality
   c) increased availability of quality information to the consumer
   e) none of the above, they were all factors

SHORT-ANSWER QUESTIONS

1. Describe the zones of the importance-performance matrix. What is the value of the importance-performance matrix for a service organisation?

2. What is a benchmark? Who is responsible to carry out benchmarking in organisations?

3. List and describe the six process improvement tools presented in this chapter.

4. Contrast the approaches of breakthrough improvement and continuous improvement.

5. How can operations measure their performance in terms of the five performance objectives?

Summary

This chapter provided an introduction to operations improvement. In particular, it focussed on how managers can make their operations perform better and how they can measure their performance in terms of the five performance objectives of quality, speed, dependability, flexibility and cost. The chapter also examined how operations managers prioritise improvement of performance objectives. The chapter also investigated the stages of benchmarking and how benchmarking fits into the improvement framework. The performance-importance matrix together with the business process re-engineering philosophy was explored as part of the operations improvement strategy. Finally, the common techniques for process improvement were examined with an individual exercise.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to operations improvement

- ☐ The concept of operations improvement and its many facets

What is performance improvement?

- ☐ How operations can measure their performance?
  - ☐ The concept of polar diagrams
  - ☐ The four types of performance standards

- ☐ The principles and stages of benchmarking
  - ☐ The types of benchmarking
  - ☐ The 5W2H approach

- ☐ The importance-performance matrix
  - ☐ The zones of the importance-performance matrix

- ☐ Continuous and breakthrough improvement strategies
  - ☐ Continuous improvement
  - ☐ Kaizen
  - ☐ Deming plan-do-study-act cycle

- ☐ The business process re-engineering approach
  - ☐ The principles of business process re-engineering (BPR)
  - ☐ The difference between continuous improvement and BPR

- ☐ Common techniques for process improvement

- Input-output analysis
- Flow charts
- Scatter diagrams
- Cause-effect diagrams
- Pareto diagrams
- Why-why analysis

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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Chapter 9 Waiting line models for service improvement

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Waiting line models for service improvement

Learning outcomes

This chapter goes beyond the operations improvement issues covered in Chapter 8 and looks at how managers can reduce waiting time since waiting takes place in virtually every productive process or service. By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- understand the underlying factors that contribute to the formation of queues.
- recognise the elements of a waiting line problem in a real situation.
- understand what the differences between the different arrangements of service facilities are.
- understand the purpose of using different service facilities and the operating characteristics of a waiting line system.
- Be able to solve simple and complex waiting line problems.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Be familiar with the definitions of the 'queuing' theory and waiting line systems
- Understand the dynamics between the different components of a queuing system
- Examine the benefits of the different arrangements of service facilities
- Know when and how to use simple and/or more complex waiting line models
- Describe how waiting line models can be used to make managerial decisions
- Examine the strengths of simulations and develop excel spreadsheets to solve complex waiting line problems

What you will need

Suggested study time	Text Books	6 hours
	Activities and exercises	5 hours
Other resources:	Suggested readings	2 hours
	Total	13 hours

Introduction

Passengers arriving at a suburban rail ticket office during the morning peak commuter period frequently have to wait for service. There is one clerk who issues tickets and provides an information service for passengers. The manager has received complaints regarding the time passengers spend in the queue waiting to be served. People are often dealing with such an inconvenient experience in everyday life and everyone wishes that the 'queueing' problem did not exist. From the operations management perspective however, the questions that arise are:

- why should we (operations managers) reduce the waiting time?
- who is responsible in addressing the waiting line problem? and
- how it can be addressed?

A *waiting line* is one or more "customers" waiting for service. When customers go into a bank to take out a loan, cash a check, or make a deposit, take a car into a dealer for service or repair, or approach an airline counter for a boarding pass, they equate quality service with quick service (Russell & Taylor II, 2000). Therefore, the reduction of waiting time is an important aspect for operations management because providing quick service is a crucial element of quality customer service. Companies focus on reducing waiting time as a component of quality improvement. Moreover, by reducing waiting time organisations can provide faster service by increasing their *service capacity*, an important variable in operations management, which usually means adding more servers- that is more tellers, more mechanics or more checkout clerks. However, increasing service capacity has a monetary cost, and operations managers would like to know what are the trade-offs between the cost of improved services and the cost of making customers wait.

This chapter deals with some of those questions by analysing the components of a waiting line problem and describing how waiting line models can be used to make managerial decisions. Waiting line problems are analysed with a set of mathematical equations, which comprise a field of study known as **queuing theory**. Since the problem of 'waiting' is complex and varies from one situation to another, there are different queuing models and mathematical equations that deal with different types of waiting line systems. These models will be presented later in the chapter.

This chapter also recognises the elements of a waiting line problem in real-life situations and uses waiting line models to estimate the operating characteristics of a 'waiting line' system. It also discusses why waiting lines form and gives examples of waiting line systems in which the leaving customers from several queuing systems provide the arrivals for succeeding queuing systems.

Why queues form?

Queues or *waiting lines* form because people or things (i.e., detail parts, subassemblies, etc) arrive at the service function, or server, faster than can be served. This does not necessarily mean that the service operation is understaffed or does not have the capacity to serve the incoming customers. To the contrary, most organisations have the right serving capacity to handle their customers in the long run. If that is the case then, what are the causes of a waiting line problem?

Generally a waiting line forms because of a temporary imbalance between the demand for service – customers do not arrive at a constant, evenly paced rate – and the capacity of the system that provides the service – customers are not all served in an equal amount of time. In other words, in most real-life waiting line problems, the demand rate varies. Suppose that the checkout counters at the supermarket have enough clerks to serve an average of 100 customers in an hour, and in a particular hour 120 customers may arrive. During this particular hour there is a formation of a waiting line because: (i) there is an imbalance between the demand for service – 120 customers arrived – and the existing capacity of the system, which is set to 100 customers per hour, and (ii) each customer is not served in an equal amount of time.

Waiting lines can develop even if the time to process a customer is constant. For example, a subway train is computer controlled to arrive at stations along its route. Each train is programmed to arrive at a station, say every 20 minutes. Even with the constant service time, waiting lines develop while riders wait for the next train or cannot get on a train because of the size of the crowd at a busy time of the day. As a result, variability in the rate of demand determines the size of the waiting lines in this case. In general, if there is no variability in the demand or service rates and enough capacity has been provided, no waiting lines form.

From the examples discussed thus far one can argue that as the queues get longer, customers may leave without getting served resulting in a loss of revenue. Although queues could in practice be eliminated, operations managers would like to know what is the trade-off between the cost of reducing waiting time and the cost of making customers wait. Decisions about waiting lines and the management of waiting lines are based on the averages of customer arrivals and service times. But how can we accurately forecast customer arrivals and service times? How can we determine the length of the queue and its impact on the revenue of an organisation? These questions can be easily answered through the understanding of the queuing theory and its components.

Components of a queuing system

Queues consist of discrete or distinct items such as people, cars or components. Queuing theory is concerned with the mathematical analysis of waiting lines (queues). The objective of such analysis is to find out important characteristics of a queue such as the number of items in the queue, the average waiting time and the percentage of time that the service facility is busy. The components of a simple waiting line system are shown in Figure 9.1. As shown, the simplest type of waiting line system, which is known as **a single server with a single queue**, has four elements which are common to all situations:

- **source of customers** or **customer population**, that generates potential customers;
- **arrivals**, that is the rate at which customers arrive at the waiting line;
- **waiting line**, or '**queue**' of customers; and
- **server**, or **service facility** consisting of a person (or crew), machine (or group of machines), or both necessary to perform the service for the customers.

After the service has been performed, the served customers leave the system.

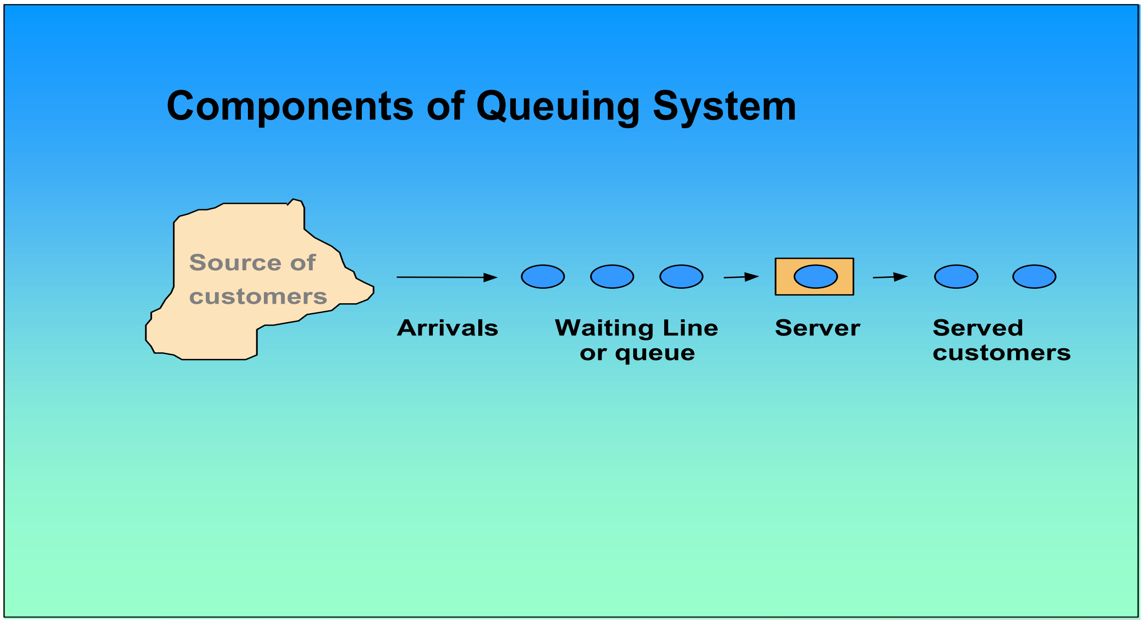

Figure 9.1 Components of a Simple Queuing System

Adopted from Russell and Taylor, III (2000: 771)

The components of this simplest type of waiting line system are described below in more detail.

Customer population: the population is the input source, e.g., customers, telephone calls, airline traffic, etc. A *finite population* is one in which the number of potential customers is limited, e.g., the number of people who own a private jet. On the other hand, the amount of traffic arriving at a busy intersection can be considered as unlimited, i.e., that is an *infinite population*.

In a *finite population* there is a countable number of potential customers and it is possible for all the customers to be served or waiting in the line at the same time. In other words, it may occur that there is not one more customer to be served. In the *infinite population* there is such a large number of potential customers that it is always possible for one more customer to arrive to be served. Therefore, the *infinite population* can generate waiting line problems through the rate at which customers arrive at the waiting line: Operations managers usually study the queuing problem that has resulted from such a population.

Arrival rate: the arrival rate is the "frequency at which customers arrive at a waiting line according to a probability distribution" (Russell & Taylor, III, 2000: 771). This rate can be estimated from empirical data. For example, if 1000 passengers arrive at a suburban rail ticket office during a 10-hour day, we could then say that the arrival rate averages 100 passengers per hour. Although we might be able to estimate the rate of arrivals by counting the number of passengers during a specific time period, we would not know exactly when these passengers would arrive. It might be that 230 passengers arrive during the 30 minutes of the morning peak commuter period and only 15 passengers arrive during another time. The challenge for operations managers is that arrivals are independent of each other and their arrival varies randomly over time. The variability of customer arrivals often can be described by a *Poisson* distribution, which specifies the probability that η customers will arrive in T time period (Krajewski & Ritzman, 1999). The arrival rate (λ) is most frequently described by a *Poisson* distribution (Russell & Taylor III, 2000). If the arrival rate of customers is greater than the service rate (μ) of the service facility, then the waiting line will continue to grow. In other words, $\lambda > \mu$.. In the business environment however, we assume that the service rate exceeds the arrival rate, $\lambda < \mu$, hence there is no formation of queues.

Waiting line, or '**queue**': a queue is a single waiting line. In real-life there are *infinite queues* and *finite queues*. *Infinite queues* can be of any length, whereas the length of a *finite queue* is limited. In waiting line systems customers are served in certain order known as the **queue discipline**. Most service systems are operating a *fist-come*, *first-served* (FCFS) priority facility at a constant speed. In other words, the customer at the head of the line has the first priority and the customer who arrived last has the lowest priority. In addition to FCFS priority, operations managers often employee other priority disciplines such as the:

- Earliest promised due date (EDD); and
- Shortest expected processing time (SPT).

Moreover, operations managers apply a rule that allows a customer of higher priority to interrupt the service of another customer, commonly known as the **preemptive discipline**. The classic example of the *preemptive discipline* is that of a hospital emergency room where the most life-threatening injuries receive immediate treatment regardless of their arrival.

The length of a queue depends not only on the arrival pattern but also on physical constraints such as storage space or room for waiting customers. If a queue has reached its capacity limit then arrivals cannot enter the system, e.g., a full up waiting room in a doctor's surgery, an issue that brings up the fourth component of the service system, the *service facility*.

Server, or **service facility**: service facility consists of a person (or crew), machine (or group of machines), or both, necessary to perform the service for the customers. A review of the literature revealed that operations managers can choose different arrangement of service facilities in order to satisfy the volume of customers and the nature of services performed. The arrangement of service facilities can be distinguished from the number of *channels* and the number of *phases* (Krajewski & Ritzman, 1999). *Channels* are the number of parallel servers in the waiting line service system; *phases* indicate the number of sequential servers that a customer must go through to receive service.

Arrangement of service facilities

As discussed earlier, service facilities consist of the people and the equipment necessary to perform the service for the customer. Customer service can be achieved utilising different arrangements of the service facilities. According to the literature, waiting line processes are generally grouped into four basic arrangements of service facilities:

- **Single-channel**, **single-phase** shown in Figure 9.2: in this arrangement customers from a single line go through one service facility, one at the time. An example of such arrangement might be a bank with only one teller clerk waiting on a single line of customers.

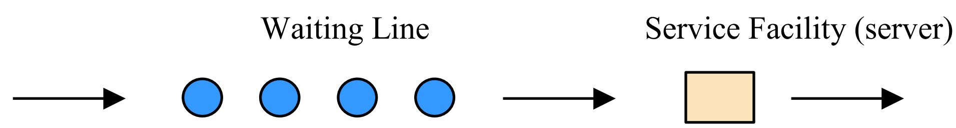

Figure 9.2 Typical Single-channel, Single-phase Facility

- **Multiple-channel**, **single-phase** shown in Figure 9.3: this arrangement is used when the demand is large enough to warrant providing the same service at more than one facility or when the services offered by the facilities are different. An example of such an arrangement is a bank with several teller clerks waiting on a single line of customers. In *the multiple-channel,* the first available server serves *single-phase* service facility customers.

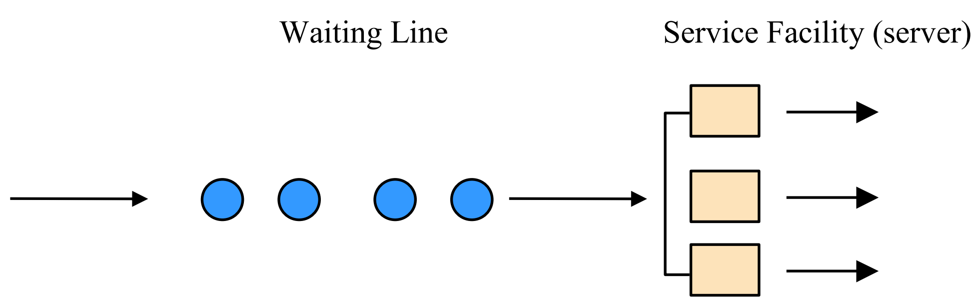

Figure 9.3 Typical Multiple-channel, **Single-phase Facility**

- **Single-channel, multiple-phase** shown in Figure 9.4: when patients go to a doctor for treatment they wait in a reception room prior to entering the treatment facility. Patients form a single line proceed from one service facility (initial check-up), to the next facility (treatment from a nurse), followed by treatment from a doctor. If there are several doctors and nurses, the process is a *multiple-channel*, *multiple-phase,* shown in Figure 9.5.

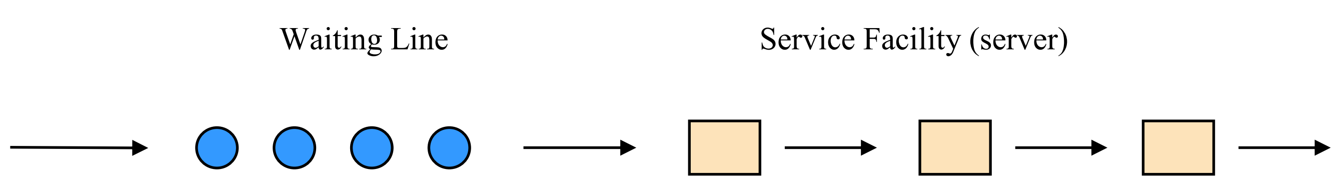

Figure 9.4 Typical Single-channel, Multiple-phase Facility

- **Multiple-channel, multiple-phase** shown in Figure 9.5: this arrangement occurs when customers can be served by one of the first-phase facilities but then require service from a second phase facility, and so on. An example of another multiple-channel, multiple-phase system is a manufacturing assembly in which a product is worked on at several sequential machines or operators at a workstation.

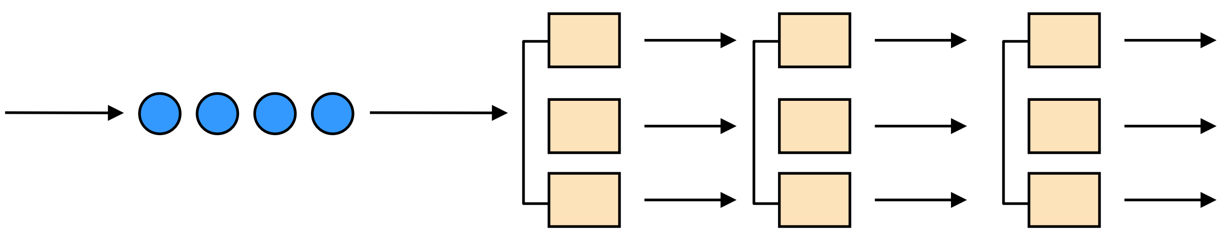

Figure 9.5 Typical Multiple -channel, Multiple-phase Facility

Examining the strengths/weaknesses of the four basic types of service facilities presented above one can argue that customers cannot be served if customers have unique sequences of required services. Under such circumstances a more complex arrangement is required, i.e., a mixed arrangement. In the mixed arrangement, waiting lines can develop in front of each service facility, as in a shop where each customised job may require the use of various machines and different routings. Queuing models, therefore, can become very complex. But the basic elements of the queuing theory can be used to analyse all queuing problems regardless of their complexity. Queuing theory assists operations managers to balance the gains that might be made by increasing the efficiency of the service system against the costs of doing so. In addition, operations managers should consider the costs of *not* making improvements to the system. Long waiting lines may cause customers to balk or renege. All in all, it has been recognised that the solution to queuing problems is a compromise between having excessive queues and an underutilised resource.

The question that arises then is; what is the optimum level of service? The cost relationship between the service costs and waiting line cost (see Figure 9.6) might be a good starting point in answering this question. As shown in Figure 9.6, there is an inverse relationship between service cost and the cost of waiting. As the level of service increases (introduction of additional servers), the cost of service goes up. On the other hand, as the level of service increases, the waiting cost decreases. The point at which the two curves intersect is being perceived to be the optimum level of service provided with a minimum cost (Russell and Taylor, III, 2000). (Note that other types of waiting costs exist, including the loss of production time and salary of employees, load and unload machines, and so forth.)

Operations managers therefore should be considering a number of operating characteristics of a waiting line system in order to understand the determinants of waiting lines thereby improving the service system through their decisions. These characteristics are presented in the following section of this chapter.

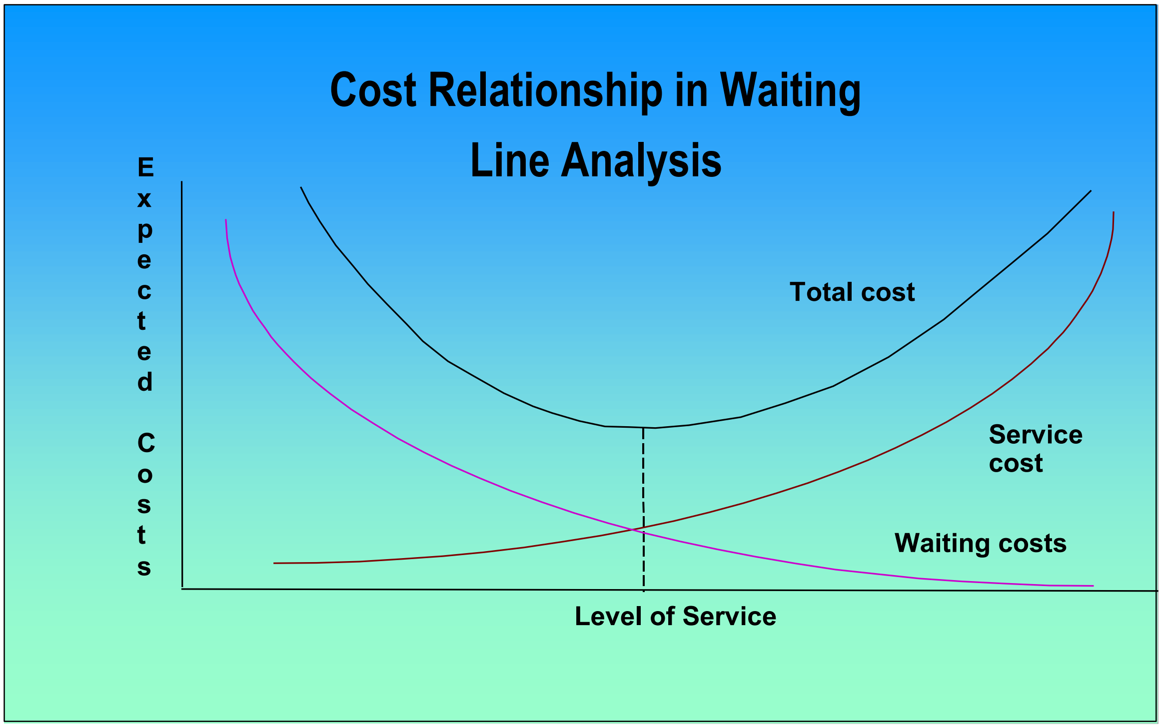

Figure 9.6 The Cost Relationship in Waiting Line Analysis

Adopted from Russell and Taylor, III (2000: 775)

Operating characteristics of a waiting line system

There are at least five operating characteristics, which should be considered for analysing a waiting line problem. These are:

- **Length of line**: the number of customers in a waiting line mean that there is either:
  - good customer service or too much capacity (short queues); and
  - low service efficiency or there is a need for more capacity (long queues).

  The challenge of operations management then is to balance the demand for service and the capacity of the system that provides the service.

- **Number of customer in the service system**: a large number of customers in the service system causes congestion and often results in customer dissatisfaction. Adding more capacity might solve the problem. More capacity however does not necessarily mean an efficient service system. The challenge for operations managers therefore is to increase the efficiency of the service system.

- **Waiting time in line**: Long lines do not necessarily mean long waiting times. There is a perception that if the waiting time is long the quality of service is poor. Operations managers should try to change the arrival rate of customers or change the arrangement of the service system to make long waiting times seem shorter than they really are. For example, during the morning peak time employees (customers) of a 30 storey building in Dubai, United Arab Emirates, frequently have to wait long for the elevator service. Customers in line to enter the elevator are entertained by large mirrors and informed about expected waiting times, which seems to help them tolerate the wait. Moreover, supermarkets locate magazines at the checkout counter, not only as a diversion while waiting but as potential purchases.

- **Total time in the service system**: the total elapsed time from arrival until having been served and exit the service system might be perceived by customers to be far too long indicating that the service is inefficient or lacks capacity. Under these circumstances the operations manager might consider changing the priority discipline, increasing productivity, or adjust the capacity (Krajewski & Ritzman, 1999).

- **Service facility utilisation**: ideally any facility should be utilised 100 percent. Because 100 percent utilisation is impossible in real-life situations, the goal of operations management is to maintain high utilisation of the service facility without affecting its operating characteristics.

Through the careful study of the above characteristics operations managers can improve the quality of service that requires waiting without actually incurring the cost of reducing waiting time. Placing a dollar value however on certain characteristics (the cost of the total time in the service system) is difficult. Thus, operations managers must weigh the cost of implementing the alternative service arrangement against the cost of *not* making the change. In order to understand the major determinants of waiting costs and how management can improve the service system by making decisions we need to analyse a problem using the simplest waiting line model.

Solving simple waiting line models

The simplest waiting line model involves a single server (service facility) and a single line of customers. Krajewski and Ritzman (1999) have suggested the following assumptions to accurately specify such a model.

- The customer population is infinite and all customers are patient. (In the context of waiting line problems, a patient customer is one who enters the system and remains there until being served.)

- The customers arrive according to a Poisson distribution, with a mean arrival rate of λ. (Poisson approximation involves treating the mean of the binomial distribution as the mean of the Poison; for more details see Stevenson, 1999:483-484.)

- The service distribution is exponential, with a mean service rate of μ.

- Customers are served on a first-come, first-served basis, and

- The length of the waiting line is unlimited.

These assumptions are used to describe the basic operating characteristics of a single-server, single-line model, which are:

- Probability that no customers are in the system (P_0);
- Probability of exactly η customers are in the system (P_η);
- Average number of customers in the service system (L);
- Average number of customers in the waiting line (L_q);
- Average time spent in the system, including service (W);
- Average time customers waiting in the line (W_q);
- Probability that the server is busy, that is the utilisation factor (ρ); and
- Probability that the server is idle and customers can be served (I).

The formulas to compute these characteristics were adopted from Russell and Taylor II (2000: 776-777) and are shown in Figures 9.7 and 9.8.

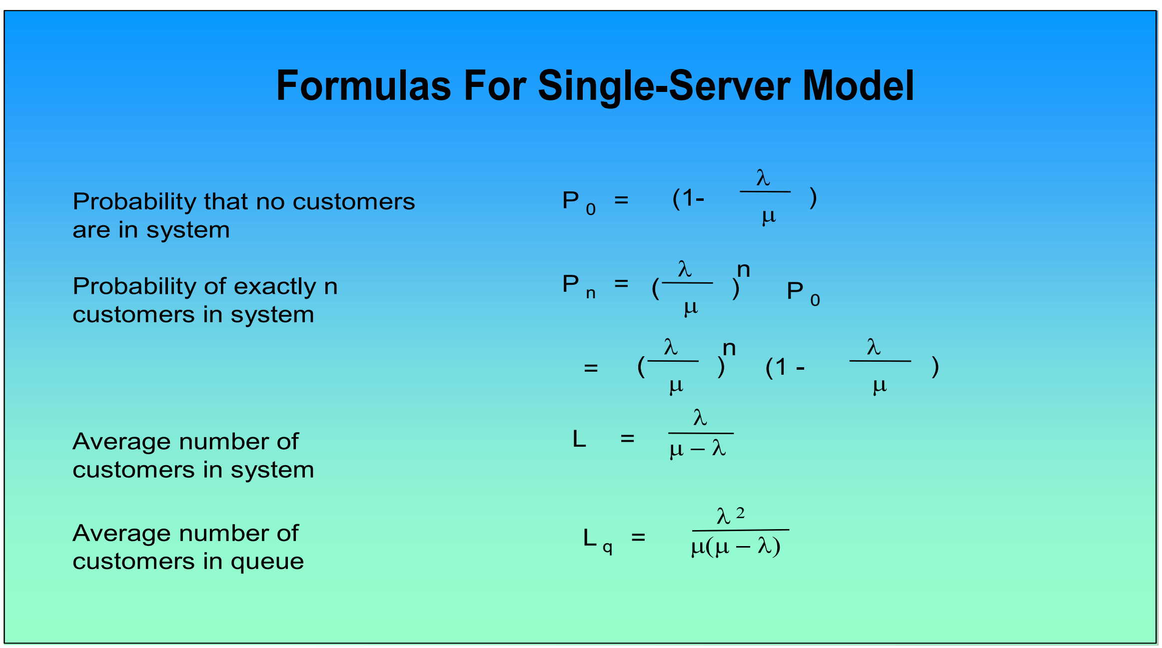

Figure 9.7 Formulas for P_0, P_η, L, and L_q

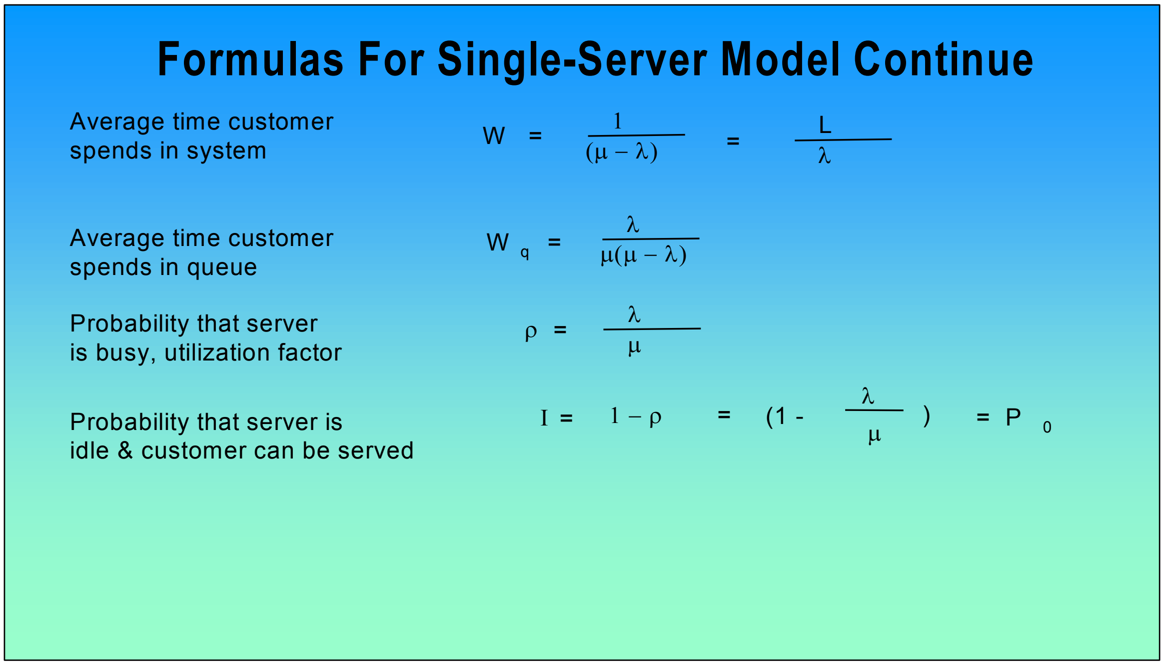

Figure 9.8 Formulas for W, W_q, ρ, and I

(Note that the notations of the various formulas were taken from Russell and Taylor II (2000).

In order to understand the interdependencies between the operating characteristics of a single-channel, single-phase system we are going to compute: (i) the utilisation of the checkout clerk (i.e., server is busy), (ii) number of customers in the system, (iii) number of customers in line, (iv) the time spent in the system, and (v) the waiting time in line of a real-life service facility. For the purpose of this exercise, we have chosen the supermarket and department store of Choithram in Jumeirah, Dubai, in the United Arab Emirates.

The manager of Choithram is interested in providing good service to female customers who shop in his store. Presently, the store has separate checkout counter for female customers. On average, 40 female customers per hour arrive at the counter, according to a Poisson distribution, and are served at an average rate of 45 customers per hour, with exponential service times.

In other words, the mean arrival rate $\lambda = 40$ and the mean service rate $\mu = 45$. Using the equations of Figure 9.7 and 9.8 we can compute:

(i) the utilisation of the checkout clerk is:

$$\rho = \lambda / \mu = 40 / 45 = 0.888 \text{ or } 88.8\%$$

(ii) the number of customers in the system is:

$$L = \lambda / (\mu - \lambda) = 40 / (45 - 40) = 40 / 5 = 8 \text{ customers}$$

(iii) the number of customers in line (queue) is:

$$L_q = \rho L = 0.888 (8) = 7.10 \text{ customers}$$

(iv) the time spent in the system is:

$$W = 1 / (\mu - \lambda) = 1 / (45 – 40) = 1 / 5 = 0.20 \text{ hours, or 12 minutes}$$

(v) the waiting time in line of Choithram's check-out counter for female customers is:

$$W_q = \rho W = 0.888 (0.20) = 0.18 \text{ hour, or 10.66 minutes}$$

In addition, the manager of Choithram is also interested to analyse the service rates and give answers to the following questions:

(a) What service rate would be required to have customers averaging only 8 minutes in the system?
(b) For that service rate, what is the probability of having more than 4 customers in the system?
(c) What service rate would be required to have only a 10 percent chance of exceeding 4 customers in the system?

Using the equations of Figure 9.7 and 9.8 once again we can compute:

(a) The service rate that would be required to have customers averaging only 8 minutes in the system is:

$$W = 1 / (\mu - \lambda)$$
$$8 \text{ minutes} = 0.133 \text{ hour} = 1 / (\mu - \lambda)$$
$$0.133 \mu - 0.133 (40) = 1$$

$$\mu = 47.52 \text{ customers / hour}$$

(b) The probability of having more than 4 customers in the system is:

$$P = 1 - \sum_{\eta = 0}^{4} P_\eta$$

$$P = 1 - \sum (1 - \rho) \rho^\eta \quad {}_{\eta = 0}$$

and $\rho = 40 / 47.52 = 0.84$

Then $P = 1 - 0.2\,(1 + 0.84 + 0.84^2 + 0.84^3 + 0.84^4)$
$P = 1 - 0.639 = 0.361$

Therefore there is a 36 percent chance that more than 4 customers will be in the system.

(c) The service rate that would be required to have only a 10 percent chance of exceeding 4 customers in the system is:

Using the same logic as in question (b), except that μ is now a decision variable.

$$P = 1 - (1 - \rho)\,(1 + \rho + \rho^2 + \rho^3 + \rho^4)$$

working through the mathematics we end up with

$$P = \rho^5$$

or $\rho = P^{1/5}$
if $P = 0.10$
then $\rho = 0.10^{1/5} = 0.63$ (i.e., utilisation rate)

Therefore, for a utilisation rate of 63 percent, the probability of more than 4 customers in the system is 10 percent. For $\lambda = 40$, the mean service rate must be:

$$40 / \mu = 0.63$$
$$\mu = 63.49 \text{ customers/ hour}$$

The manager of Choithram must now find ways to increase the service rate from 45 per hour to approximately 63 per hour. This can be achieved by:

- employing helpers (low cost labour) to help bag the groceries
- installing electronic point-of-sale equipment that reads prices from bar-coded information on each item, and or
- even considering changing the arrangement from a single-channel, single-phase system to a multiple-channel, single-phase.

Waiting line cost analysis – practical examples

The following waiting line problems have been adopted from Russell and Taylor II (2000) CD. Students are encouraged to solve/understand them and consequently interpret the results.

Problem 1

A bank drive-in teller window can serve an average of 25 customers per hour (Poisson distributed). Customers arrive in their cars at a rate (Poisson distributed) of 20 per hour. The driveway for the teller-window can only accommodate three cars (two waiting and one being served). Determine the average waiting time, the average queue length, and the probability that a customer will have to drive on.

Solution:

$$\lambda = 20, \qquad \mu = 25, \qquad M = 3$$

$$P_0 = \frac{1 - \lambda / \mu}{1 - (\lambda / \mu)^{M+1}} = \frac{1 - \frac{20}{25}}{1 - \left(\frac{20}{25}\right)^4}$$

$$= 0.34 \text{ probability of no cars}$$

$$P_3 = (P_0)\left(\frac{\lambda}{\mu}\right)^3 = (0.34)\left(\frac{20}{25}\right)^3$$

$$= 0.17 \text{ probability that a customer must drive on}$$

$$L = \frac{\lambda / \mu}{1 - \lambda / \mu} - \frac{(M + 1)(\lambda / \mu)^{M+1}}{1 - (\lambda / \mu)^{M+1}}$$

$$= \frac{\frac{20}{25}}{1 - \left(\frac{20}{25}\right)} = \frac{(4)\left(\frac{20}{25}\right)^4}{1 - \left(\frac{20}{25}\right)^4} = 1.23$$

$$L_q = L - \frac{\lambda(1 - P_m)}{\mu} = 1.23 - \frac{20(1 - 0.17)}{25}$$

$$= 1.20 \text{ customers waiting}$$

Problem 2

An airline terminal has several terminal gates at the Hartsfield International Airport in Atlanta. Under normal conditions the airline assigns one operator to the desk at each gate to serve passengers, including making seat assignments, checking passengers in, rerouting passengers, and solving customer problems. At one specific gate that is in constant use throughout the day, passengers arrive at the desk at the rate of 80 per hour according to a Poisson distribution. The airline agent is able to serve passengers in an average time of 0.667 minutes, exponentially distributed. Determine L, L_q, W, and W_q for this waiting line system, and indicate if it seems adequate to be perceived as quality service.

Solution:

$$\lambda = 80, \qquad \mu = 90$$

$$L = \frac{\lambda}{\mu - \lambda} = \frac{80}{10} = 8 \text{ customers}$$

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{(80)^2}{90(10)} = 7.1 \text{ customers}$$

$$W = \frac{1}{\mu - A} = \frac{1}{10} = 0.1 \text{ hr} = 6 \text{ minutes}$$

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{80}{90(10)} = 0.089 \text{ hr} = 5.33 \text{ minutes}$$

Passengers probably wait too long in the system for the service to be viewed as good.

Problem 3

Problem Statement:

The manager of a video game arcade has installed a new video game that makes use of virtual reality. The game requires a constant 2.6 minutes to play. Customers arrive to play the game at an average rate of 20 per hour (Poisson distributed). The manager wants to know the average length of the waiting line and the average waiting time for a customer to play the game.

Solution:

$$\lambda = 20, \qquad \mu = 23.1$$

$$L_q = \frac{\lambda^2}{2\mu(\mu - \lambda)} = \frac{(20)^2}{2(23.1)(3.1)} = 2.79 \text{ customers}$$

$$W_q = \frac{L_q}{\lambda} = \frac{2.79}{20} = 0.14 \text{ hr} = 8.37 \text{ minutes waiting}$$

Problem 4

Mary Richards is a full-time academic tutor for the State University football team. She has 10 players assigned to her for tutoring. A player visits her for tutoring an average of every 16 hours (assuming a 40 hour week), exponentially distributed. When a player visits, she spends an average of 1.5 hours with him. She is able to tutor only one player at a time, and players study while they are waiting. Determine the percentage of time Mary is busy tutoring and how long a player must wait to see her. Does the system seem adequate?

Students should try to solve problem using the mathematical equations of Figure 9.7 and 9.8.
Solution (computer solution):

$$\lambda = 0.625 / hour, \ \mu = 0.67 / hour, \ N = 10$$
$$L_q = 1.177 \text{ players waiting}$$

$L = 1.93$ players in the system

$W_q = 2.33$ hours waiting

$W = 3.82$ hours in the system

Mary's utilisation rate seems reasonable, but the waiting time is probably excessive.

Activity 9.1

Sid Das and Sons Brick Distributors

Sid Das and Sons Brick Distributors currently employ one worker whose job is to load bricks on out-going company trucks. An average of 24 trucks per day, or 3 per hour, arrive at the loading gate, according to a Poisson distribution. The worker loads them at a rate of 4 per hour, following approximately the exponential distribution in his service times.

Das believes that adding a second brick loader will substantially improve the firm's productivity. He estimates that a two-person crew at the loading gate will double the loading rate from four trucks per hour to eight trucks per hour.

An analysis of the effect on the queue of such a change is presented below:

	NUMBER OF BRICK LOADERS	
	1	*2*
Truck arrival rate (λ)	3 per hour	3 per hour
Loading rate (μ)	4 per hour	8 per hour
Average number in system (L)	3 trucks	.6 trucks
Average time in system (W)	1 hour	.2 hour
Average number in queue (L_q)	2.25 trucks	.225 trucks
Average time in queue (W_q)	3/4 hour	.075 hour
Utilisation rate (p)	.75	.375
Probability system empty (P_0)	.25	.625

PROBABILITY OF MORE THAN κ TRUCKS IN THE SYSTEM

	PROBABILITY $n > \kappa$	
κ	*One Loader*	*Two Loaders*
0	.75	.375
1	.56	.141
2	.42	.053
3	.32	.020

Students should interpret the results by answering the following questions:

1. How long does it take to load a truck in the proposed system?

2. What percentage of the time is the loader busy in the existing system?

3. How many hours a day will the loaders be idle in the proposed system (assume an 8 hour working day)?

4. What is the probability that there will be more than three trucks either being loaded or waiting?

5. Given the situation described in the case study, what will be the characteristics of the queuing system in terms of the size of the population, the pattern of arrivals, the length of line and the service facility characteristics?

6. Truck drivers working for Sid Das and Sons earn $10 per hour on the average. Brick loaders receive about $6 per hour. Truck drivers waiting *in the queue or at the loading gate* are drawing a salary but are productively idle and unable to generate revenue during that time. What would be the *hourly* cost savings to the firm associated with employing two loaders instead of one?

Complex waiting line models

So far we have dealt with the simplest waiting line model which has one server for servicing customers (i.e., that is the *single-channel*, *single phase* waiting line model). With large number of customers in the service system it has been observed that a *single-channel, single phase* waiting line system causes congestion and often results in customer dissatisfaction. Therefore, a large number of operational waiting line systems include multiple servers. Waiting line models with multiple servers can be very complex. In this arrangement the service system has only one phase and there are *s* identical servers, as shown in Figure 9.3. The service distribution for each server is exponential, with a mean service time of $1/\mu$, and $s\mu > \lambda$. In other words, the total number of servers must be able to serve customers faster than they arrive. Under these conditions the average utilisation of the system is: $\rho = \lambda / s\mu$.

The probability that there are no customers in the system (all servers are idle) is given by the following equation (Krajewski & Ritzman, 1999).

$$P_0 = \frac{1}{\left[\sum_{n=0}^{n=s-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s\left(\frac{s\mu}{s\mu - \lambda}\right)}$$

The probability of exactly *n* customers being in the queuing system, $\mathbf{P_n}$**,** the probability of an arriving customers that must wait for service $\mathbf{P_w}$ (i.e., the probability that all servers are busy), and average number of customers in the system **L,** are computed by the equations of Figure 9.9 (Russell and Taylor II, 2000).

Probability of exactly n customers in system

$$P_n = \frac{1}{s!\, s^{n-s}} \left(\frac{\lambda}{\mu}\right)^n P_0, \quad \text{for } n > s$$

$$P_n = \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n P_0, \quad \text{for } n <= s$$

Probability an arriving customer must wait

$$P_w = \frac{1}{s!} \left(\frac{\lambda}{\mu}\right)^s \left(\frac{s\mu}{s\mu - \lambda}\right) P_0$$

Average number of customers in system

$$L = \frac{\lambda\mu \left(\frac{\lambda}{\mu}\right)^s}{(s-1)!\,(s\mu - \lambda)^2} P_0 + \left(\frac{\lambda}{\mu}\right)$$

Figure 9.9 Formulas for P_n, P_w, and L

Although equation P_0 takes far too long to compute manually and often the selected values of P_0 for the multiple-server model are given on tables, close examination of the above formulas reveals that the multi-server model equations are extensions of those already used in the single-server model. These new formulae may appear rather complicated, but they are quite simple to set up in an excel spreadsheet. Therefore, setting-up and simulating different operating scenarios might be useful when waiting line models become too complex. It is generally agreed that operations managers perform simulations for studying alternative solutions to the problem because:

- In many real-life operations the relationship between the variables being analysed is non-linear;
- In service operations there are too many variables and/or constraints to handle with optimising approaches;
- Simulation models conduct experiments fast without disrupting the real system;

- Simulation models can be used to estimate operating characteristic estimates in much less time than is required to gather the same operating data from a real system; this feature of simulations is called **time compression**; and

- Simulation models are useful in sharpening managerial decision-making skills through gaming. (Gaming also enables managers to experiment with new ideas without disrupting normal operations.)

Because simulations are powerful in assisting operations managers in making decisions we encourage students to develop the appropriate excel spreadsheets and solve the waiting line problems of the following activities. Help can be obtained from the Excel Models for Business and Operations Management written by Barlow (1999:312).

Activity 9.2

Pepsi Cola company in Dubai
Estimating idle time and hourly operating costs with a multiple-server model

The management of Pepsi Cola company in Dubai, United Arab Emirates, is concern about the amount of time the company's trucks are idle, waiting to be unloaded. The terminal operates with four unloading bays. Each bay requires a crew of two employees, and each crew costs AED 15 per hour. The estimated cost of an idle truck is AED 25 per hour. Trucks arrive at an average rate of three per hour ($\lambda = 3$), according to a Poisson distribution. On average, a crew can unload a semitrailer rig in one hour, with exponential service time. What is the total hourly cost of operating the system?

Activity 9.3

Grand Cineplex in Dubai
Estimating average utilisation and average time spent in the concession area

The Grand Cineplex operating in Dubai, United Arab Emirates, has three concession clerks serving customers on a first-come, first-served basis. The service time per customer is exponentially distributed with an average of 2 minutes per customer. Concession customers wait in a single line in a large lobby, and arrivals are Poisson distributed with an average of 81 customers per hour. Previews run for 10 minutes before the start of each show. If the average time in the concession area exceed 10 minutes, customers become dissatisfied.

(i) What is the average utilisation of each concession clerk?
(ii) What is the average time spent in the concession area?

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. The order in which customers are served is known as queue discipline. **True**

2. FCFS is the only queuing discipline used by operations managers. **False**

3. The source of customers to a waiting line is called customer population. **True**

4. Infinite queue is the waiting line that has a limited capacity. **False**

5. In a waiting line system where $\lambda > \mu$ there is no formation of queues **False**

6. If customers have unique sequences of required services, *single-phase, single channel* waiting line model is appropriate in solving waiting time problems. **False**

7. Simulating waiting line modes is useful *only* to large manufacturing organisation. **False**

8. FCFS rule of queuing discipline is appropriate in a hospital emergency room. **False**

9. '*Time compression*' means that simulation models can be used in sharpening managerial decision-making skills through gaming. **False**

10. Phases represent the number of parallel servers. **False**

MULTIPLE CHOICE QUESTIONS

1. _____________ is a single waiting line.
   a) finite population
   b) **queue**
   c) infinite population
   d) calling population

2. _____________ represent the number of parallel servers.
   a) **channels**
   b) phases
   c) queue disciplines
   d) steps in a process

3. A system whose performance characteristics attain a constant average value after a lengthy period of time is said to be
    a) in transition
    b) at optimum
    c) **in steady state**
    d) in decline

4. A personal computer with two CPUs is an example of a
    a) single-channel, single-phase system
    b) single-channel; multiple-phase system
    c) multiple-channel, multiple-phase system
    d) **multiple-channel, single phase system**

5. The probability distribution most often associated with the arrival rate is
    a) Normal
    b) **Poisson**
    c) Beta
    d) Negative exponential

6. The probability distribution most often associated with service times is
    a) Normal
    b) Poisson
    c) Beta
    d) **Negative exponential**

7. The probability $P_O = (1 - \lambda / \mu)$ represents ________________________________.
    a) the probability that a customer is in the queuing system.
    b) **the probability that no customers are in the queuing system.**
    c) the probability that a server is busy servicing an arrival.
    d) none of the above.

8. λ / μ represents the _______________________.
    a) arrival rate
    b) service rate
    c) mean service rate
    d) **utilisation rate**

9. Given an arrival rate of 20 and a mean service rate of 25 customers per hour, what is the probability that a customer will be served?
    a) 25%
    b) 80%
    c) **20%**
    d) 75%

10. _________________ occur with machinery and automated equipment.
   a) Variable service times
   b) Constant arrival times
   c) Variable arrival times
   d) **Constant service times**

SHORT-ANSWER QUESTIONS

1. For each of the following queuing systems, indicate if it is a single-or multiple-server model, the queue discipline, and if its customer population is infinite or finite:
   a. Hair salon
   b. Bank
   c. Laundromat
   d. Doctor's office
   e. Adviser's office
   f. Airport runway
   g. Service station
   h. Copy centre
   i. Team trainer
   j. Mainframe computer

2. Under what conditions can the basic single-server and multiple-server models be used to analyse a multiple-phase waiting line system?

3. Why do waiting lines form at a service facility even thought there may be more than enough service capacity to meet normal demand in the long run?

4. What types of waiting line systems have constant service times?

5. Discuss the relationship between waiting line analysis and quality improvement. What are the financial benefits, if any?

Summary

This chapter focused on operating systems of service organisations. The chapter looked at how operations managers can reduce waiting time since waiting takes place in virtually every productive process or service. In particular, it focussed on elements of a waiting line, the customer population, the arrival rate, service times, queue disciple and length, waiting line analysis and quality, and the single-channel, single-phase and multiple-channel, single-phase models. The chapter also discussed the waiting line cost analysis and solved real-life waiting line problems. Finally, the advantages of simulation in the context of operations management were examined.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel that you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to waiting line models and queuing theory

- ☐ The underlying reasons for the formation of queues

- ☐ Components of a queuing system
  - ☐ Source of customers
  - ☐ Arrivals and arrival rate
  - ☐ Waiting lines and/or queues
  - ☐ Service facilities

- ☐ Arrangement of service facility
  - ☐ Single-channel, single-phase facility
  - ☐ Multiple-channel, single-phase facility
  - ☐ Single-channel, multiple-phase facility
  - ☐ Multiple-channel, multiple-phase facility
  - ☐ Mixed arrangement

- ☐ Operating characteristics of a waiting line system
  - ☐ Length of line
  - ☐ Number of customers in the service system
  - ☐ Waiting time in line
  - ☐ Total time in the service system

- ☐ Solve simple waiting line models
  - ☐ Assumptions of the simple waiting line model
  - ☐ Mathematical equations for the simple waiting line model

  - Practical examples of waiting line cost analysis

- Complex waiting line models
  - Mathematical equations for complex waiting line models
  - Waiting line models simulations exercises

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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Chapter 10 Project based management today

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Project based management today

Learning outcomes

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- relate project based management to operations.
- understand how projects originate.
- identify when project management is justified.
- understand features, principles and objectives of project management.
- describe the life cycle of a project.
- understand project organisational structures.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcomes stated above.

- Differentiate project management from operations management
- Define and originate a project and apply the four-phase model on it.
- Set out an overall management framework for a project and select its organisational structure
- Set simple performance measures for non complex projects at various stages
- Set up the rules for planning and control a project through its life cycle.

What you will need

Suggested study time	Text Books	5 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	2 hours
	Total	10 hours

Introduction

The planning of the 2000 Olympic Games in Sydney, Australia, exemplifies the complexities of managing large projects. Undertaking projects of any size (large or small) and the management of projects has been happening for as long as we are aware from our historical understanding. Just think about some of the great building projects around the world; for example, the pyramids, ancient cities, the Great Wall of China, skyscrapers, bridges, dams, and the Euro tunnel. What about the building, testing and use of airplanes, submarines, the space shuttle and landing on the moon? These are but a few of the many 'projects', which have been undertaken and completed through human endeavour. For much of our history though, many of these 'projects' were considered as work to be done; a job to complete; or a new endeavour. It is only in relatively recent times that 'project management' has become recognised as a central management discipline. Project Management has been developing as a distinct science since, the late 1950s, when operations research techniques such as Program Evaluation Review Technique (PERT) and Critical Path Method (CPM) were introduced to help manage major defence and petrochemical projects.

As the value of these techniques became recognised and as organisations increased pressure on delivery within scope, cost and time objectives, 'project management' responded with the development of:

- A Project Management Body of Knowledge "PMBOK" (www.pmi.org)
- Professional Institutions, Project Management Institute – PMI (US), Project Management Association - PMA (UK), International Project Management Association – IPMA (Europe), Australian Institute of Project Management – AIPM (Australia), and
- Globally recognised competencies.

The development of project management has been hastened by recognition that, operational and industrial management has been slow to respond to rapid technological change. In addition the organisational arrangements underpinning these management approaches are designed (Fayol, 1949a; 1949b) to:

- Divide work by specialisation
- Clearly define authority and responsibility, and
- Enforce a hierarchical command structure (single reporting line).

The rapid pace of change has meant organisations based on functional lines, cannot adjust quickly enough and needs an added or complementary process, which cuts through functional barriers.

With the information technology (IT) revolution of the 1970s, 1980s and 1990s, came an urgent need to mix technologies and outcomes to meet client demands. According to Turner (1999), most major projects or products require:

- Understanding of functions to be performed;
- Financial, Engineering;
- Integrated IT and communications; (it should be noted that managing a project involves much more than using IT and project management software (Rosenau, 1998));
- Life Cycle Operation Management of the asset, including its financial performance.

No longer can even a simple change management project be seen as just restructuring of the operations. Drucker (1992) says technologies are no longer discrete. They overlap and criss-cross each other. No industry or company can be fed out of one technological stream.

Therefore, Modern Project Management is seen now by most organisations as the driver of change, and as such it is a change delivery tool that middle and senior management ignore at their peril. The ability to draw organisational strength and depth of knowledge from every corner of the organisation, through a well managed project team is now established as a company-wide core competency by most organisations. Project management is the preferred vehicle for:

- Change;
- Introducing new projects; and
- Delivering client requirements.

In summary, project management fulfils two purposes: (i) it provides the technical and business documentation to communicate the plan and, subsequently, the status that facilitates comparison of the plan against actual performance, and (ii) it supports the development of the managerial skills to facilitate better management of the people and their projects(s) (Knutson & Bitz, 1991).

All in all, project management is a means by which to fit the many complex pieces of the project puzzle together. This is accomplished by dealing with both human and technical elements of the discipline of project management.

Brief history of project management

Although the first official recorded account of project management was in 1950s, there is evidence that some of the principles of project management have been incorporated into the management of the United States defence force activities as early as the 1930s. This does not mean that they were the first to undertake the management of projects. However, it seems they were the first to identify and classify techniques for managing projects as a dedicated management activity.

During the 1950s, the development and production of the Polaris ballistic missile by the United States Air Force was done using specific techniques of 'project management'. A technique commonly used for the planning, scheduling, and controlling of the Polaris missile project is known as the **Critical Path Analysis** (CPA). Dupont (www.dupont.com) also used this technique independently for the construction and overhaul of a chemical plant. Similar techniques were developed and used during the same period in Russia, France and the UK. In the UK, *CPA* was used for the overhaul of power stations, where it was credited with reducing overhaul time to 42 percent of the previous average time. Thus, project management became an accepted approach in delivering large, defence aerospace and construction endeavours.

Because the application of project management has demonstrated that groups of people can achieve higher levels of performance and productivity, professional associations emerged in the 1970s in response to the need for technical and terminology standardisation, to move this new management approach from an art to a science. About this time operations research techniques such as PERT/CPM were able to be computerised and computers with sufficient power to utilise these models became cheap enough to be used on projects.

As industry demands for more rapid delivery of outcomes has accelerated and time to market is seen as a competitive edge, an increased range of applications for project management became the key feature of the 1980s. The 1990s saw the emergence of more powerful desktop-based support and the consolidation of the Project Management Body of Knowledge (PMBOK) as the Global Standard. The Institute of Project Management (PMI) (www.pmi.org) headquartered outside Philadelphia, Pennsylvania, USA, aiming at building professionalism in project management, in 1996 has crated a first guide to the PMBOK. During that same year, the first PMI seminars and symposium was held in Atlanta, Georgia, USA, and had an attendance of 83 people.

Parallel competency standards were also evolved such as the Australian National Standards for Competency in Project Management. Standards of competence and a Global approach to project management is now accepted, throughout Europe, America and Australia. The terms, "managing projects" and "project based management" are now accepted in most technology based industries, as a delivery model for most major change management programmes.

The project management profession is now equipped with a Global frameworks of knowledge and competencies. The three defining standards for project management are now:

- The "Project Management Body of Knowledge" (PMBOK), developed by the Project Management Institute, (www.pmi.org);
- The "Australian National Standards for Competency in Project Management", developed by the Australian Institute of Project Management, (www.aipm.org); followed by the:

- The European Institute of Advanced Project and Contract Management (www.epci.org).

The future of project management will be developed in Chapter 11. The remainder of this chapter deals with concepts and tools of project management.

Definitions of project management

Project management, has many similar definitions, such as:

It is “a complex, non routine, one-time effort limited by time, budget, resources and performance specifications designed to meet customer needs” (Gray & Larson, 2000: 4).

Knutson and Bitz (1991: 2) defined project management as “a set of principles, methods, tools, and techniques for the effective management of objective-oriented work in the context of a specific and unique organisational environment”.

Moreover, Russell and Taylor, III (2000: 809) defined project management as “the management of the work to develop and implement an innovation or change in an existing operation. It encompasses planning the project and controlling the project activities, subject to resource and budget constraints, to keep the project on schedule”.

Similarly, Rosenau (1998: 15) states that successful project management must simultaneously satisfy the ‘triple’ constraint of a project, that is “performance specification, time schedule, and money budget”.

However, the most commonly accepted definition is, that set out in “A guide to the “Project Management Body of Knowledge —2000 Edition, [Project Management Institute (PMI) December 2000], as follows.

“Project management is the application of knowledge, skills, tools and techniques to a broad range of activities in order to meet the requirements of the particular project. Project management knowledge and practices are best described in terms of their component processes”.

These processes can be placed into five process groups:

- Initiating,
- Planning,
- Executing,
- Controlling, and
- Closing.

and nine knowledge areas:

- Project Integration Management,
- Project Scope Management,
- Project Time Management,
- Project Cost Management,
- Project Quality Management,
- Project Human Resource Management,
- Project Communications Management,

- Project Risk Management, and
- Project Procurement Management.

The project team manages the work of the project, and the work typically involves:

- Balancing competing demands for: project scope, time, cost, risk and quality;

- Satisfying stakeholders with differing needs and expectations; and

- Meeting identified requirements.

The term "project management" is sometimes used to describe an organisational approach to the management of ongoing operations. This approach treats various aspects of ongoing operations as projects in order to apply project management techniques to them.

Although the above definitions provide a good description of the project management discipline, in order to understand the underlying theme of project management, it is necessary to define the terms *Project* and *Management,* separately.

What is Project?

The term *Project* is associated with a unique set of objectives, e.g., a building, software package, plant or, indeed, an organisational change. The outcomes have to be achieved within a predetermined scope, cost limit (operating and capital) and time frame. A project is a once only or unique task usually carried out by a project team. This contrasts with a repetitive task for which a line manager or production manager is more clearly suited. Project Management will usually be from conception to completion and the handover of outcomes to line managers. This process is distinct from, say, a marketing manager, designer or financier who may have a role during one stage of the project only.

According to the Project Management Institute (2002) (www.pmi.org/projectmanagement), "a project is a temporary endeavour undertaken to achieve a particular aim. Every project has a definite beginning and a definite end". While projects are similar to operations in that both are performed by people, both are generally constrained by limited resources, and both are planned, executed and controlled, projects differ from operations in that operations are ongoing and repetitive while projects are temporary and unique.

Projects are created at all levels in an organisation. They may involve a single person or thousands. Their time spans vary greatly. They may involve a single department of an organisation or cross-organisational boundaries.

Project management can be applied to any project regardless of size, budget or timeline.

Some examples are:

- Developing a new product or service

- Designing a new vehicle
- Running a political campaign
- Building a bridge
- Sending a probe to Mars, and/or
- Setting up an e-commerce Internet site.

What is Management?

Again many loose definitions are available. However, the essential parts of the management function are:

- Leadership of a team

- Determination of team objectives

- Communication control of a team with its client or sponsor

- Comparison of achievement against set objectives

- Authority to change what a team is doing; and

- Resolution of conflict.

All in all, project management is 'the planning, scheduling, staffing and controlling of project activities to achieve project objectives'.

How do projects originate

For most organisations a Corporate Plan or Subset of this, say, a Business Plan will have determined the future needs for change, re-equipping, systems development or other investment strategies as part of the process of improving performance. A process of this nature is described in Figure 10.1 below.

If such a process does not exist, the Project Manager may have to reverse engineer the business framework e.g., start with the concept (idea) and create the business around it or develop the justification for the investment, within the organisations strategic objectives. Under these circumstances it is important for project managers to understand the relationship between '*venture*' and *project*.

A '**venture'** is defined as the development of an asset (building, system, piece of plant, new product, etc.) and the use of that asset to help in the achievement of an organisation's objectives and mission. A *venture* is considered to continue until the use of the asset ceases, at which time it may be replaced by a modification or a different asset. This would then be considered as a new and separate venture.

A venture is normally cash generating in some form, and its feasibility can be judged in the initial stages of analysis by discounted cash flow or similar techniques.

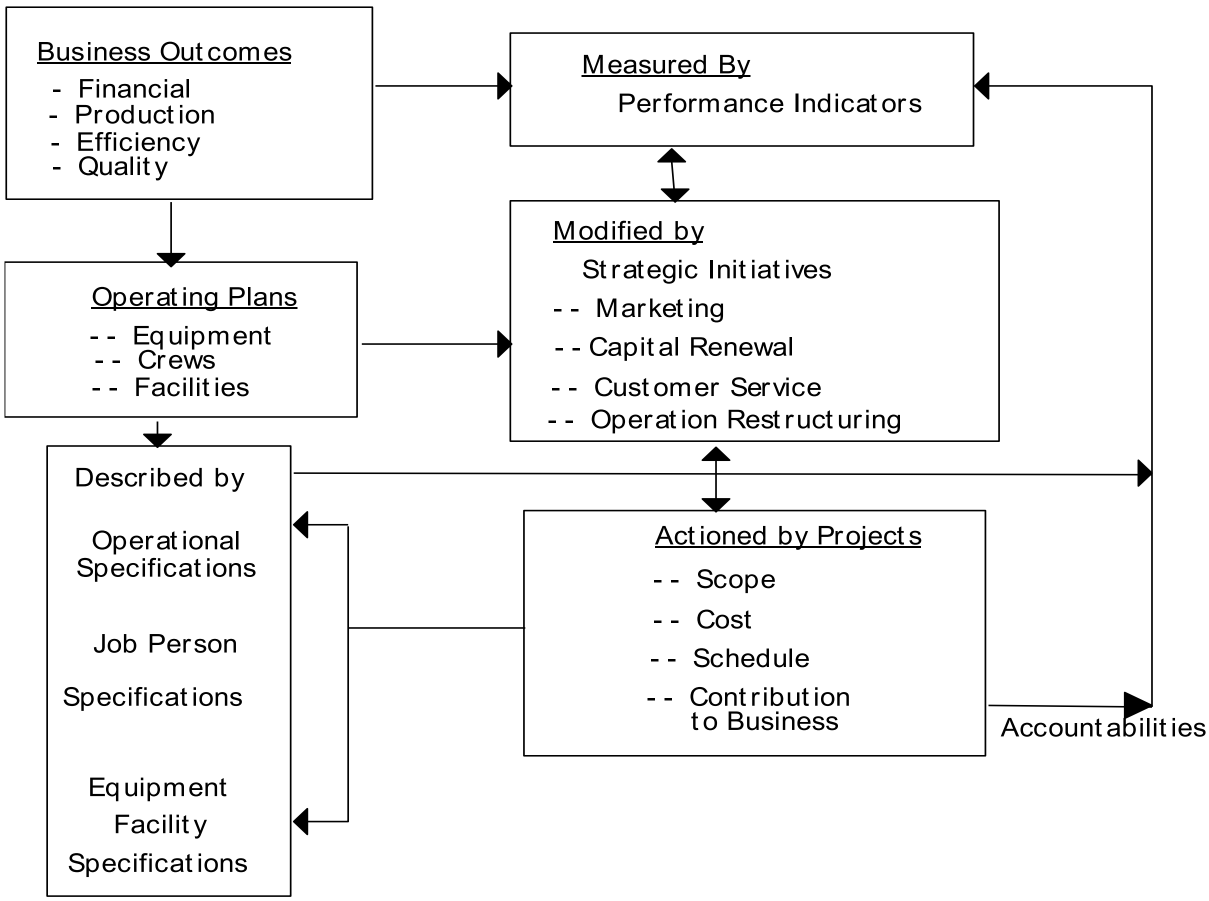

Figure 10.1 Project Development Process Diagram

On the other hand, a *project* is defined as the sub-set of activities needed to create the asset ready to hand over to the user. The relationship between venture and project, as defined, is shown in Figure 10.2. (Note that the four phases of a project will be discussed later in this chapter.)

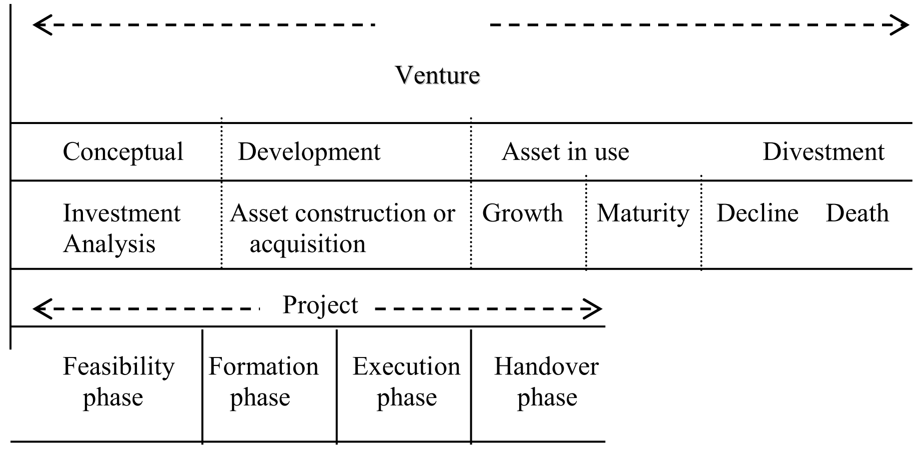

Figure 10.2 Relationship between a Venture and a Project

It is vital that the difference in responsibility for a venture and a project is understood. The person responsible for authorising a venture must ensure (as far as possible) that the factors in the future likely to affect the profitability of the venture have been taken into account. This person is responsible for the profitability of the venture over its full term.

The project manager on the other hand, is responsible for delivering the specified asset to the user, meeting the broad project objectives of **scope, quality, time and cost.** The Australian Institute of Project Management, (www.aipm.org), defines these project objectives as follows:

Scope: The work content of a project or component of a project. Scope is fully described by naming all activities performed, the end products, which will result, and the resources consumed.

Quality: The standard of the end products whenever possible in quantitative terms, Standards could cover tolerances, performance finish, reliability, maintainability, and so on.

Time: The date when the assets are to be delivered to the Principal, Owner, User, etc. This date may sometimes be varied under specific conditions or contingencies.

Cost: The budgeted costs of the project: these can also be varied under specific conditions or contingencies. Costs can also be expressed in dollars (or any other currency) of the day or dollars of the future, which can be particularly important in a long project.

Objectives of project management

As discussed earlier, the objective of a successful project management is to simultaneously satisfy the 'triple' constraint of a project, that is, the performance specification (scope), time schedule, and money budget. This relationship is shown in Figure 10.3.

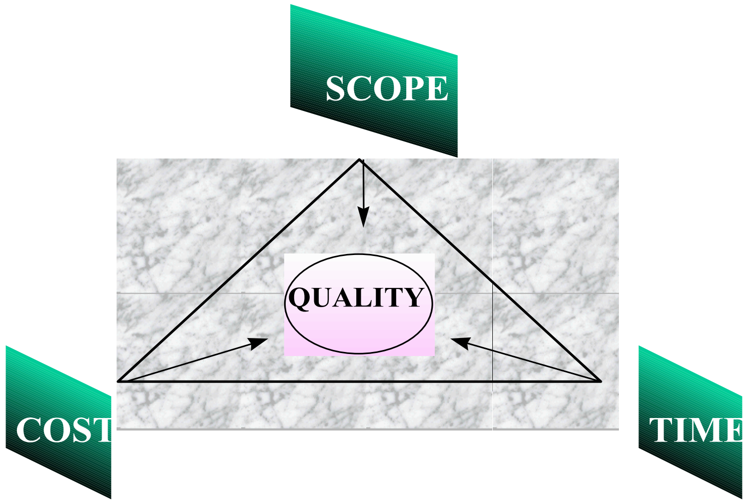

Figure 10.3 The Triple Constraint

Adopted from Rosenau (1998: 16)

There is, of course, an element of optimisation within any project management task. Figure 10.3 above illustrates the pressure for performance in meeting the three objectives. The key point the Triple Constraint illustrates is the need to simultaneously satisfy three independent goals – not just one. The pressures to achieve, maximum scope and quality, minimum cost and faster delivery, leads to conflict.

Globally, particularly in America, professional and academic bodies have added other objectives and sources of conflict to the triangle above, leading to the now recognised 10 elements of project management.

- Integration
- Scope
- Cost
- Time
- Risk
- Procurement
- Quality
- Human resources management
- Communications management, and
- Systems management.

These elements are managed within a process or methodology. The most commonly accepted process that is used by the Project Management Institute (PMI) is shown in Figure 10.4. It is a Five-step Process Model, including the process of initiating; planning; controlling; executing and closing.

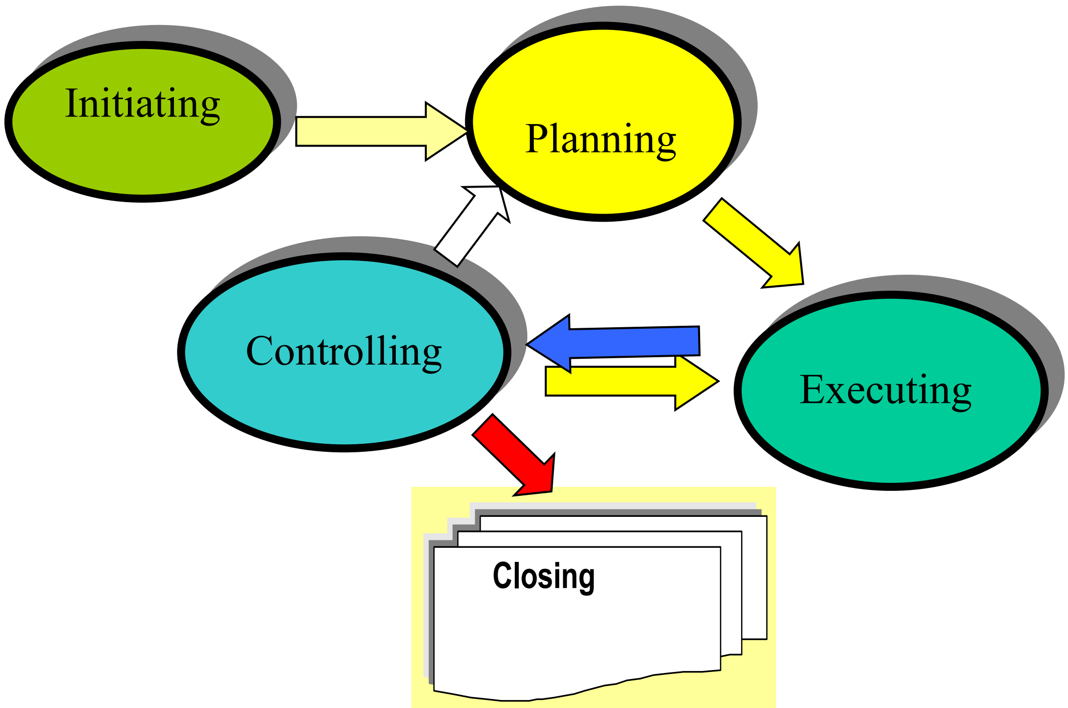

Figure 10.4 Five-step Process Model

In achieving maximum scope and quality, minimum cost and faster delivery through the five-step process model (see Figure 10.4), it is important to understand and appreciate the role of project managers.

Role of the project manager: he or she has the responsibility to integrate the efforts of people from various functional areas to achieve specific project goals. The project manager is responsible for establishing the project goals and providing the means to achieve them. He or she must also specify how the work will be done and ensure that the appropriate hiring is done and the necessary training is conducted. The project manager must demonstrate leadership and provide the motivation necessary to accomplish the tasks required. He or she evaluates project progress and takes appropriate action when project schedules are in jeopardy.

In summary, project manager's prime responsibility is the integration of:

- scope, including quality;
- time; and,
- cost,

followed by the effective management of:

- human resources (including the project team);

- communications;
- risk; and
- procurement.

Since the elements of scope, cost, and time are closely interrelated (i.e., the ‘triple’ constraint), project managers should be vested with specific characteristics/skills enabling them to understand each component, as well as, its relationship with the others. These characteristics and/or skills will be outlined in the following section.

Characteristics of a good project manager

Although every project and every project team is different, there are some characteristics, which distinguish successful project managers (i.e., the ones that simultaneously satisfying the ‘triple’ constraint of a project) from unsuccessful ones. These are:

- formal status in the company structure;
- leadership/management skills, for example, communication, persuasion, negotiation;
- expertise relevant to the project, for example, marketing, engineering, manufacture, finance, purchasing, etc.;
- respect in which the individual is held;
- personality, that is, informal authority;
- availability over expected project horizon;
- knowledge of company structure and policies;
- commitment to project;
- experience in project management;
- involvement in preliminary project e.g. feasibility study, investment analysis, tender, market research; and
- involvement in start or finish of project.

The project manager should be matched with the project to the greatest degree possible, especially for important projects (and most projects are).

Defining a project – scoping a project

While the elements of scope, cost, and time were briefly defined earlier in this chapter (see The Australian Institute of Project Management, (www.aipm.org) definitions), these components will be discussed herein in more detail from the perspective of defining/scoping a project.

The starting point for managing any project should be a clear definition of what the objectives of the project are. While these may change at various times throughout the project life cycle the definition will serve as a baseline against which to measure and judge achievement and approve changes.

The *Project Definition* would consist of:

- Narrative description of work to be accomplished including objectives, brief description and specifications - **SCOPE.**
- Financial constraints including project and ongoing revenue/operating costs; - **COSTS**.
- Milestone schedule defining key dates – **TIME**

Scoping

The *scope* of a project is the *desired outcome* as set by the aims and objectives of the sponsor. The scope of a project will be defined in the Needs Identification stage. It will be expressed in terms of Performance or Function. For example, in a public transport project, objectives such as number of passengers, speed, time per journey, reliability, safety and maintainability would be set.

During the early stages of scoping it is advisable to develop the *Scope of Works* into a **Work Breakdown Structure (WBS)**. This can be a very effective tool for integrating scope, time, cost and the organisation structure.

The use of Work Breakdown Structure (WBS) is essentially an estimating process that tries to answer some fundamental project questions:

- What must be done? (identifies the discrete tasks)
- How long will it take? (determining the task durations)
- How much will it cost? (what budget is required), and
- Who can do the work? (what resources will we assign to the tasks?).

The approach taken by the WBS is quite simple and it looks a lot like an organisational chart. It begins by identifying the total project as one complicated task or 'chunk' and then it breaks it down, level by level, each task into several, smaller more manageable tasks. The process is continued until the task can no longer be broken down any further. At this lowest level of task breakdown, an estimate of the task (or sub-task) duration, cost and resource requirements can be made. Figure 10.5 shows the basic arrangement of a Work Breakdown Structure.

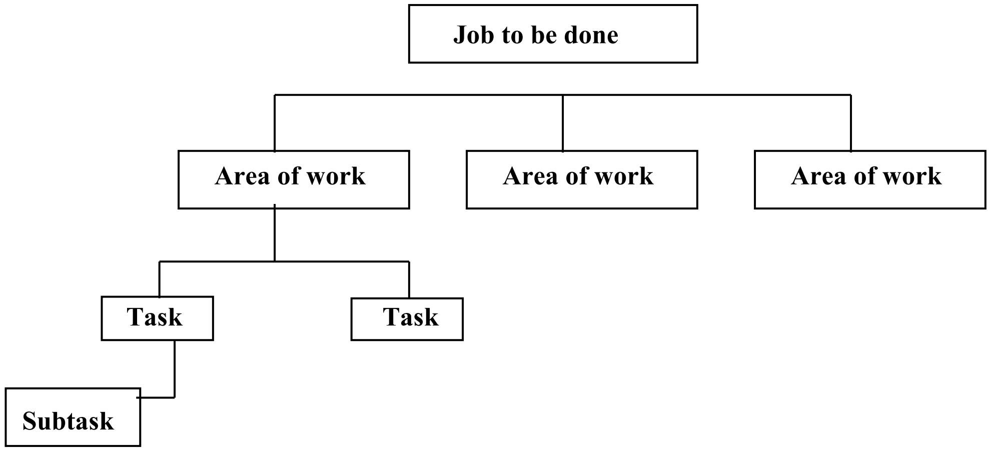

Figure 10.5 Basic Layout of a Work Breakdown Structure

Consider the example the job of 'cleaning a home'. The **Work Breakdown Structure** could be drawn as shown in Figure 10.6 below.

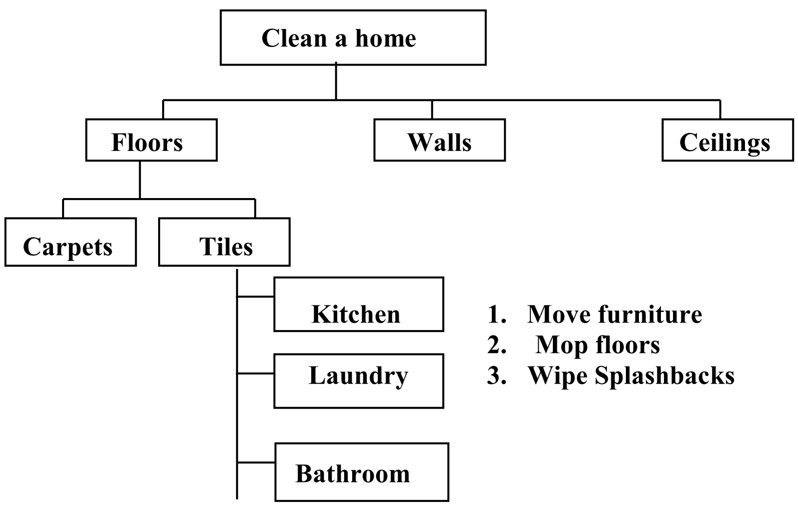

Figure 10.6 Example Work Breakdown Structure

In Figure 10.6, three discrete sub-tasks under the 'Tile' grouping have been identified:

- move furniture;
- mop floors, and
- wipe splashbacks.

At this lowest level of task breakdown, an estimate of the task's duration, cost and resource requirements can be made. Project managers can use some of the following rules (protocols) for drawing and using Work Breakdown Structures:

- the diagram is a graphic portrayal of the total project scope;
- work not in the WBS is outside the scope of the project;
- confirms a common understanding of project scope;
- it shows the deliverable-oriented grouping of project elements;
- it shows dependencies (relationships) between all project tasks;
- the logic is not time based;
- all tasks are grouped under key stages;
- the diagram is a hierarchical structure;
- all sub-units of work are identified;
- the different levels of detail (decomposition) are shown;
- the levels shown are sufficient to achieve estimating accuracy;
- each descending level shows an increasingly detailed description of the tasks;
- all tasks are captured;
- ties the project together;
- is drawn top down;
- makes a complex (large) project manageable;
- does not need to be symmetrical; and
- can often be 're-used' as some projects resemble other projects.

The Institute of Project Management (A guide to the Project Management Body of Knowledge —2000 Edition, [Project Management Institute (PMI) December 2000] states that the intent behind completing a Work Breakdown Structure is to ensure that each major project deliverable is sub-divided into smaller more manageable components, until the deliverables are defined in sufficient detail to support future project activities (planning, executing and closing).

Remember, a Work Breakdown Structure must be manageable, independent, integrateable and measurable. It is similar to a job analysis in that it breaks down every project into a number of distinct sub-units or work components. Because all elements of the project are identified, there is less chance of neglecting or overlooking an essential step. The goal of this technique is to identify work units that are discrete and that will advance the project towards its completion.

In terms of listing the activities, anything that only consumes time but not resources must also be included as an activity (e.g., curing concrete, waiting for responses to questionnaires, waiting for approvals, etc.). However, non-essential activities should not be included.

It is important to clarify the level at which the work breakdown occurs. Most activities can be broken down into smaller, discrete sub-tasks, however, if broken down too much, the planning and management of all the discrete sub-tasks can become laborious and over-complicate the entire process. It is very useful at this stage for each person responsible for a task to nominate the immediate pre-requisite activities for that task. Table 10.1 is an example of a form, which may be used to document this step. Additional information can also be recorded on the form, such as:

- cost of the activity, which could be split up into various components of cost;
- duration;
- department or individual responsibilities; and
- resources needed.

Table 10.1 Example Activity List Form

Immediate pre-requisites	Code	Description	Duration	Resources	Cost	Person responsible

Cost

The *cost* of a project is the measure of resources consumed to achieve the desired objectives. It represents the investment made. Normally it is measured in monetary terms although units specific to the particular resource may also be used (e.g., man-hours for people).

As shown in Figure 10.7, the project manager will usually have six resources to control costs, namely: human, financial, equipment, materials, facilities, and information.

The WBS allows these costs to be allocated across the work packages. In addition to costs that can readily be identified it is generally prudent to allow a contingency within the total project cost. Note that this is not for increases to the scope but rather for the unexpected. The amount of contingency will vary depending on the level of information available. Typically contingency will reduce from around 30 percent of the project total cost at initiation to 2 percent at project completion.

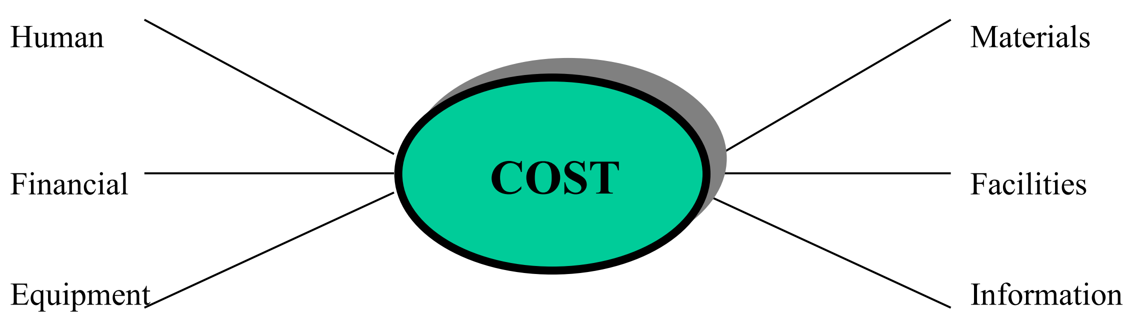

Figure 10.7 Resources of Cost Control

Time

Again during the initiation stage the *time* objectives can be specified. This may be to take advantage of a specific opportunity or meet a need identified at some particular date in the future.

As the *scope of works* is developed and project tasks identified, a detailed schedule can be worked up. These time schedules will specify the duration for each task and the order they must be done in. Where a WBS has been established the schedule can reflect WBS tasks, sub tasks, work packages, etc.

All major events and milestones should be identified. Techniques such as bar charts (Gantt), critical path and PERT charts can be used. The exact sequence of work would be defined.
As with *cost* it is prudent in managing *time* to provide a contingency within the overall program. This is expressed in terms of 'net' and 'gross' program duration.

Project life-cycles

A typical formal starting point for a project is when management (or the owner) authorises the use of resources to investigate an idea that may result in an outcome that will enhance the organisation's ability to achieve its mission (new product, system, building, facility, etc).

The typical finish point is when the project outcome has been produced and has been handed over to (and accepted by) the owner or user.

Phases of a project

In between the start and finish of any project there are typically the following four phases, shown in Figure 10.8.

- Feasibility;
- Formation;
- Execution; and
- Hand over.

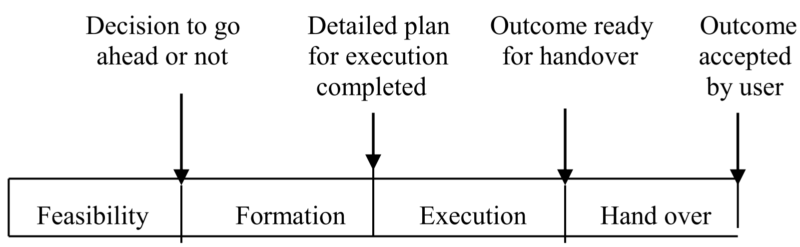

Figure 10.8 Typical Phases of a Project

The four phases – ***feasibility, formation, execution,*** and ***hand over*** are given various titles in the literature. There is, however, general agreement as to what each of those phases covers.

Phase 1 – Feasibility (conceptualisation of the idea)

A conceptual idea or potential investment is explored to see if it can be done and whether it will pay. Its financial contribution will be measured normally by the methods of investment analysis, using for example the discounted cash flow (DCF) method. At the end of this phase the investment analysis team will report to management or the owner who will then decide whether to proceed or abort.

Phase 2 – Formation (design, planning, and structure)

This phase converts the concept into a clearly defined specification and budget, together with a plan and schedule showing how those objectives will be achieved. At the end of this phase the major investment decision is taken, once again whether to proceed or abort. At this point the objectives should be precisely set so that they can be used as the criteria against which performance in the next phase is measured.

Phase 3 – Execution (production, process, and operation)

In this phase the outcome or product that was approved at the end of Phase 2 is constructed; this is generally the phase when by far the largest cash outflow is incurred. In the case of a building project, for example, equipment is procured, civil and structural works are undertaken, and equipment and facilities are installed. This phase differs totally in character from the previous two phases in that its aim is not to develop new technical options, but to construct as efficiently as possible the building defined in the specifications and by the formative phase.

The mode of control in this phase is one of tight monitoring to keep actual quality, duration and cost within the target limits.

Phase 4 – Hand over (termination, commissioning, conclusion)

This phase may overlap Phase 3, and involves planning all the activities needed for acceptance and operation of the project: for example, training, debugging, etc. This phase is alternatively called the warranty phase, defects period, or guarantee period; it may include an audit of the effectiveness of Phase 3. The objective of Phase 4 is to integrate the project's outcome through the:

- testing of systems, facilities or products;
- generation of procedures, manuals and guidelines; and
- allocation of resources and training for the on-going operation.

It is often undertaken by a special group of people, not in any way connected with the project team. The results of Phase 3 may thus be handed over not only to the sponsor but also to the maintenance or audit team.

It is important to note that in any one project:

- not all of the phases necessarily take place; and
- the phases and the boundaries between them are not always clearly defined.

Planning and scheduling a project

The methods used for planning and control will vary throughout a project's life. These will reflect the amount of detail available and order of accuracy possible.

A value judgement needs to be made on the degree of sophistication required, the relative costs of different tools (generally greater cost for more sophistication) and the accuracy of outputs such as budgets and time programs. Early in the project life cycle the effort and cost of setting up sophisticated planning and control tools may not be warranted because details are not known and the order of accuracy is relatively low.

Control Tools and Techniques used in managing a project which may be required include:

- Information management databases;
- Scheduling software (Gantt/Pert Systems);
- Cost management systems; and
- Modelling systems.

These tool and techniques will be discussed in more detail in Chapter 11.

Project team structure

In many cases, projects are undertaken to provide organisations with revenue-generating outcomes or the equivalent for non-profit organisations. The project team responsible for the execution of the project is generally a sub-unit within a parent organisation. But often a project team is undertaking a project for an organisation other than its parent, and often it will have some temporary and partial control of another organisation (a contractor or sub-contractor).

In this chapter we describe the organisational units with which a project team may be associated. We then show some of the possible relationships between those units and consider possible organisational structures for a project.

Parties to a project

Many projects (especially large-scale projects) involve relationships with a range of different people, with each person being involved, interested or responsible for a different part of the project. These are the parties to a project. These people can be either:

Project team: The group of people, led by a project manager, responsible for the achievement of project objectives, as defined to them: they will normally be assigned to the project team by the parent organisation.

Parent: the organisation to whom the members of the project team belong, who sets their objectives and provides their resources, and to whom they are accountable as a team for achieving project objectives.

Client/sponsors: the organisational unit for whom the project outcome is being created, or the project is being carried out. The client could be:

- the parent itself
- a sub-unit of the parent
- a completely distinct organisation, not in any way connected with the parent.

Contractor/subcontractor: a legal entity engaged by the client, parent, or project team to carry out a defined section of the work needed to achieve project objectives.

Links between the parties

Typical relationships between the various organisational units involved in carrying out a project are shown in Figure 10.9. These are typical relationships for a medium to large project carried out for a client by a firm with special skills in project management.

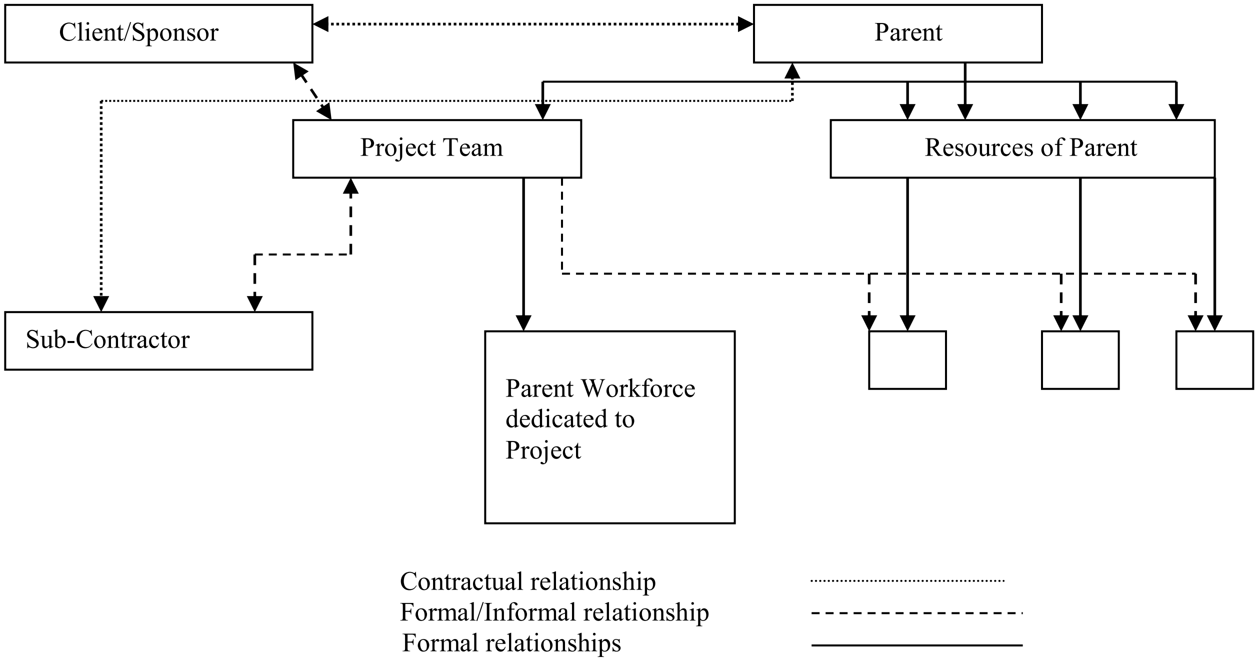

Figure 10.9 Organisational Links Relevant to a Project

Formal contracts should exist between parent and client and between parent and sub-contractor. Because the project team is not normally a separate legal entity it cannot enter into contracts: however, there must be clearly established procedures for control, communication, and reporting between the project team, client and sub-contractors. The links between the project team, the parent, and any workforce dedicated to the project are the formal links defined by the parent organisation.

Additional links, which may be formal or informal, exist between the project team and other resources of the parent. Such resources could include:

- Accounting;
- Procurement;
- Computing;
- Drawing office; and
- Personnel.

Under some circumstances resources may be seconded from these and other functional groups to the project team for the duration of the project. However, there will still be some relationship between the people seconded to the project team and the functional groups within the parent.

Teams and teamwork

A team or working group is a logical and fundamental element of an organisation, which can be a focus for improving the effectiveness of the organisation.

The use of teams and teamwork can improve the performance of a group through the involvement and participation among members.

A project team is usually best formed for each project. Each project is different often requiring quite different resources (including staffing) due to its size and complexity. Common members of a project team are:

- project manager/controller;
- project engineer;
- contract administrator; and
- service manager.

For the project team to work effectively, several factors must be included in the main objectives of the team including:

- communication;
- problem solving;
- decision making;
- group process management; and
- resource utilisation.

Organisational structures for projects

When projects are initiated, a decision must be made as to how to integrate the project and its parent organisation. Often there is senior management influence (non-project). The role of project manager is strongly affected by the nominated organisational structure. As a result, the project manager needs to understand and appreciate the advantages and disadvantages of all the different organisational structures.

Process for planning a project organisational structure

The steps listed below are those that apply to all forms of organisation, however, they need to be modified to meet the particular needs of project organisation.

1. Decide the objectives of the project and the method by which it will be carried out.

2. Identify the activities to be undertaken in achieving project results and in managing the project: the second group of activities include such things as: managing, operating the planning and control system, accounting, purchasing, quality control (if not included as a project activity) and all other 'overhead' functions.

3. Divide or group the 'overhead' activities into jobs so that each job represents a reasonable amount of work for one person.

4. Arrange those jobs into an organisational structure (or incorporate them into an existing structure) to give the project manager an effective system for co-ordination and control.

Principles of an organisation

Project managers should considering the following principles of an organisation:

- There should be one boss – an individual should be accountable to only one superior: however, in the management of projects this is sometimes impossible.
- A manager is responsible for the work of subordinates.
- Responsibility requires commensurate authority.
- An individual's span of control should be limited.
- There should be some similarity between the departments or activities controlled by one person (homogeneity).

There are three different types of project organisational structures, each with their own advantages and disadvantages:

1. Functional;
2. Matrix; and
3. Projectised (pure).

Functional organisation

Advantages	**Disadvantages**
• Maximum staff flexibility	• Client not the focus of activity or concern
• Temporary assignments	• Activities oriented to functional unit
• Grouped specialist	• Few staff given full responsibility
• Normal career path advancement	• Lack of co-ordinated effort
• Staff rotation	• Several layers of management to navigate
• Easy to re-assign back to normal work	• Not a mainstream activity or interest resulting in a lack of direction and motivation

Matrix organisation

Advantages	Disadvantages
• Project is the point of emphasis	• Delicate balance of authority and power
• Sole responsibility assigned to one individual	• Political infighting and avoiding blame
• Access to entire staff reservoir	• Highly resistant to shutting down project
• Reduced duplication of functional divisions	• Violates the principle of 'unity of command'
• Preserves consistent practices and policies	• Split loyalties and confusion
• Company-wide balance of resources	• Variety and disorder
• Integrated functional specialists	
• Functional units can lend capacity	

Projectised organisation (pure project)

Advantages	Disadvantages
• Full line authority	• Personnel become narrow focused
• Complete dedicated workforce	• Ostracized from functional area
• Workforce responsible exclusively to project manager	• Possibility of duplication of effort in clerical, administration, and other required support functions
• No permission from functional heads required	• Inconsistent policies and procedures
• Shortened lines of communication, faster communication and fewer failures	• Stockpiling of knowledge and equipment longer than needed, 'just in case'
• Strong and separate identity	• Corner cutting justified by needing to respond to client exigency
• High level of commitment	• The disease 'projectitis' develops as the project takes on a life of its own

• Task orientation • Swift decision making due to centralized authority • Faster reaction time • Unity of command • Structurally simple and flexible • Holistic approach to the project • More or less permanent cadre of experts	• Bitter competition and rivalry between different projects • Uncertainty about life after the project (being laid off, re-assigned, low prestige work, team broken up, rusty and dated skills)

Choosing an organisational structure

Realistically, the choice of an appropriate organisational structure should be determined by the situation at hand – that is, the variables underpinning the project. Sadly, there are no step-by-step procedures, rule books or generic guidelines (other than intuition) that provide detailed instructions as to the best structure for every project. Consider the evidence, organisation culture and the project variables and aim for a 'best fit' structure under the current circumstances.

Types of project organisational structure

The organisation to carry out a project can be structured in a variety of ways, which can be classified into five groups (refer Table 10.2). They move from a weak structure (functional) in which there is often no single project manager to a strong structure (projectised) where there is one project manager with effectively total authority over all resources required in the project.

Table 10.2 Project Organisational Structures

Structure	**Description**
Functional	The project is divided into segments and assigned to relevant functional groups: the head of each functional group is responsible for his segment of the project. Functional and upper levels of management formally co-ordinate the project.
Weak matrix	A person is formally designated to oversee the project across different functional areas. This person has limited authority over functional people in the project, and serves

	primarily to plan and co-ordinate the project. The functional managers retain primary responsibility for their specific segments.
Matrix	A person is assigned to oversee the project and interacts on an equal basis with functional managers. This person and the functional managers jointly direct work flow segments and approve technical and operating decisions.
Strong Matrix	A manager is assigned to oversee the project and is responsible for the completion of the project. Functional managers' influence is limited to assigning personnel and providing expert advice.
Projectised	A manager is put in charge of a project team composed of a core group of personnel from several functional areas, assigned on a full-time basis. The functional managers have no formal involvement.

Activity 10.1

Dubai Festival City

The Dubai Government has appointed you as Project Manager for the Dubai Festival City. Debate the pros and cons of the different types of project organisational structures and decide which is the most appropriate structure, which will ‘best fit’ your project variables under the current circumstances. What advantages are you anticipating to gain from such a structure?

Activity 10.2

Setting Project Deadline

Consider projects with deadlines that are currently under way in your department. How was the deadline for each project determined? Was the deadline determined from the project plan or was the project plan determined from the deadline? What was the involvement of the project team in setting the deadline?

Activity 10.3

Discussion group

When a large project is mismanaged, it makes news. Form a discussion group and identify penalties associated with a mismanaged project in your experience or in recent headlines. Identify the causes of the problem such as inaccurate time estimates, changed scope, unplanned or improperly sequenced activities, inadequate resources, or poor management-labour relations.

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. A project is a unique, one-time operational activity or effort. **True**

2. One of your colleagues comments that software is the ultimate key to project management success. **False**

3. Projects have become increasingly pervasive in recent years. **True**

4. There are only five recognised elements of project management: scope, time, risk, quality, and money budget. **False**

5. The Triple Constraint defines a project in terms of performance specification, time schedule, and money budget. **True**

6. Project-oriented activities play less of a role today in organisations than they in the past. **False**

7. The primary focus of control in project management is on determining project completion time. **False**

8. CPM and PERT have been effectively merged as project management tools since 1950s. **True**

9. Normally suppliers are not part of the project team. **False**

10. A WBS breaks down a project into components, sub-components, activities, and tasks. **True**

11. There is usually no more pressure, both real and perceived, associated with project management. **False**

12. PMI is the only project management association dealing with PMBOK. **False**

MULTIPLE CHOICE QUESTIONS

1. Which of the following is a reason for the increased popularity of project management?

a) diversity of new products and product markets
b) shorter life span of products
c) rapid technological changes
d) all of the above

2. Which of the following is *not* typically considered a project?

a) making automobiles in the assembly production line
b) planning a holiday trip
c) launching a satellite
d) developing a tunnel

3. Which of the following groups is *not* usually included on a project team?
a) engineering staff
b) purchasing staff
c) suppliers
d) company directors

4. Which of the following is the primary focus of control in project management?
a) making sure all activities have been identified
b) identifying resource needs
c) establishing precedence relationships
d) maintaining the project schedule and making sure work is completed on time

5. All of the following are traditional project management techniques for scheduling and planning *except*
a) CPM
b) **PLAN**
c) Gantt Chart
d) PERT

6. Which of the following defines the purpose of WBS?
a) to identify activities
b) to determine project workloads
c) to identify relationships between modules and activities
d) all of the above

7. Which of the following project objectives fully describes the names of all activities performed in a project?
a) scope
b) quality
c) time
d) cost

8. A successful project manager is vested with
a) leadership and management skills
b) experience in project management
c) formal status in the company structure
d) all of the above

SHORT- ANSWER QUESTIONS

1. Consider a project currently underway in your department. What problems can you attribute to the project's work life? What measures are being taken to overcome these problems? What measures do you think should be taken?

2. What activities do you consider to constitute effective project management? How do they map into the four project objectives of scope, quality, time, and cost?

3. In the 1970s the approach to project management has moved from an art to a science. Why? Justify your response.

4. Is ‘projectised’ organisational structure the ‘best’ structure for every project? Support your argument with a practical example.

Summary

This chapter focused on a history of project management and stressed the importance on the techniques used over the years (i.e., PERT and CPM) to manage a project. The chapter looked at how projects originate and how project managers can satisfy the project's 'triple' constraint (i.e., scope, cost, and time). Moreover, it focussed on the role of a project manager in terms of planning and scheduling a project and discussed the project life-cycles. The chapter also discussed the project team structure and the types of organisation structures for projects. Finally, the advantages and disadvantages of different project structures were examined.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel that you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to project management

- ☐ Brief history of project management

- ☐ Definitions of project management
  - ☐ The five process groups
  - ☐ The nine knowledge areas
  - ☐ What is a project?
  - ☐ What is management?

- ☐ How do projects originate
  - ☐ Project development process
  - ☐ Venture
  - ☐ Relationship between a venture and a project

- ☐ Objectives of project management
  - ☐ Triple constraint
  - ☐ Role of the project manager
  - ☐ Characteristics of a good project manager

- ☐ Defining a project – scoping a project
  - ☐ Scoping and Work Breakdown Structure
  - ☐ Cost
  - ☐ Time

- ☐ Project life-cycles

- ☐ Project phases
- ☐ Planning and scheduling a project

☐ Project team structure

- ☐ Organisation structures for projects

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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Chapter 11 Project based management futures

Contents………… .... Page

Project based management futures

Learning outcomes

By successfully achieving the stated ‘enabling objectives’ for this chapter, you should be able to:

- integrate project based management into operations planning.
- identify future trends in project management.
- be familiar with future support tools for project management.
- understand the value of the critical path scheduling techniques.
- recognise the strengths and weaknesses of project management software applications.
- understand features and principles of project management expert systems.
- work in virtual project based teams.
- be familiar with international project management competency standards.

Enabling objectives

For assessment purposes you will require to achieve a competency in:

- Linking projects into programs
- Applying contingency and critical chain management to project scheduling
- Set up a framework for linked projects
- Identify and select the best available project management tool for a project of your choice
- Apply new approaches to project planning such as:
    - Critical chain (CC)
    - Quality Function Deployment (QFD)
    - Statistical Process Control (SPC)
- Set up virtual project teams

What you will need

Suggested study time	Text Books	5 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	5 hours
	Total	13 hours

Introduction

Project Management is an evolving discipline and emerging profession. Multi-billion-dollar corporations, governments and small non-profit organisations alike would use project management globally in the future. Project management leadership is a highly sought-after skill as global competition demands that new projects and business development be completed on time and within budget. Professionals working in project management will drive the successful development of exciting new business enterprises in the twenty first century.

As discussed earlier in Chapter 10, the original tools of project management, Program Evaluation Review Technique (PERT) and Critical Path Method (CPM), have been submerged within the concept of an integrated system for optimising the 9 recognised elements of project management. A 10th element, *Systems Management,* is now also emerging, as web based project and program management emerges as an operational management alternative.

Modern thinking on project management now puts emphasis on achieving a balance of scope, cost and time, or in summary quality, within the customer, client and project risk, human resources and communications, comfort zones. The enhancement of traditional tools, such as CPM and sometimes their rediscovery as modern computing power, is now being overshadowed by new demands in project management.

According to Tooher (1999), these demands would be part of the continuing knowledge development in project management over the next 20 years (see Figure 11.1).

The demand by Industry for improved performance in projects, is focusing on several key areas for development as follows:

- Web based systems for multiple, project or program management.
- Common language, protocols and approaches.
- Recognised and measurable competencies for practitioners.
- Project management applications to organisational change.
- Development of expert systems which automate many of the labour intensive project management tools such as CPM/PERT, contingency, planning specification, resourcing and costing.

- Managing teams across functional and product boundaries.

- Whole of life (life cycle costing) including impact of environment and sustainability policies by regulatory agencies.

- Wider recognition of project based management competencies.

Adopted from Tooher (2001)

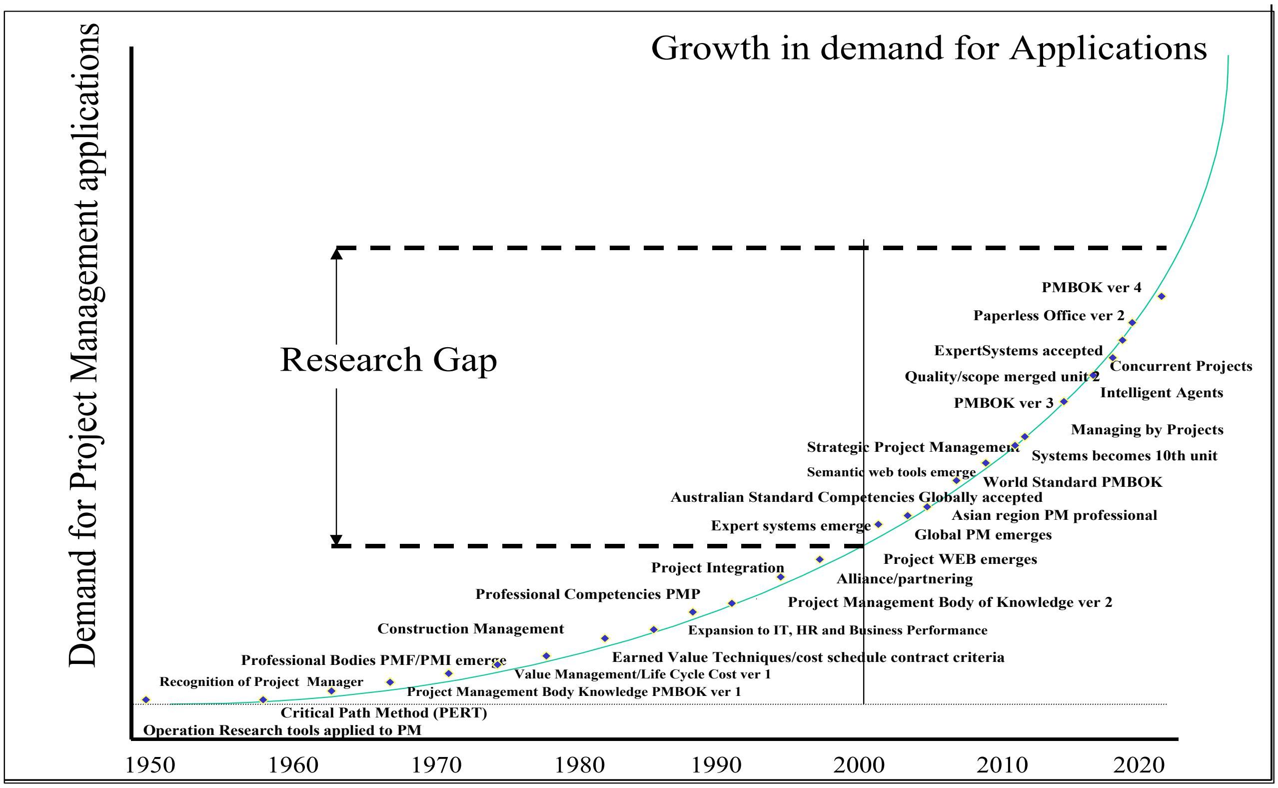


Figure 11.1 Demands for Project Management over 20 Years

Adopted from Tooher (1999)

In this chapter we have explored three of the seven areas that are believed to be able to make the most contribution to project management within the operations management environment.

These areas are:

- Project planning and management, using tools and techniques.

- Teams in project management and the virtual project environment.

- Project management competencies.

Project planning and management tools and techniques

Three areas of development have emerged in recent years and promise to become part of the future support tools for project management.

These are:

- Economic analysis including lifecycle costing;
- Schedule optimisation using critical chain/ critical path techniques; and
- Project management systems - expert systems.

Economic analysis

Economic analysis including increased use of lifecycle costing although developed in the late 1960s has not been extensively used, due to the poor linkage between project outcomes and organisational performance.

According to Tooher (2001), as operations management demands improved profitability, a variety of tools which link project to business outcomes have become available. The traditional model whereby, new project investment has been capitalised off the balance sheet then bought to account when commissioned, has been replaced by projects such as new product development, IT, software enhancement, where, investment is part of operations and in some cases is the operational expenditure i.e. the product or project based company.

Many software tools are becoming available on the Internet or in literature, to assist managers in not only verifying that a project is worth while, but also that throughout the project and product life the returns on investment for the remainder of the economic life of the product is above weighted average of cost of capital.

Additional factors now being brought to account in the project life economic analysis, such are:

- Sustainability
- Customer acceptance
- End of life disposal, and
- Taxation, Research and Development offsets.

An example of a software tool that provides a limited range of features directed towards satisfying some of the above concerns of operations managers is the Automated Cost Estimating, Integrated Tool (www.aceit.com).

The Automated Cost Estimating Integrated Tool (ACEIT) is an automated architecture and framework for cost estimating and other analysis tasks. ACEIT is a government developed tool that has been used for over a decade to standardise and simplify the Life Cycle Cost estimating process in the government environment. It is a generic, flexible, Windows-based system for estimating virtually any task (government or otherwise) or the Life Cycle Cost of any type of a project.

As shown in Figure 11.2, ACEIT is an integrated tool suite of several software products specifically designed for the cost estimating community. Core features include a database to store technical and (normalised) cost data, a statistical package specifically tailored to facilitate cost estimating relationship (CER) development and a uniquely designed spreadsheet that promotes structured, systematic model development, and built-in government approved proven inflation, learning, time phasing, documentation, sensitivity/what-if, risk and other analysis capabilities. ACEIT integrates all the necessary cost estimating functions and allows project operations managers to enter the process at any level.

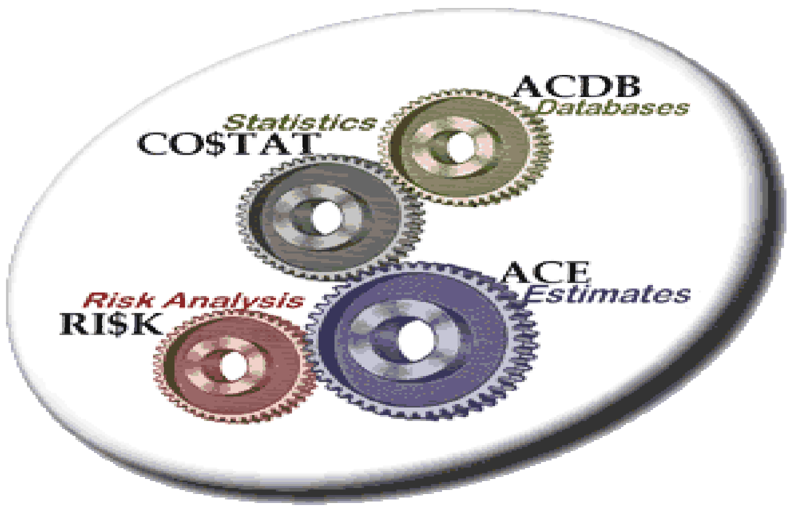


Figure 11.2 Automated Cost Estimating Integrated Tool

ACEIT has several integrated tools that provide the following functions:

- Automated Cost Database development, search, and retrieval (ACDB)
- Statistical analysis (CO$TAT)
- Automated Information Manager for building CER libraries (AIM)
- Automated Cost Estimating, model creation and documentation (ACE)
- Risk analysis (ACE/RI$K)
- Operation from Excel and interfaces with other tools (ACEIT Executive)
- Custom Inflation Indices creation (Inflation Editor)
- Functions to obtain inflation factors from any Excel spreadsheet (Inflation Utility)

The future will see a much more integrated and available range of tools for project evaluation on a continuous basis.

Critical chain and critical path scheduling techniques

Automated systems, with scheduling algorithms and the availability of templates of previous projects has relegated the need for detailed planning on most common simple project to the project planning specialist. Of greater importance is the linkage of tasks, duration's, cost and scope to maximise value and the increasing focus on the whole of life cost on the outcome of the project.

Therefore, in addition to the project time schedule there is the lifetime schedule, encompassing upgrades, maintenance, regulatory policy, consumer risk evaluation and investment protection. These are now in demand as companies switch to management by projects.

Critical chain

The concept of *critical chain* has recently emerged as a project application of a scheduling technique for reducing project delivery time (Zultner, 1997). By applying selected methods such as Quality Function Deployment (Blitz QFD for Projects—Project QFD), Theory of Constraints (Critical Chain), and Statistical Process Control (Quality Improvement Story and Control Charts), product development and project schedules can be reduced by at least 15-25 percent, *without* cutting features, increasing risk, or adding resources. The interested operations manager who wishes to apply these methods to a real life project, should visit the material of Appendix I. Appendix I also offers a case study of a software development project of module design, coding and unit test.

Software tools specifically addressing *critical chain* may emerge in the near future, however, many of the advantages can be realised with current software capability by utilising the PERT chart features to select duration probabilities, and using a contingency management approach.

Project management tools - expert systems

A review of the literature revealed more than 70 project management software applications such as: Primavera Project Planner; Microsoft Excel; Project Workbench; Time Line; Sure Track; CA-SuperProject; Project Schedule; Artemis (Lucas Management Systems); and FasTracs (Applied Microsystems), which are currently in use by various managers (Meredith & Mantel, 2000).

Some project management applications distinguish themselves from others in that they track inter-related tasks and usually provide a mechanism for scheduling and reserving resources, as well as automatic minimisation of time-lines or costs by re-arranging schedules. Resource allocation is a well-known NP-complete problem, and there are many complex algorithms that have been discovered to try to efficiently solve this problem (hill-climbing, simulated annealing, monte-carlo methods, genetic algorithms, etc.). "Gantt chart" is a keyword here. These systems are often used to manage construction and (large) engineering projects, where twiddling a schedule can save tens of thousands of dollars or more.

Since managers are faced with a plethora of project management tools, we have selected a number of complete project management tools that do not only traditionally issue the status tracking of a project, but also have some ability to solve the resource-scheduling problem. The following three tools are commercial, and have a wide assortment of features.

Intellisys Project Desktop

The Intellisys Project Desktop is a new commercial, Java-based project management client for Linux/BSD and other Unixes, MacOS 9 and 10, as well as Windows. The visual layout is reminiscent of Microsoft Project (MS) Project: a hierarchical to-do-list next to a Gantt chart. Free download, although this is licensed software (shareware?).

Intellisys Project Enterprise

The Intellisys Project Enterprise uses the same graphical interface as the Project Desktop (above), but adds multi-user, role-based access and communications. It is a commercial, Java-based tool.

Advanced Management Systems RealTime Project

Advanced Management Systems (AMS) RealTime Project from Advanced Management Systems is a suite of tools, clients and servers for tracking projects, project schedules, and doing cost management, in real-time. This is an enterprise-class system, suitable for tracking and scheduling the largest projects. The tool suite consists of 'Projects', 'Costs', 'Resources', 'Solo' and 'Server.

- The *Projects tool* has all the features one would expect from a true project management tool: critical path analysis, resource loading and levelling, and the full spectrum of reports and graphs.

- The *Costs tool* is integrated in and provides budget and actual costs for work performed, schedule and cost variance, estimate to complete, etc.

- The *Resources tool* can be used to create plans, make work assignments, and work with timecard information. It includes data import/export capabilities, and can be used not only with AMS Projects, but also Microsoft Project.

- The *Solo tools* is a client that individuals use to view all assigned tasks, enter and update actual task status, update estimates to complete a task, etc. Task timecard and status information can be routed to management for review and approval.

- The *Server* provides a company-wide, managed, secure repository for project, task and resource management information.

WebProject

WebProject from Novient is a suite of Java applications for resource scheduling, collaboration, plan development, and document management. It is billed as an enterprise-class system with a 3-tier client-server architecture. This tool is not an open source, and given that it has enterprise features, it probably has enterprise pricing (e.g. $100,000 starting price). WebProject comes with:

- Online Demo (a bit weak, not many projects pre-entered, and therefore does not really show off the capabilities).
- Export/import projects from/to most major project management tools.
- SSL and x509 certificate based security/authentication.
- Cross-platform: NT/95/98, Linux, Solaris, other.
- Oracle and other DB back-ends.
- ASP hosting service available.
- Variety of training classes offered, also consulting.

Schedulers, Planners and GANTT Chart Tools

These are not full-fledged project management tools. Rather, these are pieces of software that focus on either solving the scheduling equations, and/or tools that draw Gantt charts.

MrProject

MrProject is a project management system for Gnome. GPL'ed. This is an active project, with a good website (live CVS, lxr, mailing lists, etc.) and corporate sponsorship (CodeFactory). Although it is still at the 0.1 version number, it none-the-less is the most advanced and modern of the GPL'ed, open-source crowd.

KProject

KProject is a project management system for KDE. So far, only the Gantt chart graphing widget has been developed. It looks absolutely beautiful, if a bit over-busy and hard to understand. GPL'ed.

OpenSched

OpenSched is a project to create a project scheduler. One inputs tasks, resources (people, equipment, etc.); it solves the scheduling problem, assigning resources to tasks. On output, it produces a variety of reports, including a summary of tasks and task dependencies, GANTT charts, and work schedules. GPL'ed. Uses a hand-edited file for input, outputs LaTeX.

QtGantt

QtGantt is a project to develop a Gantt-chart drawing tool for Linux. As of this writing, version 0.0.4 == alpha level code, Screenshot, is available.

Xplan

Xplan is an older X11/Xview based project management system. One can create and edit project files containing task info (task name, description, dates, etc.). The tool graphically generates both PERT and Gantt charts on screen, and has an option to generate LaTeX source for Gantt charts and task sheets. For a while, this was dead code; its been revived and patched for modern Linux versions. The above web site points at a CVS tree, as well as a number of screen shots. Originally developed for SunOS, it requires the XView libraries and header files to compile.

PyGantt

PyGantt is a Gantt-chart drawing tool implemented in Python. It accepts XML input and output Gantt charts. GPL'ed.

General Purpose Project Scheduler - gscheduler

gscheduler is meant to be a gnome-based scheduler. It is pre-alpha, but is nothing functional yet.

Associates.com (New Listing!)

Associates.com have a simple web-based gantt-chart creation tool. It is implemented as a set of Perl CGI-bins.

For more information those interested can visit Linas Vepstas at http:// linas.org/linux/pm.html.

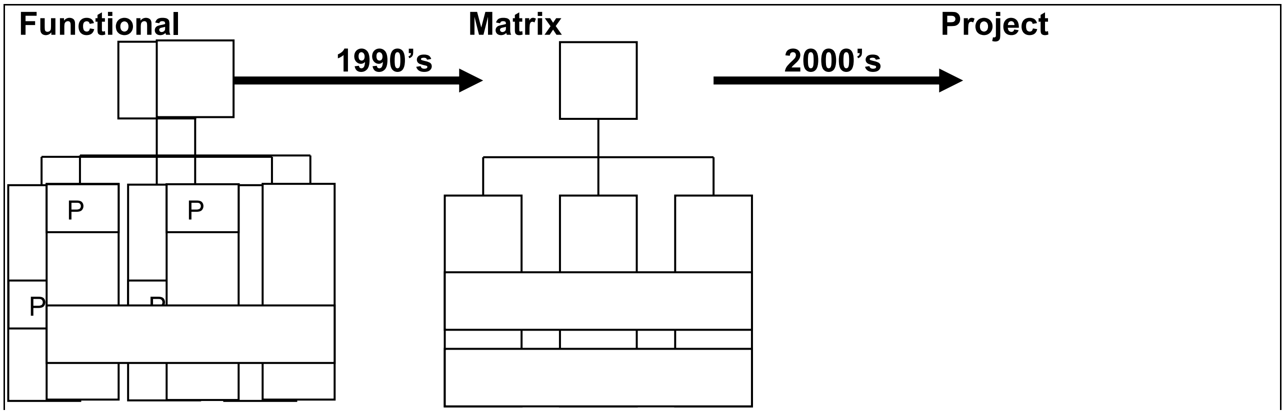
In the near future the above systems when incorporated with the critical chain models discussed in Appendix I might be used as *Expert Systems*.

Virtual project teams

In Chapter 10 we discussed briefly the role of teams and the emergence of global development and implementation teams. Project management in the future will be increasingly conducted within a:

- Virtual framework, (24 hour offices)
- Teams which never meet physically, (strong matrix or projectised organisations)
- Projectised or strong matrix structure now replacing the traditional structure.

The project operations manager will be required to manage virtual project teams, often without resorting to the hire and fire approach typical of infrastructure projects. Resource negotiation and internal resource charging will replace contracting. Thus, the project managers of the twenty-first century would require to 'manage functions across projects' (Tooher, 2001). The paradigm shift of managing projects across boundaries to managing functions across projects is shown in Figure 11.3 below.



Projects managed within sites	Projects managed across boundaries	Functions managed across projects

Figure 11.3 Project Management of the Future

Ted Tooher in Appendix II discusses some tools and applications for managing projects through virtual teams. Appendix II also includes a self-assessment test for team competency, which can assist in measuring team performance.

Global competencies

A side effect of the virtual team, globalisation of projects and the standardisation of knowledge definitions, has been the emerging demand for measurable and consistent competencies in project managers. Industry competency standards such as the Australian Public Services (APS), and the generic standards Australian National Standards for competency in Project Management, as well as the American based Project Management Institute have met this demand.

A world-wide knowledge standard accredited by The Project Management Institute entitled the Project Management Professional (PMP), has gained major world-wide acceptance in the IT industry. This standard attests experience and knowledge, but not competence and it has been driven by the global needs of IT companies for a common approach and language to project management.

Several international bodies are now utilising the Australian standard as the base standard for competency. This includes the Project Management Institute (PMI) and the International Project Management Association (IPMA), as well as the Australian Institute of Project Management which developed the Australian National Standards (see: aipm.com).

Activity 11.1

Dubai Festival City

As discussed in Chapter 10, the Dubai Government has appointed you the Project Manager of the Dubai Festival City. Debate the pros and cons of the different project management software applications and decide which is the most appropriate software, which will reduce cost, without cutting features, increasing risk, or adding resources. Justify your decision.

Activity 11.2

Identify Value Fast

The Dubai Government recently announced that the existing airport of Dubai would be expanded to meet the challenges of the twenty-first century. Using *Project Quality Function Deployment (QFD)*, identify the airport's high value needs, project characteristics and project tasks to generate maximum value.

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. *Systems Management* is emerging as web based project and program management tool. **True**

2. Paperless offices and the PMBOK are irrelevant concepts in managing projects of the future. **False**

3. *Economic analysis* can be classified as one of the future tools for project management. **True**

4. *Expert systems* are not in a position today to successfully manage projects. **True**

5. Blitz QFD is an 'essential minimum method' to identify high-value needs, product characteristics and project tasks. **True**

6. The *House of Quality Matrix* and the concept of '**customer value**' are not related. **False**

7. The *Theory of Constraints* does not provide solutions to traditional project management problems. **False**

8. Critical Chain project management is a *paradigm shift* from traditional critical Path project management. **True**

9. In project management 'variation' does not mean 'risk'. **False**

10. Critical Chain Project Management application can reduce project schedules up to 25 percent. **True**

11. Project management teams which understand reflective learning are able to self-assess and correct their work rapidly and effectively. **True**

12. PMI is the only international body which utilises project management competency standards. **False**

13. Project managers of the twenty first century would be managing projects across boundaries. **False**

14. Competency of virtual teams is the only variable that can be assessed using the *Team Competency Assessment Matrix*. **False**

SHORT- ANSWER QUESTIONS

1. Contrast the way of thinking between the approaches of *Critical Path* project management and *Critical Chain* project management.

2. Name seven tools of the ACEIT and discuss how these can improve the four project objectives of scope, quality, time, and cost?

3. Identify and discuss the six layers of resistance in implementing Critical Chain Project Management. Suggest ways project managers can effectively work through the resistance and achieve buy-in to the solution?

4. Are virtual project teams the 'best' approach for managing every project? Support your argument with practical examples.

Summary

This chapter focused on the enhancement of the traditional project management tools and examined the new way of thinking – called critical chain project management – of managing projects. The chapter looked at the demands of project management over the 20 years and how these can be satisfied. It focused on the future tools for project management – economic analysis, critical chain/critical path techniques, and expert systems (software applications) – and provided sufficient information for the web based systems for multiple, project or program management. Moreover, the importance of virtual project teams was presented coupled by a practical example in assessing the performance of virtual teams in a learning environment. Finally, the chapter presented *global competency standards* for project management and their associated professional institutions.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel that you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to project management futures

- ☐ Demands for project management over 20 years

- ☐ Project planning and management tools and techniques
  - ☐ Economic analysis – automated cost estimating integrated tool (ACEIT)
  - ☐ Critical chain and critical path scheduling technique
    - ☐ Blitz Quality Function Deployment (QFD) for projects
    - ☐ Theory of constraints
    - ☐ Statistical Process Control (SPS)
  - ☐ Project management tools – expert systems
  - ☐ Schedulers, Planners and GANTT Chart Tools

- ☐ Virtual project teams
  - ☐ Project management of the future
  - ☐ Experience with virtual teams
  - ☐ Team Competency Assessment Matrix

- ☐ Global competencies
  - ☐ Australian Public Services (APS) Competency Standards
  - ☐ Project Management Professional (PMP) Standards
  - ☐ International Project Management Association (IPMA) Standards

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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APPENDIX I

Better Projects in Less Time: How Quality Function Deployment (Blitz QFD for Projects—Project QFD), Theory of Constraints (Critical Chain), and Statistical Process Control (Quality Improvement Story and Control Charts) Shorten Development Schedules

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Abstract

By applying selected methods from Quality Function Deployment (Blitz QFD for Projects—Project QFD), Theory of Constraints (Critical Chain), and Statistical Process Control (Quality Improvement Story and control charts), product development project schedules can be reduced by at least 15-25%, *without* cutting features, increasing risk, or adding resources.

Keywords: QFD Schedule Deployment, SPC Statistical Project Control, TOC Critical Chain Project Management, Value Delivery, Schedule Reduction, Risk Reduction.

Introduction

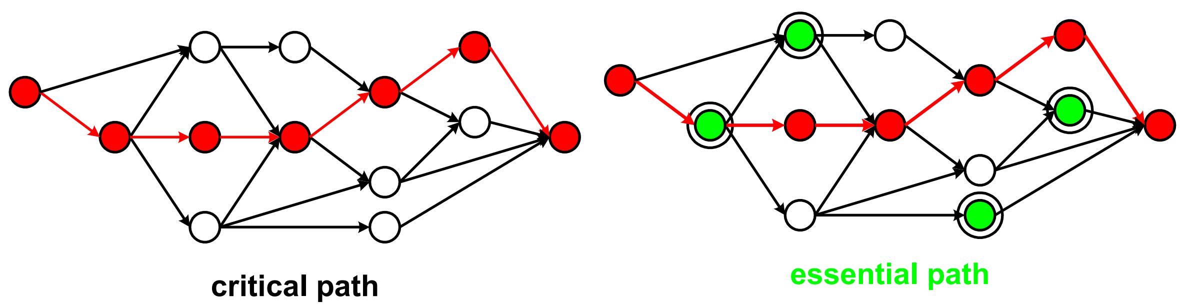
In order to do development projects better, we must find ways to more efficiently *satisfy* our customers, with greater *speed*, and with less *risk*. Three different methods offer us a synergistic approach to doing product development projects significantly better, in substantially less time, with less risk: Quality Function Deployment, Theory of Constraints, and Statistical Process Control.

Identifying Value with Quality Function Deployment (QFD)

Quality Function Deployment is a method developed by Drs. Yoji Akao and Shigeru Mizuno (Akao 1990; Mizuno & Akao 1994). In recent years it has become an increasingly common and important part of project development projects because it provides tools and techniques to identify and deliver *value*.

Value comes First

In product development, the "prime directive" is to build a product that customers want. When you can deliver it, how much it costs, how reliable it is—all these are secondary to the basic question, "Will the customers want it?" If you cannot develop a product that customers want, it doesn't matter how fast, how cheap, or how well it performs. You *failed* at product development. In addition, you cannot compensate for building the wrong product by finishing development early, or at a lower budget, or with great morale on the development team. Your product development project still failed.



Critical and Essential Paths. The **Critical Path** is critical to the project *schedule*. But even more important is delivering enough *value* to enough customers so we can satisfy our business case. The activities that add maximum value define the **Essential Path**. Cutting an essential activity for one that is on the critical path is shortsighted for development projects.

Yet, it is not enough to just build products that customers want. We must build products that customers want *more* than the products offered by competitors. And enough customers must want our products, so that we can make the **business case** that justified our development project in the first place to our organisation.

In order to have a good chance of delivering on our business case, we must satisfy enough customers. To do this, we must deliver enough value in our products to enough customers—more than our closest competitors. In order to have a good chance of doing so, we need methods to identify and deliver value.

Identifying Value Fast

QFD is a quality system for assuring customer satisfaction through the efficient delivery of value to customers. The role of QFD is to assure that the product developed has sufficient value to satisfy the customers—despite the presence of competitive offerings—so we have a good chance of making our business case. Schedule is important, but value to customers is more important in product development.

Although QFD has a global track record for equipping development projects with the means to identify value, sometimes QFD requires considerable effort. Fortunately, a streamlined QFD approach has been developed that is ideally suited to development projects where time is critical to customers: Blitz QFD.

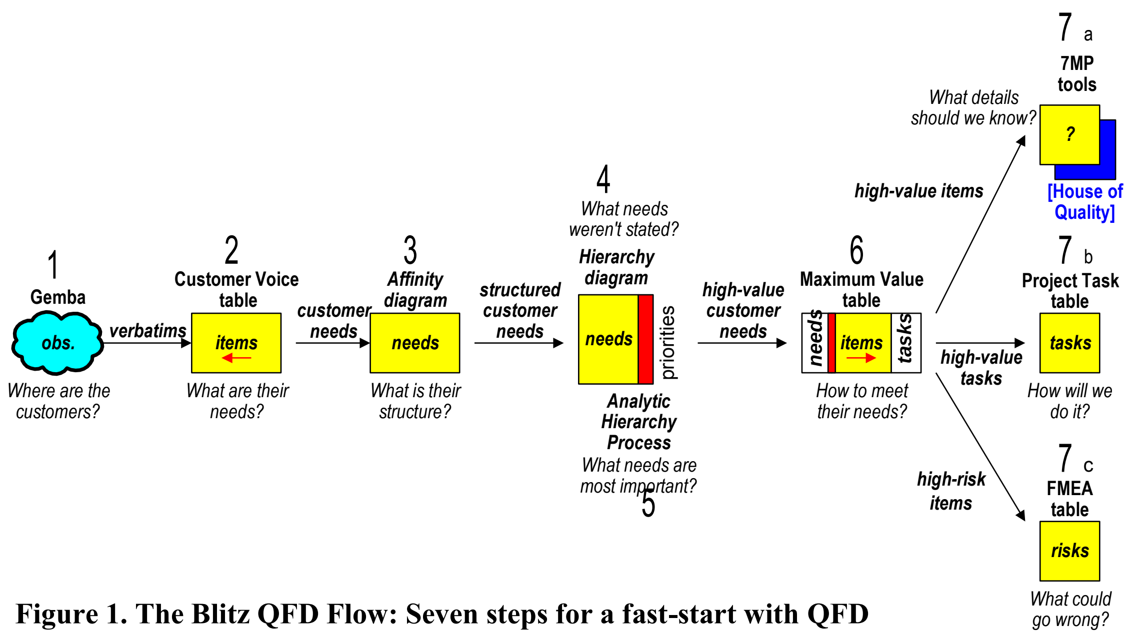


Figure 1. The Blitz QFD Flow: Seven steps for a fast-start with QFD

Blitz QFD is an "essential minimum method" to identify high-value needs, product characteristics, and project tasks, quickly (Zultner 1995):

1. **Where are the customers?** Blitz QFD begins by focusing on the most important customers, and by direct observation of their needs—by going to the *gemba*. This supplements traditional interviewing, and offers a way to obtain in-context details needed to discover unstated requirements.

2. **What are their needs?** Once we are focused on the most important customers, then we must analyse their statements—their *verbatims*. The Customer Voice table (CVT) is used to understand and analyse what customers say, and why. The result is a list of refined customer needs—what 'value' is for this customer, for this product, on this project. These are *not* product features, but customer needs.

3. **What is their structure?** Once the customer needs are clear, their structure must be determined. The KJ method is used *with customers* to produce an Affinity Diagram (AD) that shows how customers think about their needs—the skeleton structure of their requirements.

4. **What needs weren't stated?** Using the skeleton structure, a Hierarchy Diagram (HD) is produced, and analysed for unstated, but structurally implied, requirements. These must be confirmed with customers. Now we understand the wants and needs of the customers, and their structure.

5. **What needs are most important?** The customer needs hierarchy is then quantified and prioritised with customers—top-down. This allows us to identify most of the most important customer needs *first*. The result is the small number of needs that delivers most of the value to the customer.

6. **How to meet their needs?** The vital few most important needs are then analysed in depth in the Maximum Value table (MVT). Here, every important, difficult, or risky project activity required to deliver each of the most important needs is identified. The result is the clear identification of those project tasks where the most important needs are acted upon—the *maximum value-adding activities* of the development project. Here is where the project manager must see that best efforts are applied.

7. **What details should we know? How will we do it? What could go wrong?** Once we see where the points of maximum value are, there will be specific details that call for more scrutiny. The seven Management & Planning tools (7MP), the tool set of QFD, are used for this purpose. **The House of Quality matrix** is *one instance* of a matrix being used to explore in detail the interaction between (just) two columns (out of many) on the Maximum Value table. For new high-value tasks, the Project Task table (PTT) is used to define the tasks in more detail. To identify possible failure modes in high-value tasks, the Failure Mode Effect Analysis (FMEA) table can be used. This table is not only useful to consider what might go wrong, but also to plan what countermeasures could be employed to prevent, detect, and minimise project failure modes in high-value development tasks. FMEA is an important tool for risk management: the identification and reduction of project-task-related risk during development.

When Blitz QFD is applied in the context of managing development projects to identify the most value-adding activities, focus best efforts on them, and thereby assure maximum value to customers, this is QFD for Project Management: **Project QFD**. This use of QFD takes the "project manager as customer" perspective, and rapidly identifies the most important project tasks—the ones that add the most value to the customer (Zultner 1997). It is these tasks that offer the greatest leverage for the product development project manager: "where can I apply my limited resources to produce the most value for the customers of the product I am developing?"
Identifying value, and focusing our best efforts on high-value tasks, is essential for successful product development in a competitive environment. But sometimes, developing the product quickly is also critical to satisfying our customers. Then additional methods must be employed.

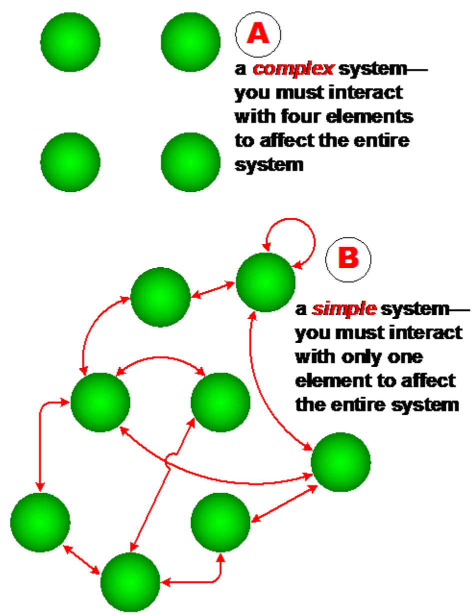
Reducing Schedule with Theory of Constraints (TOC)

The Theory of Constraints, as developed by Dr. Eliyahu M. Goldratt, is the application of the methods of the hard sciences to human systems. At its core, it uses two concepts of the hard sciences that are quite different from their ordinary use: 'complexity', and 'problem'.

'Complexity' in ordinary language refers to the ***amount of data*** required to describe a system. At right, System 'B' requires many words to describe, so we'd ordinarily say it's "complex."

Complexity in the hard sciences refers to ***degrees of freedom***—the number of points you need to interact with to impact the whole system. System 'A' is "complex", as you must interact with four elements to impact the whole system.

In the hard sciences, a '**problem**' is viewed as a conflict between two necessary conditions. Ordinarily, we seek to "solve" problems by compromise—trading off both conditions to get the "best" result we can. Sometimes this is even called "optimisation," as if to suggest that it is not possible to do better. In Theory of Constraints, we "dis-solve" problems by eliminating the conflict with a win-win "no compromise" result. By not compromising, it is possible to get big gains quickly—if you are willing to shift your paradigm…



In order to solve the problem with system A, it is necessary to develop and implement four solutions. Anything less cannot impact the entire system. This will be difficult.

To solve the problem with system B, we will work to discover the one core problem that causes the numerous symptoms we see. We will determine the conflict underlying the core problem, and break it. So we will only have to develop and implement ***one solution***—which will impact the entire system. This is faster and easier.

In looking at the problems traditionally found in managing development projects, can Theory of Constraints analysis find a single solution that could dramatically reduce their elapsed time? Yes, the Critical Chain method achieves significant schedule reduction—even on large projects (Goldratt 1997).

Case Studies

Does the Theory of Constraints solution to traditional project management problems, work on real projects? Big projects? Even huge projects?

Harris Semiconductor, Project Raptor was an investment of $250M —the largest capital investment in Harris Corporation history—in a state-of-the-art 8” wafer fabrication plant in Mountaintop, Pennsylvania USA. Management wanted the plant completed in 27 months. (The world record for completion of a wafer fab at the time was 29 months, and the world record for production ramp-up after completion was 16 months—at a different plant from the one holding the completion record.)

The project team came up with a Critical Chain schedule of 18 months. Management instructed the team to “adjust” their schedule to 23 months, as 18 months was just “too ambitious.”

The plant was complete in 13 months, with a 4% budget overrun. Usually construction projects of this type require at least 30 months.

Ramp-up to full production took 21 additional days. Usually 46-54 months is required to go from groundbreaking to full production. Harris did it in 14 months. With the plant up and running, Critical Chain was then applied to custom chip development: the time was reduced from 8 months to 6 weeks. Harris is now deploying the critical chain approach company-wide (Levinson 1998).

Software Development. There are a number of software development organisations that have completed projects in less time than initially planned by using the Critical Chain approach. One mid-sized software company experienced their first-ever-early large software development project. Another reported that for the first time, large amounts of overtime were not required in order to meet their deadline. Experience to date indicates that software projects experience even greater gains from Critical Chain than hardware projects, as a detailed project plan is required, before Critical Chain can be applied. (Software projects are often deficient with respect to project management planning.)

Shorter Development Schedules

So how are these organisations achieving shorter schedules, without cutting features, adding resources, or increasing risk? They are managing *project task variation* in a more sophisticated way, and not doing many of the usual practices that "invisibly" waste large amounts of time on development projects.

Project Managers of development projects will protest that they, and their team, are working hard every day to get their product developed as soon as possible. For an example of the tremendous losses due to traditional development practices, please see the Appendix on "The Evils of Multi-Tasking."

Avoiding bad practices, like multitasking of project resources, is necessary, but we must also manage variation in a more sophisticated, and visible, way. This is the basis for the "guarantee" that Critical Chain makes: to reduce your development project by 15-25%.

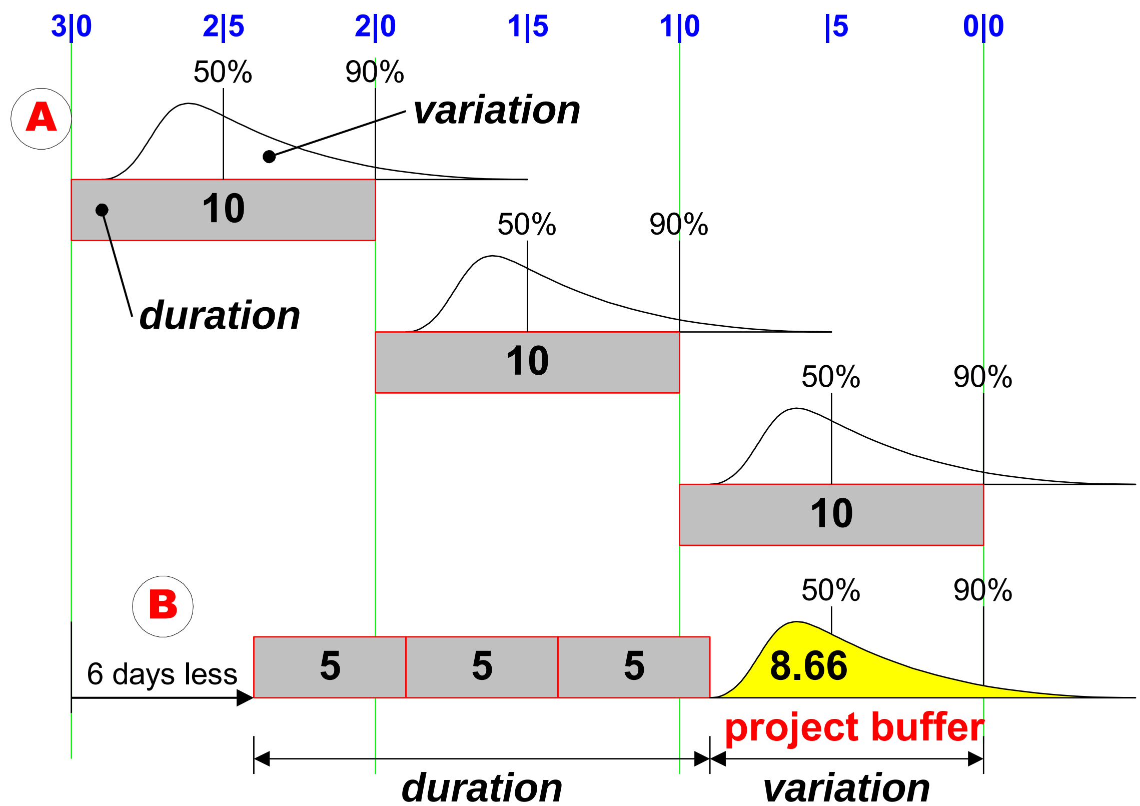


Figure 2. Managing Task Variation Efficiently

In Critical Chain Project Management, variation (risk) is not managed at the *task* level, but at the *project* level—where equal projection requires less time (much more efficient). The same principle is applied by the insurance companies.

Typically, development projects manage variation (risk) at the task level. The estimate to complete a development task is not 50% likely, but 90% likely. This means the estimate includes protection from variation—safety. In the example above (A), three tasks are estimated to take ten days (with 90% confidence). The project will take thirty days (and experienced project managers will add additional safety on to that!)

If instead, as in (B) the safety is collected in a pool for the entire project—a project buffer—a much smaller amount of time can provide equivalent protection. Here a buffer of 8.66 days provides the same safety as 15 days—when safety is managed at the task level. So by managing variation more efficiently, small projects can be done in 15% less time, and large projects in 25% less time.

There are many interesting details of both the problems with traditional critical path project management, and elements of the solution in Critical Chain, that have been developed [Zultner 1998]. In practice, the entire "how to" details of Critical Chain can be learned in two days. Critical Chain, is in many respects, a *simpler* approach to project management for development projects than traditional project management.

Implementing Critical Chain

The technical details of Critical Chain are a reasonably straightforward application of an understanding of variation to project planning. The challenge comes in implementing it in an organisation. Why is Critical Chain easy to understand, but challenging to implement?

Warning! Paradigm Shift Required! Critical Chain requires a new way of thinking about planning and managing projects. The number of things done differently justify Critical Chain as a paradigm shift:

Critical Path Project Management	**Critical Chain Project Management**
The project finish is a date we think we can hit (and then we work like hell to try and make it).	The project finish is planned with a chosen level of likelihood, and assured with a project buffer.
The critical path determines the start and end of the project.	The critical path determines the end of the project (after a project buffer is added to it), but the start is often determined by a non-critical activity.
Variation is implicit and assumed to "average out" over the length of the project.	Variation is explicitly planned and managed throughout the project with appropriate buffers.
Variation is managed at the task level (component view).	Variation is managed at the project level (system view).
To keep the project on schedule, we must keep each task on schedule.	To keep the project on schedule, we manage our buffers, which allow us to absorb variation efficiently.
Task starts and finishes are carefully tracked. Schedule "slippage" is important and is closely monitored.	Buffer status is carefully tracked. When any task starts or finishes relative to the calendar is not important.
People are evaluated in terms of whether their tasks are late relative to the planned calendar date.	Half of all tasks are expected to take longer than planned, and the buffers absorb such variation.
Fixed-date "stage gate" reviews are scheduled to evaluate project progress to date.	Floating "stage gate" reviews are triggered by phase end, and review the status of buffers remaining.
The amount of slack that non-critical path activities have is not important.	Non-critical path activities must have a sufficient "feeding buffer" to protect the critical path from their variation.
Making progress on every project, during every reporting period, is important, so resources are multi-tasked.	Multi-tasking of resources is devastating, and is avoided at all costs, including delaying the start of projects.

Table 1. Traditional versus Critical Chain Project Management.

Ten key differences that make Critical Chain project management a *paradigm shift* from traditional Critical Path project management. A paradigm shift requires a change in mindset, and behaviour, by the whole team.

Layers of Resistance. It is not easy to persuade people to do things very differently from what they have long been doing, even though your logic is impeccable, and the need is great, and the benefits are large.

People raise objections to new ideas in a pattern: the layers of resistance. The implementation of Critical Chain Project Management must be carefully structured to move people through all five layers successfully and efficiently. Only then implementation be successful, and sustained.
Here is a summary of the layers of resistance. For each layer there are specific tools and techniques used to efficiently work through the resistance, and achieve buy-in to the solution.

- **Layer 1:** “That's not our real problem”
- **Layer 2:** “That's not the right direction to look for a solution”
- **Layer 3:** “That's not a solution”
- **Layer 4:** “There are negative effects with that solution”
- **Layer 5:** “There are obstacles to implementing that solution”
- **Layer 6:** Unverbalised fear.

The layers of resistance represent defence-in-depth against bad ideas—so they won’t harm the organisation. “No resistance” to new ideas is good, for people, or for organisations. Good ideas will (eventually) make it through the resistance—but we can accelerate the process (from years to weeks).

Implementation Program. The Critical Chain Implementation Program includes methods for overcoming each layer of resistance in sequence. A “typical” implementation of Critical Chain on a project requires five to ten days of training and facilitation. Only two or three days of training is needed to teach the team “how to” do Critical Chain planning—the rest of the time is spent working through the layers of resistance with the team and their stakeholders. All key players must be intellectually and emotionally comfortable with the approach and its implications *before* the Critical Chain schedule is put into action.

To date, the Critical Chain approach has accumulated a most impressive track record in dozens of organisations. This is due primarily to a very careful and thorough implementation process. An understanding of the layers of resistance is an essential part of successful implementation of the Critical Chain approach in product development organisations.

The application of the Theory of Constraints to the problems of traditional project management gives us a new way to plan and manage product development projects: **Critical Chain**. A more sophisticated approach to planning and managing product development projects, it has consistently reduced project schedules by 15-25% without cutting features, increasing risk, or adding resources to development projects. Critical Chain is a paradigm shift for project managers, and development organisations. Some people, and organisations, are already pioneering this paradigm shift. Would you like to join them? Or will you let your competitors go first…

Once QFD is used to assure the value of our product to our customers, and Critical Chain is used to reduce our development project schedule, are there any further gains to be made on our projects?

Reducing Risk with Statistical Process Control (SPC)

Critical Chain makes variation visible in a buffer, instead of being hidden inside tasks. The variation of the elapsed time of development projects is an operational definition of project **risk**. Risky tasks require more safety, and larger project buffers, and therefore longer project schedules. Further, not all risks can be anticipated, even using a generous project buffer. How can we reduce the risk of project activities, thereby reducing the size of the protective buffer, and thus our project schedule?

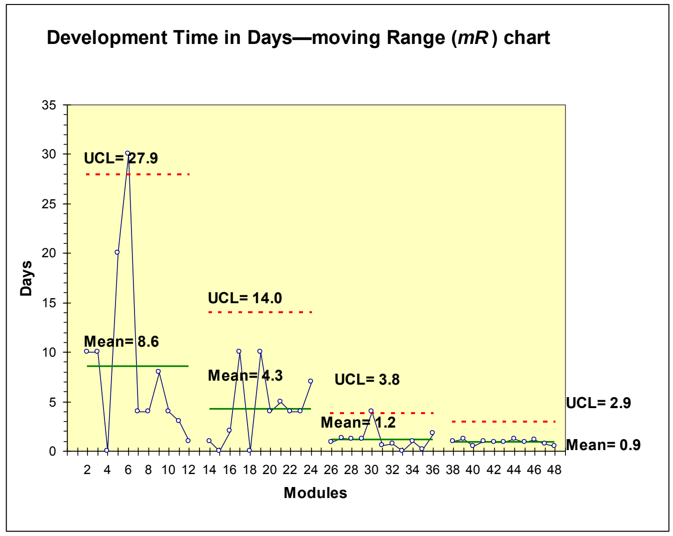
Variation = Risk

All real-world processes have "noise"—that is, they exhibit variation. Such variation can be *measured* using the oldest and most basic tool of quality—the **control chart** (Wheeler 1993, 1992: 1995). When examined in this way, a development task is a process, and can determined to be either in-control (stable) or out-of-control (unstable). Unstable development tasks are inherently risky. SPC methods, such as the **Quality Improvement (QI) Story** (Kume 1985) can be used to *stabilise* out-of-control development processes, and further, to *reduce* their variation—and often their duration as well. How would this work on actual development projects?

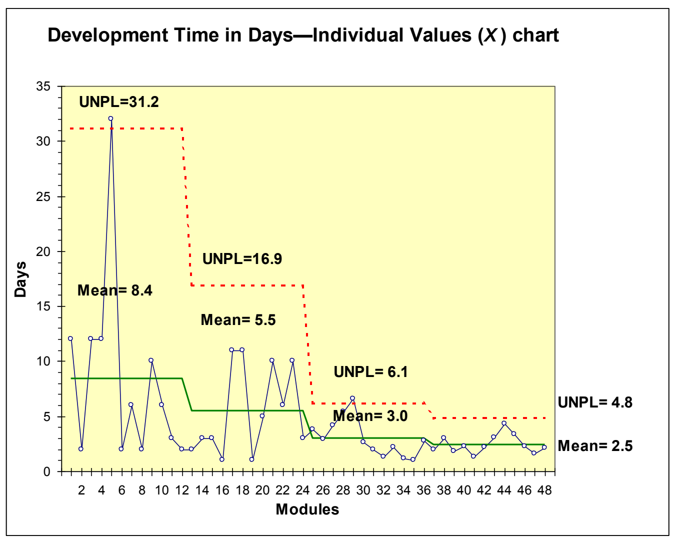
Case Study

Software Development. A software development project team had reached the activity of module development. This includes the work of module design, coding, and unit test.

As seen in the first section of the control charts, the variation (shown on the moving range chart) was averaging 8.6 days, and the duration (shown on the individual chart) was averaging 8.4 days. Further, the activity was out-of-control. The project manager realised the riskiness of the work, and led the team in applying the QI Story to try and get the activity under control, and then reduce the variation.



In the second section, the team was able to remove the special cause, and stabilise the activity with an average variability of 4.3 days, and an average duration of 5.5 days. Now the real improvement could begin.



In the third section, the initial results of the QI Story can be seen. The team made five specific changes to their work process, and as a result, the average variability dropped to 1.2 days, and the average duration dropped to 3.0 days.

This was a very significant improvement, but as is common, such changes put the process out of control. When the standardisation step of the QI Story was applied, the process stabilised at an average variability of 0.9 days, and an average duration of 2.5 days.

The team performed these improvements while developing their first 48 modules, and the gains were maintained over the next (and last) 52 modules as well. The team was able to significantly reduce the risk of a critical development activity—decreasing the possibility of missing their deadline. The team, the only resources for improvement the project manager had, made the *improvements while doing their development work*. This activity now requires less safety in the project buffer, reducing the minimum required size of the buffer, and thus shortening the project. Finally, their improvements in risk reduction also had the benefit of reducing the average time required to develop each module, directly reducing the total elapsed time required by the activity, and thus also reducing the overall project schedule.

In this way, SPC can be used to *protect* the Critical Chain project plan, and *recover* from unforeseen problems during the project—without the use of more resources or impacting the project schedule.

When SPC is applied in the context of project management to improve how project tasks are done—to reduce risk (and thereby often reducing task duration), this is SPC for Project Management: **Statistical Project Control**. For many years project managers of product development projects have complained about the riskiness of their endeavours. Now they have a way to reduce project-related risks: the Quality Improvement Story, and the control chart. Risk can be successfully reduced on development projects.

Conclusion

To do product development projects better, we must efficiently *satisfy* our customers. Blitz QFD for Projects—**Project QFD—**can identify where we add the most value to our customers, so we can concentrate our limited resources at those points, to generate maximum value in our products.

To do product development projects better, we must develop with greater *speed*. **Critical Chain** Project Management can give us project schedules 15-25% shorter by more efficiently managing protection from risk—if we are willing to change our paradigm…and stop multi-tasking project resources.

To do product development projects better, we must develop with less *risk*. **Statistical Project Control**, using the **Quality Improvement Story** and **control charts**, can safely reduce the variability, and often the duration, of high-value or high-risk project tasks.

These methods offer us a synergistic approach to doing product development projects significantly better in substantially less time *without* cutting features, increasing risk, or adding resources.

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Author

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Version: 1.20 Revised 24 July 1998 by ZULTNER & COMPANY

APPENDIX II

The Development and Assessment of Virtual Teams

Written by: Ted Tooher, Director, Tooher Gale and Associates, Sydney, Australia.

Abstract

This paper describes recent experience in assessment of performance of virtual teams in a learning environment, particularly the use of strategic assessment matrices and reflective learning tools. The lessons learnt from the application of the assessment are then applied to give guidance to organisations needing to develop competence in virtual teams.

Introduction

This paper extends the previous work presented in London at the IPMA, May 2000 conference into the assessment of teams involved in learning process. It also provides guidelines for development of virtual teams in an International environment.

Experience with Virtual Teams

The current development of project management skills focuses on the project manager's attributes and competencies, not generally, on the Teams Competency. The expression of leadership competency, through the performance of the Team, rather than assessing the individual, is a largely untested approach, in project management.

In contrast to the project environment, the business environment, has several examples of team evaluation notably by Beblin (1991).

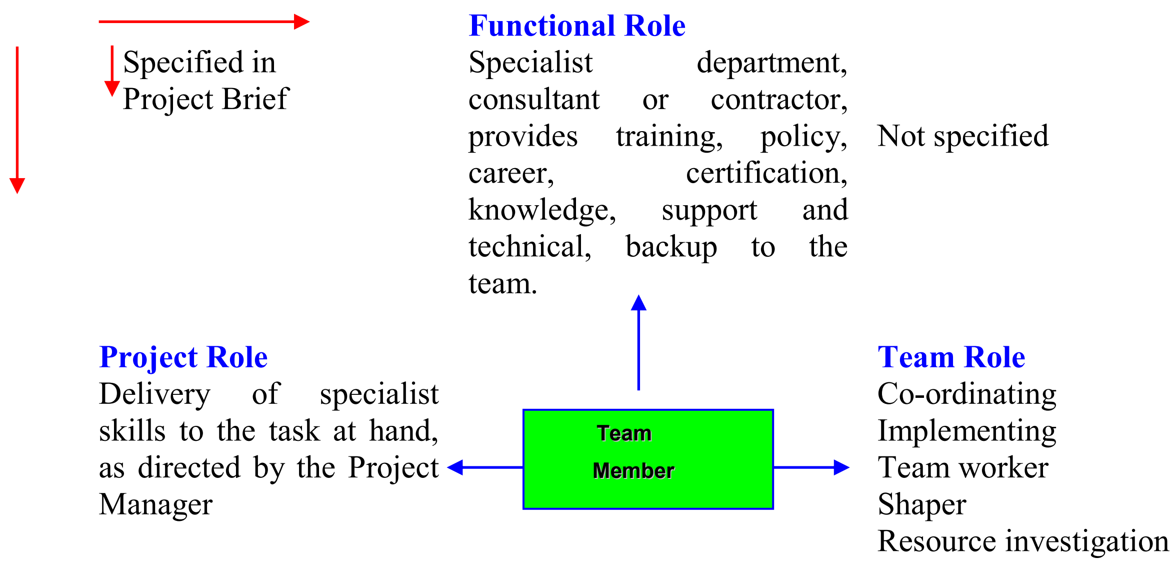
How does a virtual team work? what are measures of its effectiveness and what can be done to recognise poor performance and improve it? These are the questions a current generation of Project Directors are asking themselves, as they deal with 24-hour project teams working through the Internet.

Previous work by researchers has investigated the number of project members who work in a virtual environment i.e., through the Internet, telephone or fax, as distinct from face to face, with colleagues. Some research has also looked at how virtual teams make decisions and what software tools are most cost effective, in a virtual environment.

The author's previous paper IPMA May 2000 defined virtual teams as those of 6 to 10 persons working predominantly through the Internet, but supported by fax, phone, videophone and computer networks. Teams of larger sizes are probably common, however it is likely that normal organisational influences will limit the number to 10 members i.e. people working to a common objective (or task in the Work Breakdown Structure (WBS)), beyond this size, sub-teams or specialist teams would be formed). At higher levels in the WBS the project management team may also work virtually.

This paper does not explore the effect of the virtual team approach on different organisational structures e.g. hierarchical, matrix or flat structures, however, often by default, a matrix structured approach is adopted by most organisations.

The Matrix Structured Team is established as the most common project delivery process to which team members, as specialists contribute effort. The matrix team member relationship, most commonly, specifies a joint functional and project role as shown below:



A third role, i.e. the team role, an obscure, often forgotten, but necessary ingredient of high Performance Teams (Belbin, 1991), has also been recognised, in virtual team competence building, by the author.

The three roles of a project team member i.e.

- Functional Role (providing competent knowledge, e.g. engineering, finance)

- Project Role (undertaking a project task with others)

- Team Role (e.g., co-ordinator, completer, shaper (Beblin (1991)).

Have been observed in our work with over 40 participants in team based learning programs delivered over the Internet.

A comparison of four teams, who undertook the project, and their competence, as assessed by the author is shown below. An extended Team Performance Measurement scale matrix was used.

The extended scale, indicates assessment of leadership, specialised knowledge, process, self assessment and expanded tests for, human resources, communications and systems competence.

Team Competency Assessment Matrix

Key Result Area	Aware	Informed	Involved	Competent	Best Practice
Human Resource	Team members known	Team roles known	Balanced Team formed	Team built and balanced	Team adjust to workload
	CV's available	Specialist roles known	Workload assessed	Performance measured	Feedback used
Communications	Names & address known	Communication plan prepared	Information flow monitored	Feedback used Ethics, language, thesaurus	Plan changes to suit project
	Internet applications used	Protocols agreed adopted	Code of Ethics	Responsibilities defined	Expert
Systems	Phone and fax used	Standard software used	Templates & format agreed	Webpage developed	Software and systems used
	Computer equipment available	Compatible equipment specified	Procedures aligned	System performance measured	Systems inform stakeholders
Specialised knowledge	Specialisation known	Competency assessed	Competency gaps known	Training or additional resources used	Competencies adjusted to meet project objectives
	Skills known	Skill needs known	Performance peer reviewed	Specialised suppliers used	
Leadership	Reporting structure	Project manager (PM)	Competency & effective	Feedback used to modify	Role adjusts to meet

	known	appointed	ness measured	and adjust role	project needs
Process	No process used	4 phase project model	Uses 5 PMBOK process	Process adjusted to overcome issues	Process modified to assure project success
Self-assessment	Standard recognised	Standard used to set goal	Performance against standard measured	Peer review and reflective learning used	Review of outcomes used to modify approach

Preliminary analysis of the success of teams in this environment suggests that, team based learning, using a properly structured team achieves learning with 50% or less, of the involvement required where individuals work alone.

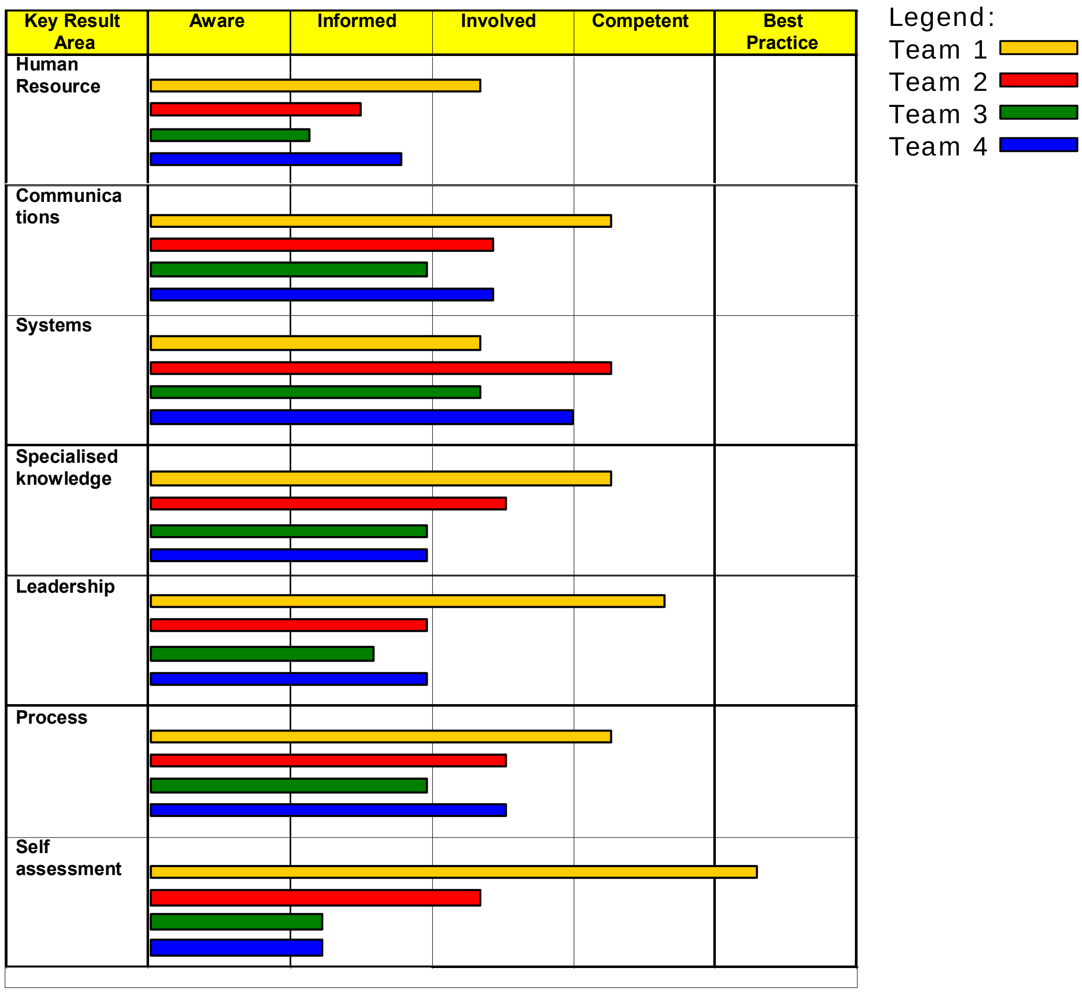
Statements by members who left teams to develop their own learning either because the team broke up or their team colleagues asked them to leave, indicate the level of effort to achieve the same competence was substantially greater, for those individuals. This appears to be due to the need to rely on their own resources and lack of access to peer support.

An additional feature of those who undertook tasks without team support was an inability to self-assess as well as high degree of reliance on outside support.

A key issue for stable teams seemed to be that, despite a wide range of contributions by team members, the team remained focussed throughout. For unstable teams, a common element was the inability to cope with non-performance of members.

The assessment of the four teams using the matrix above was conducted on completion of the project, with the result as shown below.

Measured Performance of Teams



The assessment showed that the best performing teams, that is the ones that achieved the project outcome with the least effort, were consistently either at ‘involved’ or ‘competent’ standard.

Those teams that, disintegrated or lost members were those with lowest levels of competency, particularly in, the areas of leadership and human resources.

A guide for project directors who set up and manage virtual teams is to focus on team competencies such as team leadership process and self-assessment as a shared vision, this may overcome deficiencies in communication and systems, competencies.

It seemed also that attempts to apply a strong authoritarian style of leadership, to the virtual team resulted in, friction, non-performance and disintegration. This last observation may be due to the difficulty of imposing sanctions, through a virtual environment.

Performance Measurement Tools

My previous paper looked also at how, reflective learning and peer review can be used to assess competency, and learning in virtual teams. The idea of using the performance matrix, was tested and has in this paper been applied to projects.

The previous findings i.e. that training in reflective learning needed to be included in the project team initiation, were confirmed at the conclusion of the project.

An outstanding and as yet unresolved issue concerns, learning projects primarily, but could also apply to product development projects where it is necessary that original thinking and verification is required.

In learning projects original thinking is necessary so that competency can be assessed. In other projects, it is necessary to have safeguards in place so that copyright is not breached or local regulations violated, it may also be necessary for validation of work effort.

A statement or signoff of tasks by a virtual team member may not be verifiable and given the complexity of Internet knowledge much of it protected and copyrighted, project teams which cannot recognise whether work is new and valid or merely copied are at risk.

A test is therefore needed by the team to ensure that team members' contribution is their own and, not that of an outside party, which may compromise the team.

The reflective learning test, tests whether the response or team contribution is unique to the individual i.e. only they and the recipient can verify that the task has been completed successfully.

The reflective learning statement uses phrases such as:

- My plan, was to undertake …..
- What actually happened was …..
- This was corrected or scope…, modified by …….
- In future, we need to …..
- Impact on other areas of the project will be ….

These statements can be compared with the task, product or deliverable.

Whilst this goes some way to assisting in competency assessment i.e. testing that Project Management has been applied and is working, a rigorous validation technique has not yet been discovered by the author.

Conclusion

Team performance can be measured against a range of Key Success Factors (KSF), and the relative team performance reflected in the effort required to achieve the outcome. It was also noted that ineffective teams required much greater effort and time than the teams with higher performance as measured by the performance matrix.

The assessment also shows that there is a significant benefit to be obtained by developing, reflective learning skills early on in the project so that, feedback process and team support can be modified.

A key issue still remains i.e. how to validate assessment through reflective learning and or peer review, when these are conducted over the Internet.

There is evidence that teams which understood and managed their, team role, functional role and specialist roles, performed much better than those that worked on a task allocation and responsibility basis. Those teams that understood reflective learning also were able to self-assess and correct their work more rapidly and effectively.

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Chapter 12 The operations challenge

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The operations challenge

Learning outcomes

By successfully achieving the stated 'enabling objectives' for this chapter, you should be able to:

- understand the impact of the globalisation of markets on operations management and the concept of internationalisation of operations.
- examine how an organisation can compete more effectively on global markets.
- understand how ethics come into operations strategy and how social responsibility influences operations management.
- understand the main international issues faced by operations strategies and how operations strategies can be creative.
- understand the concept of *knowledge management* and contrast explicit and tacit knowledge as a source of competitive advantage.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcomes stated above.

- Understand that globalisation and the increasingly international perspective of business, will have an impact on operations management
- Understand that international operations need to address the problems of managing their operations across national boundaries
- Understand that organisations and operations management have social responsibility for the well-being of society
- Become aware that operations managers have some kind of ethical and ecological responsibility
- Appreciate the role of *knowledge management* in operations management and become familiar with the new technologies in the operations management decision areas.

What you will need

Suggested study time	Text Book	6 hours
	Activities and exercises	3 hours
Other resources:	Suggested readings	3 hours

Total	12 hours

Introduction

Do managers and organisations realise that the world is a smaller place to do business? Intuitively, you would expect the answer to be approximately 50 percent 'yes' and 50 percent 'no'. Review of literature however, revealed that considerable opportunities for operations managers and their organisations have emerged from the globalisation of markets and that operations decisions in today's business environment have an international dimension (Rugman & Hodgetts, 1995). Such international dimension is connected to an organisation's operations strategy.

Because the evidence seems to show that an effective operations strategy helps organisations to compete more effectively internationally, there is a sign that more and more organisations today have a global operations strategy. Although technology and telecommunications have helped operations in the development of an international operations strategy, there are a number of difficulties in formulating successful global operations strategies, which will be presented later in this chapter.

Out of all operations strategic decisions perhaps the longest-term operations management strategic decision with global impact is that of international location. As discussed in Chapter 4, networks of operations can spread across several geographic regions. However, not all organisations will choose to design their international networks to the same pattern. The main international issues faced by operations strategies are those connected to operations configuration. Different configurations of operations will be appropriate for different organisations. According to Du Bois and Oliff (1992) there are four configuration strategies that are linked to the behaviour of international companies. These are:

- home country configuration
- regional configuration
- global co-ordinated configuration
- combined regional and global co-ordinated configuration.

Furthermore, operations managers should be aware that different regions in the world often develop different operations practices depending on economic, social and political circumstances. Some of these practices developed in one part of the world can be transferred, often in a modified form, to other parts of the world.

All in all, operations strategies are called to reconcile markets' requirements and operations' resources without ignoring the issues of social responsibility. Social responsibility can be seen as the broad application of ethics in decision-making (Slack et al. 2001). Therefore, all decisions made by operations managers have some kind of ethical dimension. Regardless of the country's or company's ethical framework, operations managers ethical considerations would affect one or more of the following groups:

- the operation's customers
- the operation's staff
- the suppliers who provide the operation with materials and services
- the community in which the operation exists
- the operations' shareholders and owners.

Furthermore, the good news in today's business environment is that most organisations recognise and respond to their ecological responsibilities by making their ethical stance explicit through a statement of mission and values. Operations managers often have to implement the environmental management system ISO 14000, which evaluates how products, services and processes interact with the environment.

As discussed earlier, technology and telecommunications have helped operations in the development of an international operations strategy. Over the years it has been recognised that technology in some form or other becomes a means of building competitive advantage. The use of new technologies such as Internet, Electronic Point of Sale, and Data Missing Systems for example, can assist operations to become more competitive as a result of either being better than its competitors or being different from its competitors. Although technologies are often perceived as supporting an organisation's performance objectives (known as *sustaining technologies*), there are certain technologies that cannot match the performance that customers expect from products and services. These technologies are known as *disruptive technologies* (Christensen, 1997). We will discuss *sustaining technologies* and *disruptive technologies* in a later part of this chapter.

Finally, the introduction of *knowledge management* in today's operations environment is recognised to be one of the most important challenges faced by operations managers who are the key custodians of process technology. Within the knowledge management context an important distinction is that between *explicit knowledge* and *tacit knowledge*. Explicit knowledge is codified, whereas tacit knowledge is embedded deep within individuals in the operations. The challenge for operations managers however is the process of knowledge creation, which involves moving between tacit and explicit knowledge.

In summary, creative and successful operations tend to show that they have support from top management, are business driven, make technology decisions driven by the strategy itself, have changes which are integrated, invest in people as well as new technology, manage technology, as well as, people, and finally manage knowledge.

Globalisation and operations decisions

As discussed in earlier chapters of this subject, operations are complicated by the fact that they have many elements. Putting those together into a coherent whole so that they all help the business compete is a challenging task, but this is what we seek to do when formulating an operations strategy. Over the years it has been recognised that a formal operations strategy helps ensure that the policies adopted in the operations function fit together in a coherent manner. The strategy provides a framework for future decision-making and gives operations management direction.

In addition to the complexity there are a number of difficulties that have to be faced by operations managers in formulating global operations strategies. These are:

- Operations managers have to deal with different work cultures that have different views on the nature of work

- Operations managers have to adhere to and follow international environmental policies

- Operations managers tend to be geographically dispersed

- Operations managers operate in real time and therefore need to manage the operation

- Operations resources are difficult to change

- Operations managers are often not in the habit of contributing to strategic change.

As a result of these difficulties, most of the operations management decisions in today's business environment have an international dimension (Rugman & Hodgetts, 1995), which is connected to the formation of an organisation's operations strategy.

Therefore, during the formation of operations strategies some global considerations have to be taken into account mainly connected to cultural and economic differences that impact the day-to-day activities of operations management decision-making. Some global considerations of operations management decisions that have to be carefully thought about are listed below:

- transferability of product and service design and the adaptation of design to fit different cultures and legislation
- cultural reaction to work organisation
- labour costs and skills availability in different countries
- differences in seasonality and demand patterns
- legislation and cultural views of flexible working
- legislation of part-time and temporary work contracts
- cost of capital and other storage cost differences
- cultural views of acceptable quality

- cultural views of participation in improvement groups
- cultural attitude to risk
- differences in contractual arrangements
- flexibility of response to failure.

Adopted from Slack et al. (2001)

Following on the globalisation considerations of operations management decisions, it is important for operations managers to be aware of the "content" of an operations strategy including the impact on the environment and/or the economic and social well being of the community. (for the purpose of this chapter "content" is the output of the operations strategy process.) For example, if a company decides to import some of its components from a Third World country, where wages are very low, is this a good or bad operations management decision? Local trade unions probably will oppose the 'export of jobs'. Shareholders on the other hand will most likely support the decision for higher profits. Environmentalists would want to ensure that natural resources were not affected, and everyone with a social conscience would want to ensure that workers from a Third World country were not exploited. Decisions of this nature are made every day by operations managers throughout the world (Slack et al. 2001) and are known to be troublesome and costly.

The challenge for operations managers is the reduction or even elimination of such decisions through long-term operations management strategic decisions with global impact.

International location

Perhaps the longest-term operations management decision is that of international location. As discussed in Chapter 4, networks of operations can spread across several geographic regions. However, not all organisations will choose to design their international networks to the same pattern. The main international issues faced by operations strategies are those connected to operations configuration. Different configurations of operations will be appropriate for different organisations. According to Du Bois and Oliff (1992) there are four configuration strategies that are linked to the behaviour of international companies. These are:

- home country configuration

- regional configuration

- global co-ordinated configuration

- combined regional and global co-ordinated configuration.

Home country configuration: the simplest strategy for an organisation trading around the world is not to locate plants outside its home country and to export its products and services to foreign markets. Applying this strategy an organisation is avoiding the necessity of locating any part of its facilities outside its own home country.

Regional configuration: an alternative strategy is to divide the company's international markets into a small number of regions, such as Australasia, North America or Western Europe. Any organisation choosing this strategy will try to make each region self-contained and certainly the operation in the region is independent from the home country's operation. For example, Australia's market would be served by Ford Motor Company's (www.ford.com.au) operations in the Australasia region.

Global co-ordinated configuration: the opposite of the regional configuration, for organisations with global locations, is known as *global co-ordinated configuration*. In such configuration, the various operations concentrate on a narrow set of activities, products and services, which in turn are distributed to the markets around the world.

Combined regional and global co-ordinated configuration: organisations often attempt to take advantage of the two previously mentioned, regional and global co-ordinated strategies, by adopting a compromise between them. The reason being that the regional strategy has the advantage of organisational simplicity and clarity, whereas the global co-ordinated strategy has the benefits of well-exploited regional strategy. The details of the four broad types of international operations network configurations are presented by Slack et al. (1998).

As discussed in the introductory section of this chapter, operations managers should be aware that operations in different regions in the world often develop different operations practices depending on the economic, social and political circumstances. Some of these practices developed in one part of the world can be often transferred, in a modified form, to other parts of the world, building competitive advantage to those organisations foreseeing such practices.

Finally, operations managers should be aware that international businesses encounter various problems caused by language, culture, and the local environment. Having said this, a major advantage of being multinational is that the business can begin to develop a multi-cultural perspective, which helps it understand new markets and ways of working.

How operations strategies have an ethical dimension

Operations strategies are called to reconcile market's requirements and operation's resources without ignoring the issues of social responsibility. Social responsibility can be seen as the broad application of ethics in decision-making (Slack et al. 2001). Ethics can be considered as the framework of moral behaviour, which determines whether we judge a particular operation's decision as being right or wrong (Neely, 1998).

As discussed in the introductory section of this chapter, an operation's ethical stance impacts various groups. These groups include *customers*, *staff*, and the *suppliers* who provide the operation with materials and services, the *community* in which the operation exists, and the operations *shareholders* and *owners*. In principle, any operation has a social responsibility to ensure that it does not disadvantage any of these groups. Therefore, all decisions made by operations managers have some kind of ethical dimension that has ethical implications for operations management decision-making. Some of the ethical issues to be considered for each of the major operations management decisions include:

- **Product/service design** - customer safety, recyclability of materials, energy consumption and disposal of hazardous waste, etc.

- **Network design** - employment implications and environmental impact of location, employment implications of plant closure, and employment implications of vertical integration

- **Layout of facilities** - staff safety, disabled customer access and energy efficiency

- **Process technology** - staff safety, waste and product disposal, noise pollution, fumes and emissions, repetitive/alienating work, and energy efficiency

- **Job design** - staff safety, workplace stress, repetitive/alienating work, unsocial working hours, customer safety when there is a high contact operation

- **Planning and control** - priority given to each customer, materials utilisation and wastage, unsocial working hours, workplace stress, and restrictive organisational cultures

- **Capacity planning and control** - hire and fire employment policies, working hours fluctuations, unsocial working hours, service cover in emergencies, relationships with subcontractors, dumping of products below costs

- **Inventory planning and control** - price manipulation in restricted markets, energy management, warehouse safety, and obsolescence and wastage

- **Supply chain planning and control** - honesty in supplier relationships, transparency of cost data, non-exploitation of developing country suppliers, prompt payment of suppliers, minimising energy consumption in distribution, using recycled materials

- **Quality planning and control** - customer safety, staff safety, workplace stress, scrap and wastage of materials

- **Failure prevention and recovery** - environmental impact of process failures, customer safety, and staff safety.

In summary, it is important to understand that the above ethical issues are intimately connected with the day-to-day decisions of operations managers. Operations management decisions in product and service design significantly affect the utilisation of materials both in the short-term as well as in long-term recyclability. For example, in the effort of reducing the environmental impact of its products and processes the BMW (www.bmw.com) uses recyclable plastic parts in its latest automobile models.

Process design influences the proportion of energy and labour, which is wasted and, again, materials' wastage. Planning and control may affect material wastage as well as energy and labour wastage. Operations decisions, of course, aim at reducing wastage and save costs for the organisation. Having in mind the social responsibility considerations of operations management decisions please proceed to activity 12.1.

Activity 12.1

The Reduction of Wastage

In your organisation or department suggest process, planning or quality improvements that will lead to the reduction in the wastage of materials and energy.

In your suggestion(s) you must include an estimate of the required capital expenditures. What is the effect on the annual budget likely to be?

What difficulties would you anticipate during the implementation of the suggested improvements?

ISO 14000

Furthermore, most organisations recognise and respond to their ecological responsibilities by making their ethical stance explicit through a statement of mission and values. Operations managers often implement the environmental management system ISO 14000, which evaluates how products, services and processes interact with the environment. According to Slack et al. (2001), ISO 14000 suggests a number of specific requirements, including the following:

- a commitment by top-level management to environmental management
- the development and communication of an environmental policy
- the establishment of relevant and legal regulatory requirements
- the setting of environmental objectives and targets
- the establishment and updating of a specific environmental program, or programs, geared to achieving the objectives and targets
- the implementation of supporting systems such as training, operational control and emergency planning
- regular monitoring and measurement of all operational activities
- a full audit procedure to review the working and suitability of systems

The interested reader can refer to the ISO 14000 series (i.e., 14001, 14002, 14003, 14010, 14011, 14012, etc) to obtain specific environmental management system recommendations. (Note that ISO 14000 standards are based on the quality procedures of ISO 9000.)

Technology and operations management

As discussed in the introductory section of this chapter, technology and telecommunications have helped operations in the development of an international operations strategy. The use of new technologies such as *Electronic Data Interchange (EDI)*, *Internet*, *Electronic Point of Sale (EPOS)*, and *Data Missing Systems* for example, can assist operations to become more competitive as a result of either being better than its competitors or being different from its competitors. Although technologies perceived to support an organisation's performance objectives are known as *sustaining technologies*. There are certain technologies that cannot match the performance that customers expect from products and services. These technologies are known as *disruptive technologies* (Christensen, 1997).

Sustaining technologies are those, which have been recognised in some form or other as the means of building competitive advantage. These technologies improve the performance of established products and services along the same dimensions of performance which the majority of customers have historically valued (Slack et al. 2001). Review of the literature revealed that technology:

- can increase automation, which in conjunction with centralisation can produce significant economies of scale. Thus, technology helps an organisation to be *better* than its competitors

- can increase automation, which in conjunction with decentralisation (self-managed work teams) can significantly improve communication between work teams throughout the organisation. Thus, technology helps an organisation to be more *agile and flexible* than its competitors

- may help an organisation to improve its decision-making performance. For example, video conferencing of a job interview permits remote participating parties to be actively involved in the hiring process. Thus, technology again is helping the organisation to be *better* and *more efficient* than its competitors

- can allow individuals to purchase on line products and services. For example, the internet-based bookseller Amazon.com (www.1amozon.com) has created a business based on the use of interactive order forms and 'one click' ordering. Therefore, technology improves accuracy of direct orders meaning that Amazon.com enjoys far lower return rate than its book chain competitors

- known as **'data missing'** systems which allow the sophisticated manipulation of large quantities of customer-related data, which in turn will allow operations to customise the way in which they service customers. In this way, technology is allowing the organisation to be both *better* than and *different* from its competitors.

Disruptive technologies on the other hand are those which, in the sort term, cannot match the performance that customers expect from products and services. They are typically simpler, cheaper, smaller and sometimes more convenient, but often do not provide conventionally enhanced product or service characteristics (Slack et al. 2001). Practice has shown that disruptive technologies usually improve over time, and according to Christensen (1997) disruptive technologies will eventually match the performance that customers expect from products and services. The dilemma for organisations however, is how to simultaneously improve product or service performance using sustaining technologies, whilst deciding whether and how to incorporate disruptive technologies.

In summary, technology has an impact in almost every area of operations management. For example, in the area of product and service design the technologies of virtual reality and rapid prototyping coupled with common computer aided design (CAD) systems and databases are often used in helping organisations to be *better* and *more efficient* than their competitors. In the area of supply chain planning and control, the technologies of Electronic Data Interchange (EDI) coupled with Internet-based purchasing and supply chain co-ordination allow the organisation to be both *better* than and *different* from its competitors. Last but not least, in the area of inventory planning and control, the technologies of automated warehousing and automated guided vehicles linked with bar code readers and EPOS technologies allow organisations to be both *better* than and *different* from their competitors.

Activity 12.2

Technology and the Retail Revolution

Not everyone predicts a golden future for Internet retailing. The sociologist Professor Laurie Taylor believes that hi-tech shopping is doomed unless it pays more attention to people's psychological needs. "People welcome advice", he says, "especially when buying such items as clothes, electrical goods and home decoration where they feel they need guidance". Retailers must try to bring back conversation into shopping: "Banishing customers to the remote and impersonal bank teller machines was a huge mistake", he says, "because banks lost all those wonderful human contacts as well as the chance to sell customers life insurance and pensions".

This may also limit the potential of selling through the Internet. "The most successful businesses sell books and CDs where people know exactly what they want to buy and the product goes through the letterbox ". Businesses where customers are less sure about what they want to buy and where products cannot be delivered through the mail may not be the best candidates for technology-based selling.

Questions:

1. From your own experience, what are the major technologies now being used in high-contact retailing (that is, not 'mail order' retailing) in addition to the ones mentioned above?

2. What are the advantages which most of these technologies give?

3. Do you think Professor Laurie Taylor is right in his criticisms of technology in retail operations?

Source: Slack et al. (2001: 242)

Knowledge management and operations management

In Chapter 4 of this course we presented the operations networks, which connect different operations and micro-operations in order for organisations to trade and develop closer relationships with one another. At the individual level, trade or exchange of information is often done through *knowledge*. Within the operations management framework *knowledge* creates and transforms input resources into products and services. The elements of knowledge have an impact in almost every area of operations management. For example, in the area of product and service design the *knowledge* of customer requirements and behaviour and the *knowledge* of constraints and capabilities of the operation are used during the operations management activities. In the area of quality planning and control the *knowledge* of quality requirements, process behaviour and process improvement potentials is used helping organisations to be *better* and *more efficient* than their competitors. Last but not least, in the area of job design the knowledge of anthropometric (measurements of the geometry and texture of the human body) requirements and team skill requirements is employed to improve the workplace conditions of employees. (The interested reader can refer to Slack et al. 2001, page 726, to obtain some elements of knowledge, which are created and used during the operations management activities.)

The introduction of *knowledge management* in today's operations is recognised to be one of the most important challenges faced by operations managers who are the key custodians of process technology.

Within the knowledge management context an important distinction is between *explicit knowledge* and *tacit knowledge*. *Explicit knowledge* is codified, can be explained verbally, or in writing, and often can be demonstrated in some mathematical form. *Explicit knowledge* usually is found around the operations in formal documents, product and service specifications, and information systems.

Some explicit knowledge however can not be written down or even verbalised. The knowledge of driving a car, for example, is build-up over time and is the result of our experience driving a particular car under different road conditions. This type of knowledge is difficult to explain and is known as *tacit knowledge* (Slack et al. 2001). *Tacit knowledge* is embedded deep within individuals in the operations. *Tacit knowledge* may be observed over time and accumulated over time. We can observe and attempt to imitate knowledge but usually it takes time. Leaders are often used as role models to pass tacit knowledge to new employees. These type of leaders are known in the literature as '*knowledge enable leaders*' (Politis, 2001).

The challenge for operations managers is the process of knowledge creation, which involves moving between tacit and explicit knowledge. Nonaka and Takeuchi (1997) showed that individuals acquire knowledge by moving between tacit and explicit knowledge in a cycle. Figure 12.1 below shows the knowledge creation in operations management.

As shown, learning from experience, known as **socialisation**, is a way of transferring tacit knowledge between individuals. Moving between tacit and explicit knowledge is the process which Nonaka and Takeuchi call **externalisation**. In this process, there is an attempt to articulate experience into rules and decisions. Although it is not possible to convert all tacit knowledge into explicit knowledge, experience has shown that some knowledge, which was tacit, may be capable of being written into formal procedures.

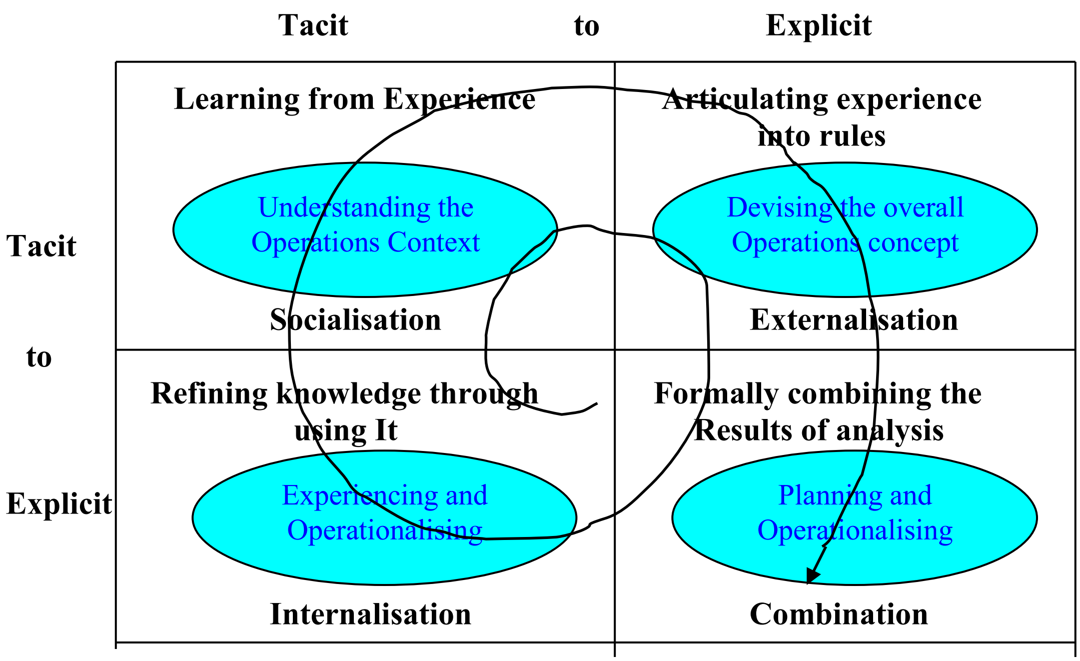

Figure 12.1 Knowledge Creation in Operations Management

Different types of explicit knowledge can be brought together in what is called by Nonaka and Takeuchi the **combination process**. In this process, different pieces of knowledge are collected together for the purpose of planning and operationalisation of the operation. Finally, Figure 12.1 shows the process of **internalisation**. In this knowledge creation process, knowledge is refined through using it and the experience is refined and adjusted. This 'learning by doing' generates tacit knowledge, which is added to the individual's knowledge database.

The cyclical model described above shows the way of understanding the creation of knowledge. Operations manager's ultimate responsibility however, is to create knowledge, to ensure the smooth running of their process and the long-term improvement of the operations. Such managers and or leaders of operations were visualised by Politis (2001) as being the '**knowledge enable leaders**'.

Activity 12.3

Issues Faced by Operations Managers

Debate the main issues faced by operations manager (s) of your organisation in terms of:

- Globalisation and international management
- Environmental management
- Social responsibility
- Technology
- Knowledge management

From the operations management perspective, identify and list the ‘knowledge enable leaders’ of your department. What are the differences of these leaders when compared to those of traditional leaders?

Complete the following questions and exercises

TRUE/FALSE QUESTIONS

1. Opportunities for operations managers and their organisations have emerged from the globalisation of markets. **True**

2. Operations strategy does not provide the framework for future decision-making. **False**

3. Operations managers in formulating *global* operations strategies are faced by many difficulties. **True**

4. Global co-ordinated configuration is to divide the company's international markets into a small number of regions. **False**

5. The various problems caused by language, culture, and the local environment of the international businesses can assist the organisation to develop a multi-cultural perspective. **True**

6. Decisions made by operations managers do not have ethical dimensions for operations management decision-making. **False**

7. ISO 14000 suggests a number of specific requirements for preventive maintenance only. **False**

8. ISO 14000 standards are somehow connected with the procedures of ISO 9000. **True**

9. Sustaining technologies are those which, in the short term, cannot match the performance that customers expect from products and services. **False**

10. *Only* Data Missing Systems can assist operations to become more competitive. **False**

11. Knowledge creates and transforms input resources into products and services. **True**

12. Socialisation is the process, which articulates experience into rules and decisions. **False**

13. Knowledge enabling leaders act in the same way as traditional leaders. **False**

14. Social responsibility is not the responsibility of the operation manger but falls within the duties of the General Manager. **False**

SHORT-ANSWER QUESTIONS

1. What impact will globalisation and an increasingly international perspective on business have on operations management?

2. How does a wider view of social responsibility influence operations management?

3. List and describe the four types of international operations network configurations presented in this chapter.

4. Contrast the concepts of tacit and *explicit knowledge*. Identify which type of knowledge (*tacit* or *explicit*) is difficult to acquire. Explain the reason.

5. How is *knowledge* connected to *new technologies*? Does knowledge management have a role to play in the operations management?

Summary

This chapter provided an introduction to the operation's challenges created by the globalisation of markets and the internationalisation of business. In particular, it focussed on the impact of the globalisation of markets on operations management and the concept of internationalisation of operations. The chapter also examined how an organisation can compete more effectively on global markets. The chapter also investigated how ethics influence operations strategy and how social responsibility influences operations management. The difference between tacit and explicit knowledge has been explored as a source of competitive advantage. The chapter also examined the impact of new technologies in the operations management decision areas.

Before progressing, return to the beginning of this chapter and revisit the stated enabling objectives.

- Can you see how this chapter establishes the context for the rest of the chapter?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this chapter and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this chapter.

Performance criteria 4

Introduction to operations challenges

- ☐ The concept of globalisation and operations decisions

- ☐ The importance of the international location
  - ☐ Home country configuration
  - ☐ Regional configuration
  - ☐ Global co-ordinated configuration
  - ☐ Combined regional and global co-ordinated configuration

- ☐ Operations strategy and the ethical dimension
  - ☐ Product/service design
  - ☐ Network design
  - ☐ Layout of facilities
  - ☐ Process technology
  - ☐ Job design
  - ☐ Planning and control
  - ☐ Capacity planning and control
  - ☐ Inventor planning and control
  - ☐ Supply chain planning and control
  - ☐ Quality planning and control
  - ☐ Failure prevention and recovery

- ☐ ISO 14000
  - ☐ ISO 14000 specific requirements

- Technology and operations management
  - Sustaining technologies
  - Disruptive technologies

- Knowledge management and operations management
  - Explicit knowledge
  - Tacit knowledge
  - Socialisation
  - Externalisation
  - Combination process
  - Internalisation
  - Knowledge enable leader

Make some notes

Insert your own thoughts about this chapter here. Make a few notes about your progress or any issues, which you may want to recall when discussing this chapter with the lecturer or another student.

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