PRODUCTIVITY AND QUALITY MANAGEMENT:

A MODULAR PROGRAMME

Edited by
Joseph PROKOPENKO
and
Klaus NORTH

International Labour Office, Geneva

Asian Productivity Organization, Tokyo
PART II:
HIGH POTENTIAL PRODUCTIVITY AND QUALITY IMPROVEMENT AREAS
CONTENTS

Part II: High potential productivity and quality improvement areas

Module 13: Developing human resources
Module 14: Productivity motivation and Gainsharing
Module 15: Industrial relations and participation for productivity improvement
Module 16: Innovation management and new technologies
Module 17: Work organization and design
Module 18: Production management
Module 19: Materials management
Module 20: Using energy efficiently
Module 21: Productivity by maintenance
Module 22: Information management
Module 23: P&Q in the office

Glossary
MODULE 13
DEVELOPING HUMAN RESOURCES
MODULE 13: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand the main ways in which developing people in an organization can contribute to productivity and appreciate the need for leaders to have a clear vision of "the business", and a positive approach to its employees.

2. Appreciate the need for an overall human resource strategy serving the organization's mission and understand how such a strategy can be established.

3. Establish human resources development (HDR) objectives, policies and plans, and identify HDR needs and priorities related to productivity.

4. Follow the processes involved in selecting and designing an HRD programme to improve productivity and understand how to assess its costs, likely benefits, and eventual outcomes.

5. Understand the kind of HRD programme that can make a major impact on productivity at all levels.

MODULE 13: CONTENTS

UNIT 1: Enhancing productivity through the development of people

UNIT 2: The need for a human resource strategy

UNIT 3: Business-led human resources development

UNIT 4: Establishing HRD needs and priorities related to productivity

UNIT 5: Selecting, designing and costing HRD programmes

UNIT 6: Assessing the impact of HRD on productivity

Bibliography
UNIT 1: ENHANCING PRODUCTIVITY THROUGH THE DEVELOPMENT OF PEOPLE

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the meaning of the term “human resources development” (HRD).
2. Understand the main ways in which the development of people in an organization can contribute to productivity.
3. Understand the importance of the organization’s “vision” and its philosophy about people, in relation to its human resource strategy.
4. Identify the kind of investment your own organization is making in HRD, and decide whether or not the investment needs to be increased.

UNIT 1: CONTENTS

1.1 Human resources development: Definition and main features
1.2 Investing in the development of people to improve productivity
1.3 Organizational vision, philosophy about people, and human resource strategy
UNIT 1: ENHANCING PRODUCTIVITY THROUGH THE DEVELOPMENT OF PEOPLE

The overall purpose of this unit is to show how productivity in organizations can be improved by a strategic approach to the development of people, thus linking human resources development (HRD) with productivity improvement. Before going into details about the interaction between HRD and productivity let us consider some relevant definitions and terms.

1.1 Human resources development: Definition and main features

“Development”, “education” and “training” are three distinct, but related processes. Please give a one-sentence definition of each of the following:

To develop is to:

To educate is to:

To train is to:

Here are some definitions:

To develop “to unfold more fully; to bring out all that is potentially contained in”.
To educate “to bring up so as to form habits, manners, intellectual and physical aptitudes”.
To train “to instruct and discipline in or for some particular art, profession, occupation or practice; to make proficient by such instruction and practice”.

Now let us relate these terms to the phrase “human resources development”. It is quite widely used in preference to “training” or “training and development”. Underpinning its use are five associated viewpoints:

- People are the most valuable resource any organization possesses. They must therefore be treated not as a cost but as an investment, with effective development adding continuously to their value.
- Development is a lifelong activity, whether planned or unplanned. It is achieved, therefore, through a variety of processes. Amongst these, even the most effective training is a limited although valuable vehicle: it helps people perform their specific tasks or jobs adequately, but of itself cannot ensure overall and long-term development. Education is, of course, a major contributor, but again not the only one.
- It is a primary function of all managers to develop the human resources for which they are responsible in the workplace. The personnel or training specialist can act as facilitator, as
catalyst, as provider of expertise where needed, but the manager is directly responsible for performance in the workplace, and therefore it is the manager who must be directly responsible for the optimal deployment of all resources that will achieve that performance, including human resources.

- Managers are the focal point of the most meaningful and lasting work experiences of their staff. It is therefore the manager who can best decide how to organize those work experiences in ways that will help the workers to become highly skilled, flexible, knowledgeable about a wide range of tasks, jobs and situations, and able to continuously improve their performance and develop their potential.

- "Productivity" is about making the most efficient use of all resources and gaining the maximum added value from them. The focus is on output, and on output at every level: of the whole organization, of every business unit, of every team, and of every individual. So human resources development must make its contribution at all these levels. Thus we come to a definition of HRD:

  Human resources development means the skilful provision and organization of learning experiences in order that business goals can be achieved, so that, through enhancing the skills, knowledge, competence, learning ability and enthusiasm of people at every level, there will be continuous organizational as well as individual growth. For HRD to be effective it must be part of a wider strategy for the business, aligned with the organization’s corporate mission and goals.
1.2 Investing in the development of people to improve productivity

Now let us look at two examples of organizations which have invested heavily in developing people specifically in order to boost productivity, although other related objectives are also evident.

SHEERNESS STEEL

Sheerness Steel (see Pickard, 1990) is a private, medium-sized company, which in 1981 was faced with the need to cut costs in order to remain competitive at a time of recession. As part of its cost-cutting drive, it stopped training apprentices and made a quarter of its workforce redundant.

In 1984 the recession began to lift, and Sheerness faced a skills crisis. It was a company without a high profile in the development of people, but at this point, looking at the needs of the business, top management realized that it must develop a skilled workforce not only to improve existing productivity levels, but in order to achieve a real competitive edge in the longer term.

By 1989 Sheerness had made a major investment in the development of its workforce at all levels, resulting in a quarter of its employees studying for vocational qualifications and over a quarter already possessing them. The target for the company was to have 75 per cent of all employees holding vocational qualifications within three years.

What have been the results of this massive injection of money, time, training and education? Over the period in question and, in the company’s view, directly related to its HRD drive, productivity has steadily increased: in the rod mill production has gone up by 60 per cent, which is believed to be mainly due to faster and more efficient working, greater flexibility and increased skills. In the bar mill and the melt shop, productivity rates have improved by a similar figure. Meanwhile, work-hour productivity figures have steadily improved and, after the introduction of a comprehensive health and safety training programme, days lost due to accidents have been more than halved. So for Sheerness, development of people has made a fundamental improvement to productivity and growth at all levels.

HMH SHEETMETAL FABRICATIONS

HMH Sheetmetal Fabrications is a small, owner-managed firm in the north-west of England, which started operation some 19 years ago. Its present turnover is £1.7 million, and it is a successful growth enterprise.

HMH Sheetmetal Fabrications seeks to differentiate itself from other sheet metal companies in four ways: a clear market focus; a high quality product; quality of service; the continuous development of its workforce.

Albert Moss, the owner, recognized from the start that in a business where differentiation is difficult, his unique strength lay in his team of 40 people.

Albert is a highly intelligent, astute businessman. He went on a government-funded “growth” course at a local university business school, and saw the importance of quality in product and service long before “quality” became a jargon word in the UK. He invested in “just-in-time” and “total quality management” and achieved BS 5750 (the Universal British
Quality Standard) at least five years before it was the norm to do so. In fact, HMH is the first company in this industry sector to attain BS 5750 approval.

Albert’s business instincts are sound in other directions too - he has had a mission statement for years, and it appears on notices all over the factory, so that no one can ever lose sight of it. He cultivates a strategic partnership with his customers, ensuring that they always receive the best possible service with a product that, although at first sight is difficult to differentiate, nonetheless is widely known for its superior quality and reliability.

But it is in relation to people and their development that Albert, as the owner-manager of a small firm, stands out. His aim has always been to recruit, train and retrain a small but high-calibre workforce, with all the task and team skills they need to maintain the highest standards of production, quality and service - this is what “productivity” means to HMH Sheetmetal Fabrications.

**Teambuilding**

Albert recruits team leaders from within, and trains them in the skills they need. He uses consultants to provide team training, and chooses teams carefully so that they have an effective balance of personalities and skills. He makes skilful use of all available external sources of funding to carry out these and other forms of development for his workforce.

**Succession planning**

When he brings people in from outside he always does this by word of mouth and networking, in order to ensure that the right skills and potential are brought in, and also that the culture of the business is sustained.

**Pay**

Pay rates are above the norm, but targets are clear and demanding, and people are appraised according to their achievement. Bonuses are given to teams rather than individuals, again to ensure that the firm operates essentially as an integrated and flexible group of people, committed to achieving a common mission.

**Training and education**

These processes are difficult in a small firm - they are expensive and they take people away from their jobs, thus leading to lost production time and lost opportunity costs. At HMH Sheetmetal Fabrications, the investment in training is relatively high - £75,000 per year on a turnover of £1.7m. In return, the workforce have to put in their own time, outside working hours, to undertake both training and education - and Albert is with them for much of that time, either training them, being trained with them, or monitoring the development processes.

Productivity, morale, efficiency and quality are high at HMH Sheetmetal Fabrications; turnover and absenteeism are exceptionally low. The company is a market leader in a field where differentiation is extremely difficult. Its success stems from its workforce and, whilst the development of people is a particular priority and a high cost, HRD is well integrated with a range of other human resource policies and practices to serve the needs of the business at the same time as ensuring individual motivation and growth.
What are the main points to learn from these studies, in relation to developing people in order to boost productivity?

1. *Investing in people can make a major contribution to productivity and growth, provided that it is carefully planned and related to the needs of the business.*

   At Sheerness, the need to improve skills was overwhelmingly clear - it was effectively an emergency situation. At HMH, it was the owner's belief, arising from his own values and philosophy, that such an investment was essential if growth was to be achieved as well as immediate productivity. In both cases, planning was thorough, and was driven by business needs. So whatever the costs - and relatively speaking they were high in both cases - when the investment is carefully planned and designed to further the achievement of business goals, the benefits as measured by ultimate results can more than balance out these costs.

2. *“Productivity” has different meanings in different situations, and productivity-linked HRD can be achieved in many different ways.*

   At first sight, Sheerness offers an example of the more traditional approach to productivity: a focus on shop floor workers, and on using training and education to achieve improvements in productivity which can easily be quantified and measured. However, it should be noted that at Sheerness the entire workforce has been encouraged to acquire vocational qualifications; “productivity” even in this example has a meaning that goes beyond increasing efficiency; it means adding value to people and thereby ensuring organizational growth and competitive edge through a superior workforce. At HMH, productivity at every level is about flexibility, teamworking, quality, commitment and ensuring a continuous supply of high-calibre people.

3. *For human resources development to succeed, it must be well integrated with a range of other human resource policies and practices, and come under the umbrella of a general human resource strategy linked to the needs of the business.*

   In both case studies there was a very clear view of overall business objectives and needs, and careful consideration of how investment in people should best be made. Development of people, both at Sheerness and HMH Sheetmetal Fabrications, was part of a much wider human resource strategy. At HMH Sheetmetal Fabrications, we saw clearly how it does not just encompass education and training, but is also achieved through other human resource processes - recruitment, teambuilding, appraisal, and rewards.

4. *Developing people for productivity does not need to be a complex, formalized process.*

   Sheerness has a complex programme but what Albert Moss does at HMH is simple, and requires only minimal documentation; yet both approaches to developing people have resulted in high productivity levels and a continued high growth rate for the firms.

5. *A clear vision of what can be achieved, and a positive philosophy about people, are essential to the success of any HRD policy.*

   Albert Moss’s success with his business and its people demonstrates how even in the small owner-managed firm, a real competitive edge can be achieved and maintained if there is a vision at the top, and the will and intelligence to carry it through into action at every level.

1.3 Organizational vision, philosophy about people, and human resource strategy

   It is important to reflect on that last point: an organization must have a vision of what it can best do, and the vision must be founded on reality: without this, there are dangers of complacency, of failure to keep in touch with the market, and of lack of expertise in strategic decision making. Once these things happen the whole organization will gradually decline, and can only - if at all - be
rescued by a major review of vision and strategy and by skilled leadership. The story of HMH shows the impact on a firm’s continuous drive for success of a clear and realistic vision, and a belief in the value of the employees.

The message of this unit can be summarized as follows:

HRD must be part of a wider strategy for the business, aimed at achieving steadily improving productivity and growth related to business goals. To do this every organization must have a clear and realistic vision of the business, and a belief in the value of its employees.

In order to reinforce the learning in this unit, please work through Exercise 1 below:

Exercise 1

What is happening to HRD in your own organization? Is it making a strategic contribution? If not, why not?

This exercise can be done in groups, or as an individual assignment, or simply as a stimulus to thought at this stage of the module. If it is done as a group activity, one member of each group should be briefed to present interesting issues that have been raised so that they can be discussed with other groups.

1. Both Sheerness Steel and HMH Sheetmetal Fabrications had compelling reasons for making a high investment in HRD. How far are such reasons applicable to your own organization - or likely to be so in the foreseeable future?
2. Sheerness Steel and HMH Sheetmetal Fabrications invested heavily in their training and education activities. Bosch invests about 7 per cent of its sales revenue before tax on training and education, and Lucas and Hoechst, two very successful companies, spend about 3 per cent. Roughly how much does your organization spend?
3. Does your organization regularly establish the cost of:
   - all its main HRD activities?
   - costs related to training and educational courses?
   - not even those?
4. How, if at all, are the results of HRD policies and plans evaluated in your organization? By whom? How often? For whom?

Questions for discussion

1. Why is human resources development increasingly seen as a major key to improving productivity in organizations?
2. Why does the success of an HRD strategy depend so much on a clear and positive vision of the business and philosophy about people, especially at the top of an organization? Give a practical example to illustrate your reply.
UNIT 2: THE NEED FOR A HUMAN RESOURCE STRATEGY

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the need for an overall strategy to ensure that the human resources in an organization make their proper impact on productivity and draw up such a strategy.

2. Understand the difference between vision, mission and strategy and their roles in an organization.

3. Understand the necessary interrelationship between the organization's corporate strategy and its human resource strategy and policies.

UNIT 2: CONTENTS

2.1 Vision, mission and corporate strategy

2.2 The relationship between corporate strategy and human resource strategy

2.3 Human resource strategy: A key issue
UNIT 2: THE NEED FOR A HUMAN RESOURCE STRATEGY

2.1 Vision, mission and corporate strategy

In Unit 1 we examined the contribution that human resources development can make to the business, and in particular its potential impact on productivity. In order to succeed HRD must relate to other policies concerning the people in the organization, and to human resource strategic objectives.

Let us first examine some concepts related to strategy. Clear thinking is essential here, and definitions are again important. There are several terms that are often confused when strategy is being discussed. See how many of them you can define accurately.

Give one-statement definitions of the following terms, which are all used in the context of an organization and its business planning activities:

Vision: ________________________________
Mission: ______________________________
Strategy: ______________________________
Objectives: ____________________________
Policy: ________________________________

Now compare them with our definitions and discuss.

Vision: The certainty about what kind of business this should be. Top management must have a clear and unwavering vision, and the determination and leadership, the creativity and skills, to drive the organization forward to realize that vision. It was these qualities that distinguished Colin Marshall in his successful fight to turn British Airways around from virtually bankruptcy in 1981. Within only two or three years his vision of BA as one of the world's leading airlines had been realized.

Mission: The mission statement expresses the vision in words which then become guidelines for strategy. It explains the organization's "raison d'être" and is "the most generalized type of objective" (Johnson and Scholes, 1989). Colin Marshall's mission statement for British Airways in the 1980s was that it should become "the Harrods of the airways of the world". A mission statement is the essential foundation for corporate strategy and objectives, organization structure, and human resource strategies. A mission must not only be clear; it must also be understood and accepted throughout the organization. It must be driven from the top, and have commitment at all levels. It must be continuously monitored and evaluated - missions become outdated, and new ones need to be established. The death of the major American railroad corporations was largely due to their failure to be clear about their mission: they did not

---

1 One of the most exclusive department stores in the world.
recognize that they should have been in the business of transportation, rather than running railways.

**Strategy:** Peter Wickens (1988) described strategy very simply as getting an organization “from here to there”. Once vision has been given concrete expression in a mission for the organization, then comes the process of strategic choice: given all possible ways in which that mission could be achieved, which should be chosen? Which route should be taken? How exactly can that mission best be carried out? Only after a thorough, fully informed analysis of strengths, weaknesses, opportunities and threats, both internal and external, can valid decisions be made about an organization’s overall business strategy and the goals or objectives to which strategy gives rise.

**Objectives:** Strategic objectives have to be set at corporate level: they specify what must be achieved in order for the strategy to be successful.

**Policy:** A policy lays down targets to be achieved in relation to each major strategic objective or set of objectives. Strategy requires the specification of goals or objectives in each key area affecting business results. Policy provides guidelines to be followed in relation to those objectives; they clarify the allocation of responsibilities, explain the main types of activity to be carried out, and allot the resources for specific targets. Detailed plans can then be devised at different levels to achieve these targets.

### 2.2 The relationship between corporate strategy and human resource strategy

An organization must have a vision, a mission, and a corporate strategy and objectives from which policies and plans for each main area of organizational activity can be derived. To quote Wickens (1988) again, “The people part of the business must be considered strategically and then fully integrated with the overall business plan.” Human resource strategy must focus on how to attract, retain, appraise, reward and develop the kind of people who can best achieve the objectives demanded by the corporate strategy.

Human resource strategy must also take account of the structure and culture of the organization within which people work, as they have a fundamental influence on people’s attitudes, behaviour and performance. Corporate culture “underlies much of the way work is carried out in the organization” (Armstrong, 1987) and can be summarized as “the way we do things here. It is... expressed in corporate values - what is good for the organization and what should or should not happen; organizational climate - the working atmosphere of the organization as perceived and experienced by its members; and management style - the way in which managers behave and exercise authority” (ibid.). Whilst human resource strategy does not of itself produce an organization’s primary culture, it must either reinforce it or, if the corporate mission requires, help to change it. We will discuss the importance of a positive interrelationship between human resource strategy and organizational structure and culture again in Unit 3.

The key components of human resource strategy are selection, appraisal, reward and development. They form the “human resource cycle” which, given an appropriate organizational structure and culture, can help to achieve efficient, effective performance and growth at all levels of the organization and to sustain its primary culture (Fombrun et al., 1984).

Now, let us illustrate some of these points with a case study.
BARRATT DEVELOPMENTS PLC: THE NEW GROUP TRAINING MANAGER

Barratt Developments plc., an international house building and construction firm with its headquarters in the north-east of England, decided in 1990 that it needed to start investing more heavily, and expertly, in developing its workforce in order to retain its competitive edge and its reputation for high quality and standards, and to achieve a continuously high calibre of management. It therefore recruited Roy Hugman, an experienced personnel and training practitioner, to the newly created position of group training manager. He was given the mission of developing at Barratt a high quality, flexible, committed workforce that would stay with the company and enable it to sustain and improve its position as one of the major construction firms in the country. He took up his post in January 1990.

Barratt had no specialist personnel/human resource function. The various personnel activities were carried out by line managers according to informal custom and practice, and seemed to work well enough: the real priority for Barratt was to “do something about training and development.”

Hugman convinced the Board that, if he was to make valid decisions on what to do about the development of people, he must first obtain information about the workforce, and about the organizational structure and culture within which people worked. Then he could recommend to the Board the human resource goals and strategy that would best serve Barratt’s business needs. Only then could meaningful HRD policy and plans be established.

These tasks took him a year, and an examination of what he did gives excellent guidelines to anyone who has to draw up a human resource strategy for their organization. The tasks involved him in:

- **Quickly establishing strong links with company directors who were particularly sympathetic to the need for good human resource management and development in the company.**

They formed the top level group who, politically, were essential if HRD was ultimately to have a chance of making a real impact.

Because there was no specialist personnel function, Hugman was free to carry out his own analysis of needs and then to report direct to the Board. He did this by:

- **Visiting senior managers and other personnel in all of the company’s 17 subsidiaries in the United Kingdom.**

This was necessary in order to identify and discuss human resource issues and needs and to establish, again, collaborative relationships and the image of a proactive HRD function that could “speak the language of the business”.

- **Presenting to the Board of Directors, in the month after his appointment, a report on human resource issues facing the company.**

The report summarized his first perceptions of the key human resource issues facing the company, the longer-term corporate strategic choices that they suggested, and an immediate action plan to obtain the detailed data necessary for an overall human resource strategy and employee development objectives. The action plan was approved.

- **Setting up, within two months of his appointment, three working parties.**
Each was led by a senior executive of a subsidiary and, after conducting an analysis of the strengths, weaknesses, opportunities and threats facing the workforce, their brief was to examine and present recommendations on a handful of major human resource issues that had by now emerged as of immediate importance to the company.

- **Establishing a database on Barratt's workforce in Britain.**
  This was derived from questionnaires sent through the senior executives to all 2,000 personnel across the company's 17 subsidiaries in the United Kingdom. This activity again reinforced the image of an active training department seeking relevant information in order to produce plans which were appropriate to individual and company needs. By the end of Hugman's first year the database had been computerized and the first of a series of "profiles" had been drawn up on the skills, performance, productivity, turnover, absenteeism, length of service, age and salary levels of each occupational group in the company.

By January 1991, after six months in which Barratts, like all construction companies in Britain, had faced the worst recession since the late 1970s, Hugman had:

- **A human resource strategy** for the company, approved by the Board and derived from the reports produced by the three working parties.
- **A comprehensive and up-to-date database** covering all the company’s British workforce and producing detailed profiles related to each occupational group.
- **HRD objectives, policy and plans** which were ready to be activated as the company moved out of the recession: these were communicated, understood and accepted throughout the company.

To Hugman, the key to these achievements was the processes that had underpinned them. They are illustrated in figure 13.1. Hugman anticipates that at an early stage a small addition will be needed to the HRD staff at Barratt, in order to deal effectively with the broad spectrum of personnel issues. However, again the focus must be on the real needs of the company at every level, and on providing a proactive strategy and a coordinating and guiding presence, collaborating with managers and constantly alert to the dangers of bureaucratization.

The Barratt case study shows the need to have a clear and agreed human resource strategy which meets business needs, before particular human resource policies can be established.

In some organizations, such as Barratt, the person charged with establishing policy and plans to develop people may find that there is no formal human resource strategy in existence. In that situation, it will be necessary to build up information about the workforce in relation to generally agreed present and future business needs, and after careful analysis of that information to develop an agreed overall human resource strategy before setting objectives and policy for HRD.

In other organizations where there is a formal human resource/personnel strategy, the task of the HRD executive (who may, of course, be the same person as the human resource/personnel manager) is to analyse that strategy and its relationship to overall business goals, and to derive from it appropriate objectives and policy for human resources development in the organization.
Figure 13.1: Processes involved in establishing a human resource strategy at Barratt Developments plc

1. *Establishing proactive* and continual collaborative relationships with line managers throughout the company.
2. *Ensuring a full and informed commitment to investing in people especially at the top levels of the company.*
3. "*Walking and talking the job*," so that the HRD function was a visible presence in the company, actively concerned with the issues confronting its managers and workforce, and with a full role to play whether or not specific training activities were taking place.
4. *Continually monitoring needs and responses related to human resources in the company.*
5. *Keeping the specialist function small and flexible,* working with managers to help, advise and service their needs.
6. *Remaining fully informed about the plans of the business,* and the overall human resource trends in the company, in order to play a proactive role in establishing human resource strategy.

### 2.3 Human resource strategy: A key issue

This unit has been concerned with the relationship between an organization's corporate strategy and objectives, and its overall strategy for attracting, retaining, motivating, rewarding and developing people. The final point that needs to be made at this stage is a crucial one, and will be followed up in the next chapter:

Human resource planners must have a thorough knowledge of "the business" and its environment in order to play a meaningful part in strategy making. A comprehensive and up-to-date knowledge of the organization as a business, its operations, and the environment in which it has to survive is essential if there are to be valid strategies for the management and development of people and within these, appropriate policies to meet strategic objectives.

To reflect the material of this unit, please complete the following exercise individually or in groups.

**Exercise 2**

Vision, mission and human resource strategy in your own organization.

Use the following questions either as a basis for assignment work or for class discussion, whichever is more appropriate.

Taking your own organization, or one with which you are familiar:

1. What do you see as the overall "vision" driving the organization forward? Is there a mission
statement, either written or understood?

2. Assess how far, if at all:
   - there is a human resource strategy in the organization;
   - it is clearly in line with business needs and the overall mission of the organization.

3. Is there anything that needs to be done in order to develop a human resource strategy, or to make the present strategy more relevant to the needs of the business?

Questions for discussion

1. Discuss the definitions of “vision”, “mission”, “strategy” and “policies” and explain how they interrelate.
UNIT 3: BUSINESS-LED HUMAN RESOURCES DEVELOPMENT

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Appreciate what is involved in “speaking the language of the business” and analyse the “fit” between strategy and other elements of the organization as a system.

2. Produce objectives, policy and plans relevant to business needs.

3. Understand how HRD policy and plans can be made operational.

UNIT 3: CONTENTS

3.1 The organization as a system

3.2 Relating human resources development to business needs
UNIT 3: BUSINESS-LED HUMAN RESOURCE DEVELOPMENT

3.1 The organization as a system

We finished Unit 2 by emphasizing the need for human resource specialists to "speak the language of the business" in order to ensure that any strategies and policies they finally produce are relevant and agreed within the organization. Let us start this unit with an exercise to test your knowledge in this very important area, looking specifically at the business of your organization.

This time-consuming activity illustrates that the human resource practitioner needs to have a thorough knowledge of the business of the organization in order to produce relevant and effective HRD plans with a potential impact on productivity. No development activity aimed at improving productivity can have any meaning unless it derives ultimately from a strategy based upon a thorough knowledge and understanding of all the factors that affect productivity.

Start the activity below, "Knowing the business of your organization" by looking through the following instructions:

1. Put yourself in the place of the HR manager or HRD executive in your organization. Then, taking your own organization, see how many of the following questions you can answer.
2. Give each group of questions (A to E) a heading which seems to you to describe the main issue that the questions relate to.
3. At the end of an agreed time, stop the activity and ask yourself (or discuss with others) what you have learnt from this exercise and how such knowledge can be developed.

Group "A" questions

1. What business is your organization in?
2. What is your organization's market share/position at present? And potentially, over the next five years?
3. What about the competition - what are their strengths/weaknesses? How are they performing? Are new sources of competition likely?
4. What are the key features of the environment in which your organization operates - economic conditions, legal-political issues, state of technology, availability of needed resources, the social values which affect your organization, its products/services, and its way of operating?
5. What do you see as the main opportunities and threats posed by the environment in which you operate?

Group "B" questions

6. What is the present vision and mission of your organization?
7. In general terms, what is the current corporate strategy? Where is the business going, and over what time scale does the strategy extend?
8. What are the present strategic options facing your organization, as you see it - growth, diversification, differentiation, contraction, acquisition, relocation or physical expansion, new products, new pricing?
9. What is the organization's financial turnover and profitability? How have the rates moved
through time, and how do they compare with those of competitors?

10. What are the main productivity goals and performance achievements at different levels and different sectors of the organization? How good or bad are they? What are the problems?

11. What are the key performance indicators - sales or profit per square metre, return on assets, unit costs of labour, etc.?

**Group “C” questions**

12. Are the structure and systems of the organization appropriate and effective, or are they putting barriers in the way of achieving business objectives?

13. Are grading structures and pay systems appropriate?

14. Does the business have effective decision-making mechanisms, productive design and efficient organization of activities?

15. Are there accurate mechanisms for specifying performance targets, monitoring performance, and measuring achievement?

16. Generally speaking, is the organization flexible or rigid? What should it be like, and why?

**Group “D” questions**

17. Is the organization making the best use of the most appropriate technology in the work systems and processes it uses, in relation to information gathering and distribution, decision making, the production of goods/services, and administration?

18. If there are problems in any of these areas, what are they and how have they arisen?

**Group “E” questions**

19. What does the workforce cost, in crude terms - i.e. what is the approximate overall wage and benefits bill? (In a service organization, for example, the employment costs overall could be as high as 70 or 80 per cent of revenue before profit.)

20. How far is the organization able to attract, retain, develop and reward the kind of people it needs? How far is it likely to be able to do so over the next four or five years at least?

21. In general terms, is the workforce producing to the standards required, and achieving targets? Do people know what results they need to achieve, and why? Are they given feedback on performance?

22. Where are the areas of highest and lowest human productivity in the organization, and what are the reasons for these levels?

23. Is the overall culture of the organization (prevailing values, attitudes to work, typical ways of behaving in relation to work and the organization) conducive to high productivity? Or is there no particularly strong culture evident? Should there be? What about general management style in the organization - how does this affect productivity?

24. Are any changes needed in performance levels, types of skill, numbers, retention rates? Any need for redeployment, redundancies?

25. Looking at a range of questions like these about people, where are the key pressure points related to productivity, and the main areas of need for action?

26. How much does the organization spend on developing people per year (expressed in any way you like), and how can this be justified? Is it enough, too little, too much - or spent inappropriately?
When you have finished this exercise, re-read the beginning of Unit 3 to find the meaning behind these questions, and to identify the names of the five categories shown above.

In the activity above, the questions were about the state of the business and about the organization as a whole, with questions about people ranging across a wide range of issues. These questions show that an organization has to be analysed as a system, operating within the context of an environment that presents a changing mix of opportunities, threats and challenges. The elements of the organization must themselves interact effectively, and so "productivity" in its widest sense is about getting the most out of those interactive elements. The following diagram depicts the organization as a system, and also puts names to the five groups of questions.

**Figure 13.2: The organization as a system**

The elements should all interact in a productive way. Often they do not. Sometimes, as with the American railroad companies mentioned before, the organization has a vision, mission and strategy that are pushing it in the wrong direction, requiring the wrong outputs; they are out of date and, unless changed, will lead to the organization’s demise. No matter what improvements are achieved by the workforce, the organization will die; and the reason will be its inappropriate vision, mission and / or strategy.

Similar examples can be produced by reference to each element of the system. A new and valid mission will not be realized if there is a culture, especially amongst the most politically powerful people in the organization, which does not support it. Strategic objectives must therefore be concerned with the need to change the primary culture — but that means changing people, their attitudes, their values, their typical ways of behaving. People, however, will not usually change unless they are developed to do so, have clear and agreed objectives that relate to ways in which they should behave as well as perform, have meaningful incentives, and receive regular appraisal and feedback on performance.
And, of course, technology can lead to great improvements in productivity, providing that the workforce has the skills and willingness to make best use of it.

If human resource planners are knowledgeable about their organization, they can take a central role in debate and decisions about strategy, as did Hugman and Barrat (Unit 2). In the face of lack of expertise, inability to know the business or speak its language, it is little wonder that HRD often makes no real impact on the bottom line.

3.2 Relating human resources development to business needs

Out of all the material in this unit and in Unit 1, we can now put together a series of steps for ensuring that HRD objectives, policy and plans will meet the needs of the business. These are summarized in figure 13.3.

It is essential to carry out the steps using processes that will ensure that action has a high degree of success. A number of processes have emerged in the case studies as critical in that respect, and these can be summarized under the eight headings shown in figure 13.4. In the summary diagram (figure 13.5) these steps and processes are represented in a continuous flow chart activity.

To reinforce and extend the learning related to this unit you should study Exercise 3.
Figure 13.3: Five steps in producing business-led development of people

1. Relate investment in the development of people to the corporate mission and strategy.
2. Produce/analyse a human resource strategy and establish objectives for human resources development.
3. Formulate an HRD policy to meet those HRD objectives.
4. Agree on specific, measurable and well-costed HRD plans that will make HRD policy operational.
5. Establish mechanisms for monitoring, feedback and further relevant action.

Figure 13.4: Eight key processes in producing business-led development of people

1. Establish informed, proactive, collaborative relationships with the key parties in the organization, especially at corporate and business unit levels.
2. Ensure understanding of key issues and commitment to action at top level.
3. Walk and talk the job, in order to identify HRD needs and establish a proactive HRD presence in the business.
4. Carry out data gathering and planning on a collaborative basis with line management and other key parties.
5. Link HRD objectives, policy and plans to business strategy, through a wider human resource strategy.
6. State desired outcomes and bottom line contribution in clear and measurable terms, with actual costs and estimated benefits spelt out.
7. Collaborate with management to ensure ongoing monitoring and feedback of results and relevant action arising from that feedback.
8. Keep fully informed about “the business”, acting on any changes in either corporate or human resource strategy that have implications for the development of people.
Figure 13.5: Steps and processes involved in establishing HRD objectives, policy and plans related to productivity.
Exercise 3

HRD policy in your own organization

Using the two checklists given at the end of Unit 3 - the five steps and eight processes involved in producing an HRD policy and plans for the business - either complete the following as a written assignment, or tackle it as a class activity (in which case group work would enable a great deal of experience and knowledge to be exchanged, to the benefit of all the class):

1. Analyse HRD policy in either your own organization or in one with which you are familiar (directly or through reading about it):

   (a) What are its objectives? Do any of them relate specifically to productivity? Are they clear and measurable, agreed and understood in the organization?
   (b) How far is HRD policy relevant to the needs of the business, both at corporate and at business unit levels?
   (c) How far is HRD policy consistent with other human resource policies in the organization - i.e. to do with recruitment and selection, appraisal, pay, etc.?

2. In relation to improving productivity only, give recommendations for improving either the policy itself, or the processes used in developing HRD policy related to productivity.

Questions for discussion

1. How can an organization best be analysed in order to identify its main human resource needs?
2. Explain, by reference to a practical example, how HRD objectives, policy and plans to serve business needs can be established and made operational in an organization.
UNIT 4: ESTABLISHING HRD NEEDS AND PRIORITIES RELATED TO PRODUCTIVITY

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the main problems involved in recognizing productivity “gaps” that HRD should tackle and in agreeing on priorities for action.

2. Identify the kinds of process as well as the stages of activity that will help to achieve agreement in these two areas.

UNIT 4: CONTENTS

4.1 Agreeing on needs and priorities for action

4.2 Processes for identifying and prioritizing needs

4.3 Collaborative action by specialists and line managers
UNIT 4: ESTABLISHING HRD NEEDS AND PRIORITIES RELATED TO PRODUCTIVITY

4.1 Agreeing on needs and priorities for action

In Unit 3 we learnt how to draw up business-led HRD plans to meet HRD objectives including those related to productivity. Within that activity, the most difficult and crucial stages are identifying and agreeing on the "gaps" in productivity that HRD ought to tackle and determining the priorities for action. In this unit both stages will be examined.

Let us start with the case below:

CASE STUDY (Part 1): PRODUCTIVITY IN BRITISH SUBSIDIARIES OF GERMAN AND JAPANESE FIRMS

A study of productivity in British subsidiaries of German and Japanese firms was reported by Sawyers in 1986. The research examined a number of British manufacturing subsidiaries to determine how their productivity compared with that in the parent factories, and what factors seemed to explain any differences. Most of the factories made light electrical and electronic equipment. Assembly was the main production activity, with some plastic moulding, machining, metal pressing, cutting and welding. Most employees were unskilled and female.

There were many reasons for differences in productivity between subsidiaries and parent companies, to do with product design, methods of production and organization, quality of supplies, and so on. However, the great majority of the reasons were to do with the skills, knowledge and attitudes of people, and therefore had direct implications for human resource management and development in those organizations. The most productive factories had:

- **High quality, industrious and dedicated managers**
  Performance and attitudes that would not be tolerated in Germany or Japan were tolerated in the UK, with foremen and supervisors singled out as being the weakest level.

- **High-quality recruits**
  Most subsidiaries gained a clear advantage by having a fresh start, either by setting up in a "greenfield" situation or by sacking the existing labour force and only re-employing selectively.

- **A high-quality labour force, with positive attitudes to work**
  More time had to be spent on motivating and persuading British workers to perform well, with less time available for other tasks.

- **Experienced workers**
  In some new subsidiaries, many workers were young and inexperienced, leading to inefficiency and errors.
- **Labour flexibility**
  This was secured by skill-related pay, frequently measured by the number of tasks the operative could perform, not to the job or the output produced; also by reducing pay scales to between three and five levels.

- **Individual responsibility**
  Every individual was responsible for good performance and for quality. Failure to achieve targets meant questions not only for the operative but also for the superior.

- **Tight Manning levels**
  Line managers often performed specialist tasks and generally employees’ talents “seemed to be fully utilized, if not stretched”.

- **Effective communications**
  Managers kept employees well-informed of any likely changes, were in close contact with them, and set an example to the workforce, especially by their technical expertise.

- **Technical competence and application**
  Good technical education was the basis for acquiring expertise, together with continuous study of the company’s operations, markets, competitors and relevant technologies. Application and the will to learn were crucial in that connection, and most training was job related.

How should we approach the task of identifying and achieving agreement on HRD needs and priorities related to productivity, when so many other factors can explain and improve poor rates?

It is essential to start by considering the processes whereby action is to be achieved. A number of different processes can be employed; they are discussed in the section below.

### 4.2 Processes for identifying and prioritizing needs

**Working parties**

At Barratt (Unit 2), the process of setting up working parties led by senior executives from the 17 subsidiaries was used to obtain detailed information and recommendations on specific human resource issues. This is a relevant and effective type of process where there has been no previous data-gathering exercise, where no clear starting point is evident, and where, above all, it is politically essential to obtain the support and active involvement of top management in analysing major issues with HRD implications and in producing recommendations to resolve them.

**Collaborative action by personnel/training specialists and management**

In some companies the process takes the form of the personnel department using its relationships throughout the company to obtain the data needed to formulate recommendations about priorities and action. It is an appropriate process where there is a well-established and effective personnel/training function with high credibility in the organization, and where it is possible to
gather and analyse data using only one or two specialists collaborating with line managers.

**Quality circles**

In most Japanese companies quality circles are an intrinsic part of the normal organization structure and culture of the factory; they continuously identify needs and ideas for action related to productivity, with the active involvement and support of higher management.

At Jaguar in the mid-eighties, when John Egan was struggling to achieve a turnaround of the company, special quality circles were set up for the purpose of identifying problems and working out how to resolve them; recommendations and decisions on priorities for action were then taken by senior management. Such a process is relevant when, as in that example, acute difficulties face the company, speed is essential in identifying and solving problems, but so is the establishment of a team-based and collaborative culture. However, if quality circles are to endure in an organization, research has shown that continuing effort will need to be put into team training and development, a flexible managerial structure, appropriate reward systems, and a fully supportive culture.

**Use of consultants**

External consultants may be employed to gather data, and to recommend where HRD action is needed and where priorities appear to lie. This is appropriate where there is no expertise in the company to carry out such enquiries; where speedy identification of issues is important; and/or where for political reasons it is evident that external consultants will carry more weight and offer more chance of success than internal personnel. Dangers obviously exist, however, unless the consultants have sufficient expertise and knowledge of the company, as well as an ability to establish the kind of relationships that will ensure that valid data are obtained and that feasible recommendations are produced and acted upon (Harrison, 1988, reprinted 1989).

4.3 **Collaborative action by specialists and line managers**

If, as is more than likely, the process chosen is one of collaborative action by the personnel/training specialist and managers, then the following three steps are recommended: identifying problem areas; deciding on action to be taken; and agreeing on priorities for action. These three steps are discussed in detail below.

1. Identify areas where there are problems with existing levels of productivity, and establish reasons; then decide which gaps would best be tackled by action related to the development of people.

   (a) **Define the meaning of “productivity” in relation to each job**

   In the case study presented at the beginning of this unit, the first step taken by the researchers was to find ways of comparing “productivity” from one organization to the next. This was difficult because “productivity” tended to be differently defined from factory to factory. So there has to be agreement on what “productivity” means in each area of work of the organization and at the level of each occupational group, each team and each individual. Illustrations of this point can be found in Unit 1, where “productivity” at Sheerness Steel and at HMH Sheetmetal Fabrications had rather different meanings, but since those
meanings were clearly understood within the companies, there was no apparent problem in assessing productivity.

(b) Analyse productivity objectives and methods of measuring performance
It will be necessary to analyse the specific productivity objectives/targets at corporate, unit, team and individual level. Are they tight enough? Demanding and precise enough? What exactly are the implications of these objectives in terms of skills, experience, organization of work, and the culture that they require?
And what about methods of measurement? Are they clear and agreed, understood by the job holders and their supervisors/managers? In the factories in the case study, productivity was generally measured by the time taken to perform a given task as a percentage of the standard hours of that task, and output per employee. These are relatively straightforward ways of measuring productivity. However, in non-operative jobs, defining productivity objectives and methods of measuring them is much more difficult and will require patient and expert enquiry and discussion.
What matters most, whatever the job in question, is that the parties concerned agree on how to express the kind of productivity targets to be achieved, and on how to measure performance in relation to these targets.

(c) Examine problem areas
Next, problem areas must be examined in detail, taking the objectives and measurements of productivity as the starting point, and then looking at exactly how far short of required levels productivity seems to be. How accurate are the measurements? How reliable and accurate are the judgements about people’s performance?
Information will come from talks with line managers, examination of performance records at unit and individual levels, analysis of appraisal interview documentation (if there is an appraisal scheme in the company) and so on. However, careful attention must be paid to the validity of this information, which may have been influenced by personal relationships between managers, supervisors and their personnel, and which may be unreliable, out of date, or not comprehensive.

(d) Agree on causes of gaps in performance and possible responses to them
It is then necessary to analyse the gaps in order to determine their fundamental causes. The case study has shown that causes can be extremely varied, so it is essential to identify where the problems really lie, in order to agree on appropriate remedies. At the same time, possible ways of meeting those gaps must be analysed, together with an examination of the costs and likely outcomes of various approaches.
A wide-ranging set of options must be generated at this point, and it is therefore essential that the discussion should be truly collaborative, focusing on ideas from line managers, unions if relevant, and human resource specialists. An example from the case study illustrates this point.
CASE STUDY (Part 2): APPROACHES TO GETTING “PRODUCTIVE” MANAGERS

In the research on Japanese and German parent companies and their subsidiaries, it emerged, unsurprisingly, that certain managerial skills were needed to achieve highly productive units:

1. Ability to exercise tight control over the labour force; tough but benevolent leadership
2. Close contacts with the factory floor
3. Care in ensuring that the workers were well informed about the company’s situation
4. Ability to set high performance standards, and continuously monitoring performance
5. Attitudes which led to a continuous search for ways of improving the product and productivity

If these skills are found to be lacking in an organization, one solution would be to carry out a management training and education programme through which existing managers could be helped to acquire such skills and attitudes. Many organizations take just such a developmental approach when faced with a need to reorientate their managers to, say, a greater concern for customer care (British Airways), for total quality, better service, and high performance management. An example would be the growing number of management development programmes in the National Health Service in the UK designed to bring about the major shift in attitudes and skills needed to focus on the patient as the “customer”.

However, in the case study factories with the highest productivity rates this was not usually the approach taken. Instead, the policy was to buy in managers who already possessed the required skills and attitudes. Furthermore, the selection panel looked for evidence of proven experience and expertise, and paid little attention to educational or professional qualifications. This recruitment solution was felt to be a far more cost effective, quick and reliable way of achieving high productivity at managerial level than a developmental approach.

In this case study, two issues stand out:

- Different actions can be taken in order to improve productivity: developing people may be one of them, and often it may even seem to be the most obvious. However, alternatives need to be very carefully assessed.
- Values prevailing in the organization will have a major influence on the final choice of action. There are organizations where “downsizing” and recruitment from scratch would be a strategy so inconsistent with the organization’s prevailing values that it would be used only as a last resort rather than, as here, a first choice.

2. The second step is to analyse productivity objectives contained in the business plan, identify changes in the present workforce needed to achieve those objectives, and decide on the most relevant actions to meet needs.
   This means establishing the implications of future productivity targets for the workforce in terms of the levels and types of skill, knowledge, experience, performance, and attitudes called for over the timescale of the plan compared to those currently present. Again, gaps
must be identified and a distinction must be made between those where some form of training or staff development seems an appropriate remedy, and those where it does not.

It is crucial to consider a variety of possible actions. Should the workforce be reduced or expanded? Should management negotiate incentives in exchange for higher productivity rates? Should jobs or equipment be redesigned? Should there be new working methods? Each possible response must be compared to the rest, with relative costs compared to likely benefits. Costs need to be longer term as well as immediate, and must include not only those that are easily quantifiable, but those which, although qualitative, have important implications for the “bottom-line results” of the business.

Let us once more take an example from the case study: it was found that in general those factories where a new workforce had been recruited gained a substantial advantage in relation to achieving high productivity rates. At first sight the immediate costs of recruiting people from outside and then giving them appropriate training and experience may well appear higher than the costs of retraining existing workers - especially if, in order to attain a “greenfield” situation in all or a significant part of an organization, some employment contracts have to be terminated. However, when the less immediately obvious costs are examined, as they were in the research, a different picture may emerge. In the case study, it was found that immediate costs involved in recruitment were more than offset by the ability to employ people who not only had the skills and potential required but also had the attitudes and values needed to achieve and sustain high productivity in the particular culture and structure of those factories.

If the information needed to carry out the second step is not readily available, it will be a lengthy process to generate it; this takes us back to the processes and activities discussed in Units 2 and 3 of this module.

3. The third step is to agree on priorities for action.

Once current needs and those related to future requirements for productivity have been identified and agreed, a process of prioritization must take place (Fairbairn, 1991). This needs agreement on three main points:

- What needs are most relevant to key business objectives (and therefore must be met if the business plan is to be achieved)?
- What needs are perceived to be most relevant to individual job and development goals?
- What needs will, if met, receive recognition and reward?

If careful questioning reveals any serious inconsistency between the views expressed by different parties (e.g. the job holders, their managers, personnel/training staff, line management, top management), then there must be an informed discussion between human resource specialists, line and senior managers, and other key partners in the productivity debate. Everything depends on how “productivity” is defined, how far it is seen as a matter of short-term tactics or also of long-term strategy: what part, exactly, it is to play in relation to the corporate mission and strategy of the organization; and the agreed relationship between productivity, the development of human resources in the organization, and other human resource processes such as recruitment and rewards.

To summarize this discussion, the crucial steps that have to be taken when the process is being carried out through collaboration between personnel/training specialists and managers are shown in figure 13.6.
Figure 13.6: Agreeing on and prioritizing HRD needs related to productivity

1. Identify areas where there are problems with existing levels of productivity and establish reasons; then decide which gaps would best be tackled by action related to the development of people.

2. Looking at the future, analyse productivity objectives contained in the business plan, identify changes in the present workforce needed to achieve those objectives, and agree on the most relevant actions to meet needs.

3. Agree on priorities for action by:
   (a) identifying the needs most relevant to ensuring productive advantage for the organization;
   (b) ensuring that adequate recognition and rewards are attached to meeting those critical needs.

Once priorities have been determined, then come the stages of agreeing on what kind of developmental activities should take place, and designing relevant programmes. These stages are dealt with in Unit 5. To reinforce and extend the learning contained in this unit, please work through Exercise 4.

Exercise 4:

Problems in dealing with gaps in productivity

This can be done in class, in groups, or it can be tackled as an individual written assignment. It involves looking at three different sorts of problem related to tackling productivity through HRD activities, and coming up with some practical recommendations.

(a) In company A it is clear that HRD activities could make a striking impact on productivity throughout the company. However, at the level of individual job holders and, in some cases, of their managers, there is failure to see the relevance of such activities, and to recognize that productivity is a problem - or at least, that it is a problem at their level. Ultimately, business strategy is threatened. What should be done?

(b) In company B there are some key needs related to improving the productivity of individuals which, if met, will not result in rewards for the workforce in the form of more pay, promotion, or recognition of some other kind. How best can this problem be tackled, and by whom?

(c) In company C certain departments and certain individuals feel the need for HRD. Meeting these needs would lead to payoffs, although not to immediate improvements in productivity. Yet the training manager has been told by the managing director that “in this company training must lead to improved productivity”. What should the training manager do?
Points for discussion

1. Suggest a three-point checklist for collaboration in establishing HRD needs and priorities related to productivity.
2. What are the three essential processes related to agreeing on priorities for action?
UNIT 5: SELECTING, DESIGNING AND COSTING HRD PROGRAMMES

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the main processes involved in the choice and design of HRD programmes focused on productivity.

2. Know how to assess the costs, likely benefits and main outcomes of such programmes.

UNIT 5: CONTENTS

5.1 Establish the purpose of the development activity and assess the learners

5.2 Decide on the development approach, assess costs and benefits

5.3 Set learning objectives and decide on measurement methods

5.4 Decide on the programme design and transfer learning to the workplace

5.5 Monitor programmes and assess outcomes
UNIT 5: SELECTING, DESIGNING AND COSTING HRD PROGRAMMES

Selecting and designing development activities are topics whose scope goes far beyond this module. There are many excellent texts that can be helpful here, some of which are listed in the bibliography. The main approach is described briefly below.

Let us assume that a particular group of people in an organization need some form of development in order to improve productivity. Five main steps are involved in selecting and designing a developmental programme to meet those needs, as shown in figure 13.7.

**Figure 13.7: Five steps in selecting and designing a development programme**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Purpose</strong></td>
<td>Establish overall purpose and consider the types of learner</td>
</tr>
<tr>
<td>2. <strong>Programme</strong></td>
<td>Agree on the most feasible and relevant type of programme, relating costs to likely outcomes</td>
</tr>
<tr>
<td>3. <strong>Objectives</strong></td>
<td>Establish learning objectives for the programme and for each of its parts; agree on how they will be measured</td>
</tr>
<tr>
<td>4. <strong>Design</strong></td>
<td>Decide who will design the programme, and how learning will be transferred back to the workplace</td>
</tr>
<tr>
<td>5. <strong>Assessment</strong></td>
<td>Agree on how, at what stages, and by whom the programme will be monitored and results assessed</td>
</tr>
</tbody>
</table>

5.1 **Establish the purpose of the development activity and assess the learners**

*The purpose*

Is the purpose to improve present productivity levels in some clear-cut, easily measurable way? Or to prepare the group concerned to achieve clearly defined higher levels of productivity when some change - in production in technology, in production methods - is introduced? Such purposes are short term and their eventual success or failure is easy to assess. At the end of the programme, performance can be measured with little difficulty and learning objectives for the different parts of the programmes should be easy to establish. McKee, personnel director of Woolworth plc, UK, explains:

A series of training programmes designed to improve marketing/buying skills should have a positive impact on key performance indicators, such as stockturn or gross margins. Similarly a training programme with the objective of enhancing staff and management awareness of shrinkage should have a beneficial impact on the level of unidentified stock loss being incurred. In a non-manufacturing environment, it can be more difficult to establish measurement criteria, but absentee levels, labour turnover, percentage of internal promotions vs. external recruitment into key jobs, level of customer complaints, productivity per employee, all can be valid indicators of effective training activity. (McKee, 1990)
However, the overall purpose of some programmes may be longer term, or more generalized, and/or more speculative. There will then be difficulty in producing objectives for such a programme overall (but not necessarily for component parts, such as training and educational courses). This, in turn, will influence the degree to which the final results of the programme can be measured precisely enough for them to be related convincingly to costs. This will then make final assessment of the programme's results hard to express in quantitative terms. However, providing that these difficulties are recognized at the start, and that the key parties are still prepared to proceed with the programme and can find meaningful ways to measure its results, then imprecision in a quantitative sense should not be a barrier. Let us consider the case below:

### CASE STUDY: FORD, UK (Hodges, 1990)

In June 1989 a company-wide employee development and assistance programme (EDAP) was introduced at the Ford UK Motor Company. The scheme is a joint initiative between Ford and the unions, funded by Ford to the sum of £2.5 million. It is controlled by a national steering group, with local committees at each of Ford's UK locations. The programme is not about vocational training but about the personal and educational development of all the company's employees. The scheme was agreed in the 1987 pay negotiations, and through it all employees are offered up to £200 per year to pay for courses that will enhance their personal development.

Although the objectives of any particular course that an employee pursues under this initiative can be clearly defined, and their achievement can easily be measured, it is impossible to find precise measures of the extent to which the programme as a whole achieves its purpose. Indeed, that purpose is very generalized: the unions negotiated the scheme as a benefit to their members, and for Ford it represented a non-confrontational area where unions and company could do significant business together. John Hougham, director of personnel at Ford, believes that the programme has probably led to a general improvement in industrial relations: "If people are enjoying learning and this is associated with the company, the company must be the better for it".

An assessment of the EDAP scheme's first year of operation showed that, compared to an expected 5 per cent take up, 30 per cent of the 43,000 workforce have taken the opportunity to do some sort of voluntary study in their own time, with educational opportunities of considerably wider interest than health and lifestyle courses. The report concluded that EDAP has started impressively, but that there must be a much greater focus on monitoring the effectiveness of the programme and on determining how best it should be developed. For both the unions and Ford, the sheer enthusiasm, weight of numbers, and interest shown in the scheme by other large companies all give sufficient short-term justification for a programme which, relative to each individual, costs them so little and promises so much.

The overall purpose of a human resources development programme may be precise or generalized; to do with easily measurable short-term gains, or with longer-term benefits that will be more difficult to measure and will depend, for their success, on other factors as well as the development programme. What matters is that a purpose is established; that it is agreed at the top of the organization; that it has the understanding and commitment of people at all levels of the organization; and that it leads to relevant learning objectives.
**The learners**

It is important to consider the size of the group, the characteristics and preferred ways of learning of the learners, and their levels of skill, knowledge and attitudes compared to those they must reach by the end of the programme. All these data will help to decide on the kind of development programme that will most improve their productivity in the time available, and on the design and content of learning activities within it. Thus at Sheerness Steel (Unit 1) the great numbers and types of people who had to be developed at every level of the organization within a relatively short period, with widely varying learning needs, led inevitably to a variety of training and educational initiatives. On the other hand at HMH Sheetmetal Fabrications (Unit 1), a narrower range of mainly job-centred activities was being established, all of which were highly relevant to the needs of the firm and to the needs of the learners, and designed to fit the ways in which they preferred to learn.

5.2 Decide on the development approach, assess costs and benefits

The next step is to agree on the kind of development activities that will be used to achieve the purpose of the development programme. As we have just shown in discussing the learners, a wide range of activities can develop people. The four categories below each include a few of many possible methods.

**Changing the structure and systems of the organization**

Examples:
- Quality circles as at British Airways, Komatsu and many other organizations, which are carefully built into the culture and structure of the organization, and are accompanied by appropriate reward and career development systems.
- A team-based organization structure with appropriately trained and developed managers, especially at supervisory level, as at HMH Sheetmetal Fabrications in Unit 1.

**Changing the culture of the organization**

Examples:
- The introduction and embedding of new values about people and their development in the organization almost invariably comes from the top, either due to a change of leadership, or to some major pressure from the external environment, or to a combination of both.
- A changed style and approach on the part of managers/supervisors, where the aim is to improve the productivity of operators by developing their managers.
- New expectations about standards and performance, notably those involved in the introduction of total quality programmes, performance management programmes, and performance-related pay systems. These encourage and put pressure on people to develop new ways of behaving and performing.
- Harmonization of pay and conditions and a more integrated grading structure can help people to develop and can have a major impact on productivity (see Unit 6).

**Learning on and off the job**

Examples:
- Coaching and counselling from a manager. This requires trained managers who have the time to spend counselling employees; managers are appraised according to their success in
training employees and they are rewarded for good results.

- Job rotation to give experience of a wide range of tasks and jobs. This is the custom in most large Japanese firms, as well as many British organizations, but it needs very careful planning, monitoring, and extension into well-planned long-term career development and financial reward systems.

- Special projects, providing they are carefully planned and well supervised, with effective transfer of learning.

- Educational programmes or training courses relevant to the needs of the trainees, and with learning which is applied at the workplace.

- Secondment within or outside the organization. This is an expensive but often very effective approach, providing that there is a career development path within the company for returning secondees — otherwise, secondments can lead to a high turnover rate for successful people.

**Continuous development**

Examples:

- Self-directed, lifelong learning at organizational as well as individual level, with the focus on helping people to learn from the work they do and the daily experiences they encounter. Employees are encouraged to reflect on experiences and then to analyse how improvements can be made, so that new ideas can gradually make individuals, teams and the whole organization more creative, more flexible, more productive, and better at making high-quality decisions. (For more information, see Harrison, 1988 reprinted 1989; Wood, 1988.)

- Developmental options must be carefully considered in relation to their direct and indirect costs. Direct costs include training overheads (related to staffing, accommodation, equipment, maintenance and so on), travel expenses, fees and other costs involved in external education and training courses; and fees, tutor expenses, equipment and materials costs involved in internal developmental activities. Indirect costs include lost production time and the opportunity costs of those being trained/developed, replacement costs to cover for learners and time spent in developing staff by line managers.

- Options must also be analysed for their suitability for the learners, their feasibility for the organization and their likely results.

Often, a combination of methods will bring the most cost-effective results: it is necessary to ensure that the costs and likely results of a variety of approaches have been adequately assessed. Finally, it is vital to get the agreement and commitment of the key parties to the ways in which people will be developed to meet productivity objectives.

5.3 Set learning objectives and decide on measurement methods

**Learning objectives**

It should be possible to give a one-sentence summary of the purpose of any learning event. Learning objectives, on the other hand, must describe as precisely as possible the skills that learners should acquire. Thus, for example, the objectives at the start of this unit are "behavioural" because they show what learners should be capable of doing once they have completed this part of the module.

At this stage, learning objectives should be established for the programme as a whole. Once
The overall purpose of a learning event answers the question “why”, whereas its learning objectives define “what”... what outcomes are to be achieved by the event in order to realize its overall purpose. They explain the kind of behaviour of which the learner should be capable at key stages of the learning process (Harrison, 1988 reprinted 1989).

All training and development programmes should have the purpose of improving output and minimizing costs, and are designed to support productivity drives. The specific objectives of such programmes are easy to define because the company has performance management programmes that include the specification of very clear performance standards against which, through a formal performance review procedure, people’s “productivity” is appraised.

Having established clear and meaningful learning objectives for the programme, agreement must be reached on how to measure results in relation to each of those objectives.

**Measurement methods**

Here, we must go back to what was said in Unit 4: What matters most ... is that the parties concerned agree on how to express the kind of productivity targets to be achieved, and on how to measure performance in relation to those targets.

Fowler (1991) advises that performance measures can be categorized, starting with the most directly quantified and going on to more qualitative indicators.

If programmes are being established for people who work where high productivity is a matter of performing quantifiable tasks in an efficient manner to reach clearly defined standards of performance, then measuring the results is a straightforward matter. Achievement of learning objectives will probably be measured by tests and other activities during and at the end of training. In the workplace this will be followed up by monitoring performance for as long as necessary to ensure that full transfer of learning to performance on the job has been achieved. Figure 13.8 illustrates a range of useful indicators (Robinson and Robinson, 1989).

When considering how to measure the achievement of objectives which are less easily quantifiable, competency-based approaches are now widely used. For an informative account of how a small but extremely successful airport in the UK used such an approach to quickly develop its 23 managers for new roles and tasks when the airport became a public company, see Jackson, 1989.
When training to improve productivity, and therefore to reduce costs and raise efficiency, typical indicators used could include:

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales training</td>
<td>Ratio of new accounts to old accounts</td>
</tr>
<tr>
<td></td>
<td>Call-to-close ratio</td>
</tr>
<tr>
<td></td>
<td>Average sales size</td>
</tr>
<tr>
<td></td>
<td>Sales volume</td>
</tr>
<tr>
<td></td>
<td>Percentage of objectives overcome</td>
</tr>
<tr>
<td></td>
<td>Items per order</td>
</tr>
<tr>
<td></td>
<td>Add-on sales</td>
</tr>
<tr>
<td>Training for supervisory/</td>
<td>Decreased rejection rate</td>
</tr>
<tr>
<td>management development</td>
<td>Increased output</td>
</tr>
<tr>
<td></td>
<td>Reduced absenteeism</td>
</tr>
<tr>
<td></td>
<td>Improved timekeeping</td>
</tr>
<tr>
<td></td>
<td>Reduced number of grievances</td>
</tr>
<tr>
<td></td>
<td>Reduced turnover</td>
</tr>
<tr>
<td></td>
<td>Decreased waste</td>
</tr>
<tr>
<td></td>
<td>Increased number of employees’ suggestions adopted</td>
</tr>
<tr>
<td></td>
<td>Decreased production costs</td>
</tr>
<tr>
<td></td>
<td>Reduced overtime</td>
</tr>
<tr>
<td></td>
<td>Climate survey data</td>
</tr>
<tr>
<td>Customer relations</td>
<td>Accuracy of orders and information</td>
</tr>
<tr>
<td></td>
<td>Size of orders and transactions</td>
</tr>
<tr>
<td></td>
<td>Number of escalated complaints</td>
</tr>
<tr>
<td></td>
<td>Adherence to credit procedures</td>
</tr>
<tr>
<td></td>
<td>Customer satisfaction</td>
</tr>
<tr>
<td></td>
<td>Number of referrals</td>
</tr>
<tr>
<td></td>
<td>Number of lost customers</td>
</tr>
<tr>
<td></td>
<td>Amount of repeat business</td>
</tr>
<tr>
<td></td>
<td>Number of transactions per day</td>
</tr>
</tbody>
</table>

Adapted from: Robinson and Robinson, 1989
CASE STUDY (Part 3): MEASURING THE IMPROVED PRODUCTIVITY OF MANAGERS IN A FACTORY

Taking the “productive manager” in our case study of Japanese and German factories, let us suppose that, in one plant, rather than recruiting new managers from outside (as was actually done in most instances in that case study), it has been decided instead to train existing managers to become proficient in the five areas of competence affecting workforce productivity levels.

To design a suitable programme, first, each type of competence has to be analysed to define the skills, knowledge and attitudes that it requires. This means agreeing on those forms of behaviour that do in fact characterize managers in the plant who - for example - exercise tight control, in contrast with the kind of behaviour characteristic of those who are only “adequate” in that respect, or who fall below acceptable standards.

Second, there must be agreement on existing levels of competence in the management group, compared to those required; and on the gaps that training, as distinct from some other intervention, must make good. (This is the stage of identifying needs that has already been covered in Unit 4).

Third, learning objectives must be set, to express the nature of the gaps that training will tackle.

Fourth, ways of measuring the achievement of objectives must be agreed. Thus one question will be, “How will we know whether a particular manager is better after training at exercising tight control of the labour force”? The sorts of method that can be considered are:

(i) Putting the managers through some form of assessment/testing before the training programme begins, in order to establish their present level of competence in each area, and then assessing them again at the end of training to establish changes in levels of competence.

(ii) Putting them through some kind of initial assessment process, and then getting them to draw up personal development plans with their own managers and/or the training specialists, in order to clarify those individual objectives which they must achieve in each area of competence.

(iii) Simply relying on general feedback about their behaviour and performance from their managers after training has finished and they are back in the workplace, prompted perhaps by some kind of checklist of questions in relation to each area of competence.

(iv) Setting up a system of regular appraisal, possibly incorporating self-appraisal, behavioural rating scales and evidence of specific achievement.

(v) Seeking and using the views of peers and colleagues in deciding how far training has achieved its objectives with the managers concerned, again perhaps using behavioural rating scales and evidence of specific performance (an approach used both at British Airways and Citibank).

Two questions have to be answered:

1. What does each type of competence mean in terms of measurable behaviour?
2. How can a direct relationship between learning in each area of competence and subsequent performance on the job be established to the satisfaction of those needing to know how far the training has been successful?

There is no single way of measuring the achievement of learning objectives. However, providing that they are clearly specified and relate well to the overall purpose of the development programme, what really matters is to get the agreement of the key parties that they have found meaningful methods of measuring performance against those objectives, and that they are fully committed to using those methods.

5.4 Decide on the programme design and transfer learning to the workplace

Designing the programme depends on the nature of the training: if it is to consist of courses, then internal or external training specialists will carry the main responsibility. If it is to consist of, or include, an educational programme, then it will be the task of the educational body concerned. If it is to be learning on the job, then the managers concerned have to agree on the relevant experiences and how best to organize them; appropriate guidance and help will be provided as required by the HRD staff. In all cases, design can only be as good as the information on which it is based, so the people responsible for design must be clear about the purpose of the programme (or part of it); the kind of learners who will be involved; the learning objectives; the skills, knowledge, and attitudes to be developed; the standards to be achieved; the methods of learning, the content and activities that will be relevant; and ways in which the programme, or component, can be made attractive and motivating to the potential learners. All of this will need a continuous process of collaboration between all the key parties.

What matters most is that design and content are agreed between the key parties as being fully relevant to the purpose and objectives of the programme and to the learners concerned; that they are feasible and cost efficient; and that ways of transferring learning to the workplace are agreed and put in place before the programme begins.

5.5 Monitor programmes and assess outcomes

The way in which the programme is monitored will be determined by circumstances. For some programmes, such as the one at Sheerness Steel (Unit 1), monitoring was done in a general way by the training officer, Alan Melrose, who studied the number of people acquiring vocational qualifications over a number of years, and correlated these with changes in unit labour costs, work-hours of production, and productivity levels over the same period.

With a longer-term programme, more regular checks are advisable, with the final evaluation being carried out by some neutral party. With a short training course, more precise methods of monitoring the progress and results of the course can be established according to perceived need, and to the resources available.

The main principle here is to achieve a sensible balance between the need to check on what is happening at various stages of a programme and doing what is feasible given the resources and expertise available to carry out monitoring and evaluation.
Module 13
Unit 5

For a full explanation of this complex area, and further practical guidelines, see Harrison 1988, reprinted 1989.

We have now gone through the five processes, shown in figure 13.7, that are involved in selecting and designing a programme to improve productivity by developing people. You should do Exercise 5 to reinforce and extend the learning.

Exercise 5

Selecting and costing a development programme to improve productivity in a group of people in your own organization

This is a major assignment, and tests knowledge you have built up throughout the module, not simply in Unit 5. Your task is to make a proposal for a simple programme aimed at improving the productivity of ONE of the following groups by some form of developmental activity or activities. If at all possible, choose a real group with which you are familiar, where some form of development would in fact be a relevant and feasible way of boosting their productivity:

(i) A group of managers/supervisors in a particular organizational context of your choice.
(ii) A group of technical/professional workers in a particular organizational context of your choice.
(iii) A group of shop floor or office workers in a particular organizational context of your choice.

The task

Draw up a proposal (which should be concise, providing a clear guide to action). In the document make sure that you:

(a) Explain the needs of the group, relating to productivity, that will best be met by some form of developmental activity. Support your explanation.
(b) Recommend how the group should be developed, specifying the learning objectives, the period of time, and the resources required.
(c) Produce a simple cost-benefit analysis to support your proposal, and state how, when, and by whom, the development programme would best be evaluated.

This proposal has two purposes: to convince senior management that developmental action of some kind should be taken, and that the development programme you are putting forward will be cost effective, efficient, relevant and feasible; and to act as an initial brief for the training/HRD specialist who will subsequently be responsible for the detailed design and running of the programme, if your proposal is accepted.

Questions for discussion

1. What are the main steps involved in selecting and designing a development programme?
2. What are the main direct and indirect costs likely to be involved in a development programme?
UNIT 6: ASSESSING THE IMPACT OF HRD ON PRODUCTIVITY

UNIT 6: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Assess the outcome of HRD programmes and their impact on productivity.
2. Assess the costs of an HRD programme.

UNIT 6: CONTENTS

6.1 Developing people for higher productivity
6.2 Assessing the contribution of HRD to productivity
6.3 General principles of assessing costs and outcomes

Bibliography
UNIT 6: ASSESSING THE IMPACT OF HRD ON PRODUCTIVITY

6.1 Developing people for higher productivity

Please start this unit with a discussion of the following case study:

CASE STUDY (Part 1): CUMMINS ENGINE CO. LTD. DARLINGTON

Cummins Engine Company Inc. is the world’s largest independent manufacturer of diesel engines, with a turnover in excess of $3 billion per annum. The company employs 23,000 people worldwide, and 5,000 in the UK alone. Cummins Engine Co. Ltd. is the UK subsidiary of the company, and has three manufacturing locations, one of which is at Darlington, in the north-east of England. In 1979 the workforce at Darlington numbered around 3,000.

By 1984 the company worldwide was suffering from overcapacity and a cyclical order board; it faced new competitors, notably the Japanese, all striving to establish the leading edge in a stagnant market. The new business strategy, born from the long-term vision expressed by the Chairman the previous year in a mission statement about “new standards of excellence”, meant investing heavily during the 1980s in order to achieve long-term growth in the 1990s and beyond. Major business goals included restructuring and high investment in new technology, research and engineering; immediate price cutting to retain a competitive edge; and a 30 per cent cost-reduction target to be achieved by mid-1986 to offset the effects of the price-cutting exercise.

At the Darlington plant, imperatives focused on the need to cut costs and, within 18 months, introduce sophisticated new technology at one of the sites. There was also the complication of having to deal with two major unions.

Human resource strategy at Cummins Engines, Darlington, 1984

Darlington was party to the new UK human resource strategy in 1984. It aimed to achieve the mission of excellence, through serving the company’s overall and specific business goals. The strategy was to develop a flexible, skilled, committed and cost-efficient workforce by achieving three broad objectives:

1. Continuous reduction in labour costs
2. Elimination of job demarcation barriers, improved rewards for people, and harmonization of the workforce in terms of pay and conditions of service.
3. New forms of work organization to improve work flow

Productivity objectives

The company’s human resource strategy was based on three productivity objectives:

1. To achieve a lean, high quality, efficient workforce. Reducing materials costs would make the most impact on the target 30 per cent reduction in costs, since materials accounted for 80 per cent of production costs. Labour costs accounted for only 20 per cent, and it was therefore less essential to reduce the labour force (although that was part of the
strategy) than to make it more efficient. All unit labour costs had to be reduced, including those related to production time, turnover and absenteeism, timekeeping, working methods and procedures, accidents, materials wastage, quality and inefficiencies due to demarcation.

2. To ensure that the workforce had the skills needed to operate the new technology. A new product, the “B” series engine, was soon to be introduced at the Darlington site, and it had to be installed smoothly with a quick transition to full operational efficiency.

3. To develop a workforce with high added value. In order to take full advantage of the growth opportunities envisaged in the 1990s the workforce needed an improved base of skills, the ability to learn quickly and flexibility in skills and attitudes. The aim was to reduce costs and add value to the human resource.

**HRD objectives, policy and plans related to productivity**

HRD objectives related to these three productivity objectives were then established:

1. To help people acquire and apply the new competencies; to work in the new culture needed for efficient operation; and to respond positively to the challenges of change.

2. To encourage and enable people to work effectively in teams.

3. To develop managers, especially supervisors, who could manage teams effectively.

In order to achieve these HRD objectives, the following policy and plans were established:

- A higher level of basic skills in the workforce.

- Relevant training for those with the capacity and motivation to learn to operate the new technology. (As a result of other business changes and the need to reduce staff, there were opportunities for early retirement.)

- Training for all, geared towards business needs.

- The opportunity for everyone to learn one new skill each year over the next five or six years, and to be rewarded financially for the acquisition of each skill. All employees could earn up to six skill increments which could ultimately take them to the top of their band — and the bands were very broad. Each skill module was worth 6.6 per cent of salary. (This pay progression supplemented the annual pay negotiations).

- Teamworking. Expectations about teamwork and supervisors in the 1980s were that supervisors would become a new breed, operating quite differently, and that, given some initial training, they would adapt quite quickly, encouraged and helped by all the other work being done in relation to achieving the three strategic human resource objectives.

These, then, were the objectives, policies and plans for developing people at Cummins in Darlington during the 1980s in order to build a more productive workforce so that expansion could be achieved in the next decade.

1. They derived from a clear definition of “productivity” in different sectors of the workforce, measurement of current productivity rates and levels in each sector, and
agreement on which needs would best be met by developing people, and which would best be met by other kinds of human resource policy.

2. They were carefully aligned with strategic human resource and corporate objectives. They were consistent with other human resource policies and plans then being made operational, of which the most crucial were the efforts to achieve integrated pay systems and total harmonization of the entire workforce.

3. The various processes involved in carrying out these steps were collaborative, business led, and pragmatic. They operated on the basis of sound and comprehensive data, gathered by personnel practitioners and managers, and they incorporated learning from carefully monitored experience.

**HRM practitioners at Darlington**

At Cummins in Darlington human resource management has always been closely aligned to the needs of business, with its practitioners — who are generalists rather than specialists — working closely with line managers. At plant level, a business plan has to be produced jointly by all operating managers, including the personnel department. At corporate level the business plan has a detailed human resource strategy section. At UK level, human resource issues are taken fully into account in all business planning and decision making.

So Cummins’ personnel specialists have a thorough understanding of the business and its needs, and are very clear that their overall mission is to ensure that the function makes a key contribution to business goals, whether at individual, business unit or corporate level. The personnel function is not simply a “resource” or “support” — it is a partner with other functions of the business. These factors were of crucial importance at Darlington from the mid-1980s onward. They meant that personnel staff had credibility and respect as they worked with people throughout the organization to introduce radical changes over quite a short space of time.

Now let us relate the main points in the case study to learning presented in the module so far, to help reinforce what you have learnt. This activity can be done in groups or individually, in class, as an assignment, or simply as an individual review process at home.

1. **Group work**
   Each group could take a particular unit and establish how far the points it makes are reinforced by information in the Cummins case study, or where there are divergences. Alternatively each group could take one of the main themes of the module, and see how far these themes are illustrated by information in the Cummins story. At the end of a set period, all the groups should make a short presentation summarizing their findings.

2. **Individual work**
   The aim here should be to take each unit and relate the main points in it to information in the Cummins study in order to better understand those points — looking especially at how they work in practice.

Now continue with the case study.
6.2 Assessing the contribution of HRD to productivity

Let us continue with the case study.

CASE STUDY (Part 2): CUMMINS ENGINE CO. LTD.

Did HRD policies achieve improved productivity at Cummins? The question is not simple, because productivity at Cummins meant different things at different levels, and so it had to be measured in a variety of different ways. More important, the impact of HRD policies on productivity depended quite significantly on a wide range of interlinked human resource policies and processes, especially those concerned with rewards and harmonization.

Therefore to answer the question about HRD and productivity, we will have to look at all the results that HR strategy at Cummins had achieved by early 1991. On the positive side, whilst the human resource strategy of itself did not result in a 30 per cent reduction in costs — it was never envisaged that it could — there were significant reductions nonetheless, together with certain "softer" outcomes which have been crucial to the company. Taking the three strategic human resource objectives, beneficial outcomes have been:

1. Reduction in unit labour costs

Through redundancies, early retirements and natural wastage, the workforce at Darlington was cut from 3,000 in the late 1970s to just 800 by late 1989, and one of the two Darlington sites, the components plant, was closed. The measurable cost reduction achieved under this heading has, however, to be balanced against the problems encountered in dismantling demarcation. Little progress was made, and this in turn reduced the otherwise positive impact of the integrated systems introduced in other parts of the workforce.

2. Elimination of demarcation barriers, improved rewards for people, and a complete harmonization process

In the UK subsidiaries there had always been a marked and negative division between blue- and white-collar workers. The harmonization programme introduced in the mid-1980s had considerable success: for example, the whole workforce, including all levels of management, was working a 37.5 hour week in 1991, and all employees had salaried contracts. Perhaps the biggest single achievement related to this objective was that in spite of the reduction from 16 grades to an integrated payments structure with five bands, there were no grading disputes between 1984 and 1991. A key to this achievement was the process used — a pragmatic approach based on what could fairly and feasibly be achieved. It aimed, not at a tight and detailed description of jobs, but at slotting existing and new jobs into the revised structure on a rather crude basis, although it seemed both sensible and fair.

The introduction of new technology was accomplished with remarkable ease at a time when there had been major changes, and when new products were being introduced in a very short space of time. When a plant in Darlington was shut down and another one was taken apart and refitted, the whole operation was executed within less than two years, on time, without conflict, and with a smooth transition from operating one type of technology to another, far more sophisticated type.
The smooth and conflict-free introduction of new technology is considered to be a major cost-benefit factor, as is the increased flexibility of the workforce and a sustained lower level of annual pay rises.

However, there have been financial costs to the harmonization programme. It was decided at the start that, in line with the company’s general positive philosophy about its workforce, pay would be levelled up not down: thus the starting point was to take existing salaries and wages and work around the status quo, ensuring that all workers had the kind of reorganized job that required at least one more area of skill; acquiring this skill would justify at least some increase in pay. In spite of many initial difficulties, this policy, which was long term in its aims, did finally obtain the two unions’ support for harmonization. It was accompanied by a gradual and comprehensive approach, with the overall aim of building up a single workforce, working under the same kinds of contract, and jointly achieving high skill, flexibility in order to cope with the future, and, above all, production of high-quality goods.

“The organization was not simply trying to negotiate the introduction of a revised remuneration package, it was attempting cultural change and a redesign of traditional concepts of work.” Despite inevitable defensive reactions at the initial stages, this has had a high degree of success.

3. New forms of work organization

The shift to a more flexible, team-based culture is obvious although hard to quantify, and it comes not from one area of activity, but from a combination of all the achievements that have taken place through the new HR strategy. For example, as people have seen that, whatever changes may occur, they will be equipped with the necessary skills and will be fairly rewarded for that skills acquisition, so they have come to see change less as a threat than as an opportunity.

The organization structure has moved from a hierarchical one that was functionally based to a much flatter one based on the concept of business units. Team groupings are now the norm, and individual job assignments are increasingly related to the work flow process of the organization.

Overall, the feeling is that life at Cummins is significantly different now, with a greater facility to move people around through a variety of tasks, jobs and processes, with training and development geared to business needs, and with help directed at enabling people to develop skills in the areas where it is clear that those skills are most needed.

What are the negatives? It is interesting that Cummins has lived up to its image of a “learning organization” by being willing to discuss the negative aspects so that they, and others, can learn from them (Pottinger, 1989). In relation to the three HRD productivity objectives, the following were the three main areas of underachievement:

1. Helping people to acquire and apply new skills
   - The resources needed for the skills module programme were underestimated in a variety of ways. Furthermore, whilst the new training modules and related pay increases were ineffective in supporting the introduction of new technology, there is some way to go before the skills base of the workforce as a whole is at the level where it can
Module 13
Unit 6

make a real impact on the organization’s overall growth and productivity.

- Another important issue is the unanticipated belief that training is an end rather than a means. Because of the way that pay and training have been linked, some see training simply in terms of acquiring more pay. There must be a change in such attitudes, so that pay is seen to reward the improved performance that results from training, rather than the training itself.

2. Encouraging and enabling people to work effectively in teams

Training groups to become teams focused on the activities and the tasks such teams had to perform, rather than on the new interpersonal relations that are essential for effective teamwork. This aspect was given attention later.

3. Developing managers, especially supervisors, who could manage teams effectively

Retrospectively, it is accepted that insufficient attention was paid in the 1980s to the need to help supervisors adapt to, as well as adopt, a new, team-centred role. After the initial teamwork training, and appropriate technical training to cope with the new technology, it was assumed that the supervisors would overnight become a new breed. This did not happen in every case. Now, to help the transition process, all supervisors are going through a work-related education and development programme leading to a national supervisory skills certificate. Progress is already being made, but more will need to be done.

The 1990s have produced unexpected problems that have adversely affected Cummins Engines — the downturn in the UK economy, and the results of the Gulf War. These unpredictable factors illustrate the need for continuous review and adjustment. Thus both human resource strategy and, within it, HRD objectives, are regularly monitored, evaluated and amended.

The overall human resource strategy for the 1990s is a strategy of continuous improvement of 10 to 15 per cent per annum, with the following specific HRD objectives:

1. Helping people to acquire and apply new skills

   - Introduce an integrated programme of education, training and retraining for all types and levels of employee.

   - Recognize and reward success through non-monetary mechanisms, especially through the introduction of career planning, incorporating the fundamental principle of continuous development.

   - Ensure maintenance of required technical resources.

2. Encouraging and enabling people to work effectively in teams

   Helping teamwork and teambuilding processes.

3. Developing managers, especially supervisors, who can manage teams effectively

   Focusing on the development of processes related to managing teams.

4. Developing functionally qualified leaders

   A process found necessary because of too extreme a shift in parts of the organization structure from crucial functional disciplines such as industrial engineering.
5. Introducing appraisal for all levels in the organization

The need has been perceived for a more systematic approach to the assessment of performance and the identification and planning of people's development needs.

Thus one can see how objectives have been amended and extended, through a process of learning from experience, and of relating assessment of results back to original objectives and forward to the revised business and human resource strategy. However, Cummins' HRD objectives related to productivity are still about enabling and encouraging people to become more efficient, less costly, and more effective — in other words, high value-added resources for the company as it moves into the future.

6.3 General principles of assessing costs and outcomes

What can be learnt from this case study about assessing the costs and benefits of an HRD programme related to improving productivity, and measuring its results?

The main relationships between different stages of human resources development and assessing the costs and benefits are illustrated in figure 13.9.

Figure 13.9: Assessing costs and benefits of a development programme and measuring results
The following checklist shows how outcomes can be assessed, and the general principles or guidelines to follow when planning the assessment.

A six-point checklist.

1. Draw up HRD objectives that will meet productivity objectives established in the wider human resource strategy, and ensure that final results are measurable against those objectives. They must make sense in relation to the way productivity is defined in the organization at every level and in each kind of position, and must be challenging enough to make a real impact on productivity at the level of the organization, the business unit, or the individual.

2. Identify the costs of the programme, both immediate and obvious, and indirect but critical.

3. Identify likely benefits that will be obtained by realizing objectives, both in the short- and long term.

4. Agree on who is to monitor and assess the results of the programme, when and how.

5. Assess the outcomes of the programme in relation to the purpose and objectives set for it at every level — organizational, business unit and individual — and use initially agreed methods of measuring achievements. Line managers, in particular, must be able to state how, and why, things have not changed, and be specific in their evidence.

6. Ensure that feedback on results is timely, goes to the interested parties and influences the next stage of planning.

At the end of this module it is very important to emphasize two critical issues in HRD: the first is that successful HRD is a continuous process and the second is that HRD practitioners must be professionals.

Development is a continuous process

The development of people as distinct simply from training, is a never-ending process. The meaning of "productivity" will change in any organization, as we move through different types of work and position, through different levels of the system — corporate, business unit and individual — and through different periods of time in the organization's life cycle. Thus programmes aimed at developing people to achieve productivity objectives must be continuously monitored and changed, like the wider human resource policies and strategies of which they are a part.

HRD practitioners must be professionals

Professional expertise is necessary to manage the HRD function. It is clear from the module that to be effective and credible in the complex and sensitive tasks involved in developing people to improve productivity, the person responsible for those tasks — a senior manager, a personnel director, or an HRD specialist — will need technical, analytical and political skills of a high order.

Even with those skills, human resources development will not succeed in contributing to the needs of the business when:

- it is left in the hands of specialists, rather than being based on knowledgeable collaboration between specialist staff (where they exist) and line managers;
- it has no real credibility in the organization;
- it does not have the support of top management;
- those responsible for it do not fulfil that responsibility properly;
- it is not integrated into a wider human resource strategy which itself is tightly linked to the business needs of the organization.

When those with major responsibility for the function have the necessary skills, and the function itself is well-positioned within the organization then, as the case studies in this module demonstrate, development of people as a strategy to improve productivity will indeed prove a fully justifiable investment in any business.

Work through this final exercise to reinforce and extend learning.

**Exercise 6**

Assessing the outcome of a development programme to improve productivity in your own organization

This can be done in groups as a major class activity, or it can be tackled as an individual written assignment. Its aim is to give you practice, using a real-life example, of measuring the outcomes of a development programme. You will find the Cummins case study particularly helpful in this assignment.

(a) Take any programme, course or other form of learning activity in your own organization, or one with which you are familiar. The approach should have as its aim — or as one of its main aims — the improvement of people's productivity, however that has been defined for those particular learners. It can be of any kind, and may consist of various activities. It should, however, be a planned approach, aimed at making people more efficient in their job, or adding value to people in some way.

(b) Establish the purpose and objectives of the activity and its direct and indirect costs; then measure its outcomes. Explain how you carried out these tasks, any problems you encountered and how you tackled them.

(c) Outcomes can be any that you choose, as can the points in time at which you decide to measure outcomes. However, you must justify your choices by showing that, in the end, you have found a convincing way of establishing how far the programme or other form of learning activity has, or has not, really made an impact on productivity.

**Question for discussion**

How can the outcomes of an HRD programme designed to improve productivity be assessed, and what principles should be borne in mind when planning the assessment?
BIBLIOGRAPHY


MODULE 14

PRODUCTIVITY MOTIVATION AND
GAINSHARING
MODULE 14: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Have a good understanding of the Gainsharing concept.
2. Isolate and analyse the key factors of a Gainsharing plan.
3. Make a Gainsharing presentation to management.
4. Assist with the design and implementation of a Gainsharing plan.
5. Relate different Gainsharing schemes to company productivity strategies.

MODULE 14: CONTENTS

UNIT 1: Definition, main features and benefits of Gainsharing

UNIT 2: Different motivation systems: An overview

UNIT 3: Two key issues: Involvement and calculation

UNIT 4: Installing the Gainsharing system

Bibliography
UNIT 1: DEFINITION, MAIN FEATURES AND BENEFITS OF GAINSHARING

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and explain the Gainsharing concept, its role and its main principles.
2. Understand the main reasons why organizations have introduced Gainsharing.
3. Explain the most important features, components and conditions for success of Gainsharing.
4. Make a clear distinction between Gainsharing and other payment schemes.

UNIT 1: CONTENTS

1.1 What is Gainsharing?
1.2 Why organizations implement Gainsharing
1.3 Why Gainsharing works: Main benefits
1.4 Supportive conditions for success
1.5 Major features of Gainsharing
UNIT 1: DEFINITION, MAIN FEATURES AND BENEFITS OF GAINSHARING

What organization would not like to combine communications, teamwork, common goal orientation, performance improvement, employee involvement and financial rewards into one system? This is exactly the reason why more and more organizations are turning to various forms of Gainsharing.

1.1 What is Gainsharing?

Gainsharing is a group incentive or bonus system that shares improved performance with most or all employees of a unit and thus motivates higher employee involvement. Some people include many systems under the heading of Gainsharing, such as profit sharing and small group incentive plans, whereas others exclude these systems.

In earlier days, the boundaries between Gainsharing and other motivation schemes were much more clearly defined, since many applications were “packaged” approaches and known by such names as Scanlon, Rucker and Improshare. Although the concept can be traced back to the 1940s and 1950s in both Europe and North America, it is only during the past 10-15 years that much interest has really been shown in the concept. In some firms, this interest was the result of increased competitive pressures; in others, people wanted to change their management system towards more participation, and thought a bonus was an important component of that change (e.g. Japanese firms, Volvo); still others wanted to link pay to organizational performance. We feel that these factors will continue to accelerate the installation of Gainsharing in many different applications and situations, with a wide range of motivational influences. Today, the trend throughout the world is more towards customized plans to meet the needs and degree of sophistication of a particular organization. As the Gainsharing concept has expanded, its flexibility and success have increased, and interest in customized approaches has probably increased too, even though these are perhaps more difficult at the outset. Most Japanese firms have a form of Gainsharing based on profits that includes most employees, but it is normally a form of contingent compensation.

Some important common characteristics of Gainsharing are as follows:

1. *Performance improvement.* A goal of all Gainsharing plans is to improve performance. This performance may be measured narrowly, using total actual time versus standard time, or physical measures of output versus physical measures of input, all the way to broad calculations based on improving profits or return on investments.

2. *Gaining upon something.* In the past, most Gainsharing plans were based on some measure of previous performance which made it easier to sell to employees. There seems to be a trend today towards basing the bonus on a combination of past and expected performance.

3. *Sharing with all or most employees.* In the past, Gainsharing plans would include select groups of employees such as hourly or factory employees, but the trend today is towards including almost everyone.

4. *Includes employee involvement.* Most private and public sector plans include considerable employee involvement since the emphasis is on developing better cooperation, communications, work and goal attainment. The concept of “working smarter” normally requires some form of employee involvement or empowerment.
5. **Site specific**. Although exceptions can be found, most plans are site specific, rather than including many locations in one plan.

6. **Long-term oriented**. Most Gainsharing plans are not installed for short-term results; the employee involvement aspects make this difficult. Few are installed on a pilot, small department basis for the same reasons.

7. **Not individual oriented**. Since Gainsharing is group oriented, individual and small group-oriented systems are typically excluded. Before installation, most firms eliminate individual-oriented systems.

### 1.2 Why organizations implement Gainsharing

Many forces are at work to promote Gainsharing's growth. These include more competition; more push for quality and cost reduction; more knowledge and resources to help; more flexible formulas; more employee involvement; more responsive managers; and a fairly high success rate of those organizations that have installed Gainsharing. Most interested firms can be grouped into three broad categories based on the reasons why they install Gainsharing:

1. **Troubled firms**. The need to change is apparent.
   - Situations:
     - poor performance;
     - poor labour-management relations; and
     - deteriorating markets.

   Important variables:
   - need to change is apparent: can everyone agree on the need to change?
   - desire to implement new philosophies and actions; and
   - often a new management.

2. **Successful firms**. They install Gainsharing because they believe in sharing, more employee self-control, employee involvement, and so on.
   - Situations:
     - good past performance:
     - good potential for growth:
     - good pay;
     - good communications (e.g. frequent meetings); and
     - good involvement and/or empowerment.

   Important variables:
   - belief in fairness of sharing;
   - past success with various programmes;
   - high levels of commitment and effort;
   - belief in capitalism and effect of money;
   - common goals; and
   - search for continuous improvement and change.

3. **Contingent compensation firms**. More and more firms are starting to tie pay or part of it to organizational performance.
Situations:
- new business may be going elsewhere;
- often part of union contract;
- would make wages more variable;
- sometimes part of wage concessions but not always; and
- similar approach to Japan (over 40 million Japanese have been reported to be in group bonus systems).

Important variables:
- most participants have to buy into concept of variable or contingent compensation;
- will concept be long lasting?
- will management attempt to control bonus?
- will participants change behaviour? and
- will participants change attitudes toward variable compensation after problems are overcome or improved?

Most installers of Gainsharing systems are manufacturing firms with 100 to 1,000 employees; perhaps 40 per cent of them are unionized; and most are plants or divisions of larger organizations rather than small, privately owned companies as was true in the past. Gainsharing is slowly moving into service sector organizations such as hospitals, banks and insurance companies, a trend which is likely to accelerate in the future.

Traditional systems such as Scanlon, which emphasizes heavy employee involvement; Rucker, which promotes value added as a calculation; and Improshare, which uses a standard-based calculation and traditionally has not promoted a need for formalized employee involvement, are still being installed but their frequency seems to be decreasing. As mentioned earlier, most firms today prefer a more customized approach.

Thus, different models of behaviour and expectations underlie each of these and other approaches. That is what makes Gainsharing so complex: it is applied in so many different situations for so many different motivational reasons.

1.3 Why Gainsharing works: Main benefits

Successful firms use Gainsharing constantly since it brings benefits for both employers and employees. These benefits are realized through the motivational forces developed by the scheme. Obviously, benefits differ greatly depending on the commitment to the change process and motivations. The commonly cited ones are examined below.

1.3.1 Possible organizational benefits

1. Improved productivity: reduced costs or increased output.
2. Improved employees' identification with history, problems, goals and opportunities.
4. Helps to link rewards with improved performance.
5. Improved communications and cooperation.
7. Greater employee involvement.
8. Greater competitive posture and job security.
9. Ideas as well as efforts are produced.
10. Improved planning and control systems.
11. Climate of efficiency, quality and competency is fostered.

The main benefits of Gainsharing are that it integrates communications, teamwork, goal orientation, quality/performance improvement, employee involvement and financial rewards into one system.

1.3.2 Possible employee benefits

1. More long-term job security because of increased productivity.
2. Greater recognition.
3. Improved communications/teamwork/cooperation.
4. Sharing in benefits of productivity increases; more money.
5. Feeling of contributing to organization.
6. Becoming more involved in changes.
7. Way to get things done.
8. Learn about the company, its history, problems and opportunities.

This helps to develop a win/win type of situation.

Obviously, many motivational factors can help to make Gainsharing successful. If only the bonus is stressed, it becomes the most important variable.

Dozens of case studies document the merits of Gainsharing. Perhaps the most comprehensive study was done in America for the American Productivity and Quality Center (O'Dell, 1987), which included over 200 Gainsharing companies. Some of the results from the study are listed below:

1. Reason for implementing: performance improvement was important or very important to 93 per cent of firms.
2. Bonuses seemed to average around 7-8 per cent, depending on the plan.
3. Percentages indicating positive effects on productivity and costs ranged from an average of 98 per cent (Scanlon) to 84 per cent (customized plans) and somewhat lower for profit-sharing; many other variables also improved.
4. Gainsharing firms disclosed much more information to employees than non-Gainsharing firms.
5. A percentage of pay was the most common bonus payment method.
1.4 Supportive conditions for success

If one assumes that a major, long-term change process is desired, some specific conditions are important for the success of any Gainsharing system. Some of them are:

1. Commitment from top management.
2. Need to change or a strong desire to do better.
3. Management acceptance and encouragement of employee input and education.
4. Higher interaction and cooperation.
5. Absence of major job security threat or business problems.
6. Adequate information on productivity and costs.
7. Performance goal setting.
8. Commitment on the part of all employees to the change process.
9. Agreement on a gains calculation which is relatively simple, perceived as fair and meeting management objectives.

At this point discuss some of these conditions in detail along the following lines and try to answer the points raised, relating them to your own business environment.

1. **Commitment or identity:** Need to change. Mandates or expectations towards:
   - clients and customers;
   - the organization itself; and
   - each other.
   Who is accountable for what?
   How much change do we expect from everyone?
   When shall we know whether Gainsharing is working or not?

2. **Involvement:** Help to build identity. Could include:
   - no formalized system;
   - steering committee to help with design;
   - department or area teams to work with implementing ideas;
   - Gainsharing review board for broader issues; and
   - see unit 3 for more detailed discussions of different involvement systems.

3. **Equitable sharing of benefits:** The bonus system. Examples of outcomes which might result in bonuses:
   - reduction of one or many costs;
   - reduction in hours of work;
   - improvement in quality;
   - reduced absenteeism; and
   - increased profit if it is a profit-oriented organization.

4. **Competent management**
   - Characteristics:
     - good planners, organizers, communicators;
     - risk-takers; and
     - not too defensive: Gainsharing does open up the organization.
5. **Other factors**
- Top management is committed to the plan;
- agreement from headquarters;
- workload can absorb increased productivity (e.g. up to 25 per cent); and
- good relations with any existing unions.

Certainly, important factors in the success of Gainsharing include the availability of a good coordinator, good labour-management relations and inside pressure for the system to be installed.

### 1.5 Major features of Gainsharing

Different Gainsharing systems concentrate on different features, depending on specific conditions and on the organization. Discuss the following subsections.

1. **Performance- or productivity related**
   - Narrow examples:
     - coalminer producing 40 tons of coal in 40 hours;
     - reducing supply costs; and
     - improving quality or response time.
   - Broader examples:
     - increasing profits in a profit-oriented firm; and
     - reducing most or all costs in a profit or non-profit organization.

2. **Gaining upon something**
   - Most plans (perhaps 65-75 per cent) are based on bettering past performance. The base period could be as short as 1 month or as long as 10 years, but the most recent year or two is typical.
   - Other plans are based on reaching a targeted level of performance; this is becoming more common. Examples include not paying a bonus until a targeted level is reached for reducing budgeted payroll or other costs, improving specific quality/customer service measures such as returns or on-time shipments, or improving upon forecasted shipments.
   - Combinations are also possible in practice, e.g. combination of reducing past and forecasted costs or quality measures: some organizations have a series of pools for labour productivity, quality-related issues and controllable costs, for example.

3. **Sharing with participants: A group bonus system**
   - Range: may be a small group to include everyone; and
   - emphasis is on teamwork, and so individual-oriented systems are frequently excluded from the concept of Gainsharing.

4. **Includes employee involvement**
   - Emphasis is on "working smarter"; some method must exist to allow this to occur;
   - studies show this is often the most important factor; and
   - with this component, Gainsharing activates both intrinsic (behavioural) and extrinsic (bonus) motivational variables.
5. **What Gainsharing is not**
- Short-term-oriented in most situations;
- easy to do well;
- a substitute for wage increases in most situations; and
- individual or typically small-group-oriented; it is normally carried out for entire units, such as a plant. Multiplant operations are normally not combined to form one Gainsharing unit (each unit is separate, but Gainsharing is not normally applied on a department basis, because of interdependencies).

**Questions for discussion**

1. What is Gainsharing? Why it is considered as a concept for change?
2. Why do organizations install Gainsharing?
3. What are the necessary general conditions for successful Gainsharing?
UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Explain the most important principles and types of motivation systems and their linkage with performance.

2. Suggest the best type of Gainsharing system in accordance with company-specific conditions.


UNIT 2: CONTENTS

2.1 Individual-oriented systems

2.2 Group-oriented Gainsharing systems
UNIT 2: DIFFERENT MOTIVATION SYSTEMS: AN OVERVIEW

There are two major groups of motivation system - individual and group oriented.

2.1 Individual-oriented systems

Individual-oriented systems may be classified into piece-rate systems and individual suggestion reward systems.

2.1.1 Piece-rate systems

This system relies on the base rate (to handle waiting and other time beyond the employee’s control) and an incentive premium and is based on engineered standards or past history or a combination of the two. It is quite common in the United States and some European countries but not in Japan. The piece-rate system is applied most commonly to manual activities in manufacturing and service sector firms with predominantly manual operations.

Advantages of piece-rate systems

- less management control/supervision is needed;
- it encourages “work harder” attitudes;
- it appeals to the individualism concept found in the United States and at present spreading throughout the world; and
- management often likes the idea - pay people for what they do!

Disadvantages of piece-rate systems

- there are a fair number of disadvantages to piece-rate systems - for instance:
- they are unfair to some employees, over-generous to others;
- they are difficult and costly to maintain;
- they are a source of many complaints and grievances;
- automation reduces applicability;
- they decrease the “best” use of employees (e.g. highly skilled maintenance employees may transfer to easy incentive jobs);
- they decrease positive attitudes towards teamwork;
- they create a “them/we/me” atmosphere;
- the interdependency of work and workers’ activities is greater today, making individual incentives less applicable;
- quality suffers because of individual incentives;
- the cost of quality maintenance is greater;
- it is difficult to include indirect employees in a piece-rate system;
- supervisors often have to spend too much time maintaining the system;
- a system may actually encourage off-incentive average time (for items with “tight” standards, non-incentive time may pay more);
- they reduce the possibility of shifting/moving/cross-training employees;
they create two classes of workers, those on and those off incentives;  
there is little incentive to help other employees;  
it is difficult to improve the productivity of indirect workers;  
they may damage good labour-management relations;  
caps on production often exist; and  
a group may put pressure on "rate busters" to slow down.

As may be imagined, with these disadvantages the trend is now away from piece rates, except in selected areas such as check processing, key punching and order picking in warehouses and for applications with limited objectives, such as finding new book customers.

2.1.2 Individual suggestion reward systems

The basis for these systems is:

- they pay people a percentage of the first year's savings from ideas submitted;  
- they represent non-monetary awards (honorary) with significant recognition systems in place;  
- they may be a combination of awards (explicit and implicit);  
- they may operate on a points basis - each idea submitted receives so many points and awards are made according to the total points awarded; and  
- they could be run as a kind of lottery - all ideas submitted and accepted in a particular period are eligible for "prizes" ranging from limited cash awards to major holiday trips.

Their advantages are as follows:

- they involve little cost;  
- they force management to listen, at least in part;  
- they may motivate some employees to submit ideas;  
- they can control the time needed for investigation; and  
- they can eliminate bad ideas.

Their disadvantages are as follows:

- they generally do not work well - management usually remains uncommitted;  
- they take too much time;  
- feedback is normally poor; and  
- determining the payment amount may be difficult.

Because you cannot reward twice for the same idea, the individual suggestion system is usually suspended in an organization in which Gainsharing is introduced.

2.2 Group-oriented Gainsharing systems

Although Gainsharing is increasingly being recognized as a generic term that applies to a wide range of alternatives, situations, organizations and philosophies, numerous individual
systems are still being installed: these may be classified in the following groups.

2.2.1 Profit sharing

Some people believe that Gainsharing excludes profit-oriented systems; others maintain that, if such payment is made more often than once or twice a year, it is a form of Gainsharing. The resulting disagreements lead to considerable confusion.

Both cash and deferred payment types are found: Gainsharing typically includes only cash types.

Possible advantages are as follows:
- they relate to overall performance;
- they are similar to top management motivation;
- they are easy and inexpensive to administer;
- bonuses are paid when money is available; and
- they may make it easier to build up employees' trust.

Profit-sharing systems may give rise to problems, however:
- employees may have difficulty in relating the system to their own efforts;
- there is often a reluctance to share information;
- they are not applicable to many situations;
- they are not directly related to performance;
- it can be difficult to stimulate involvement; and
- the amount related to profit can be controlled by management.

If the payment is made only once a year under a profit-sharing system, this is not normally considered to be a Gainsharing system (but it could be if there is a hurdle rate (some past or targeted profit) before a bonus is earned, if it includes employee involvement and if it is paid more often that once or twice a year). We believe that, if these three components are present, the system is a form of Gainsharing.

2.2.2 Scanlon Plan

This was developed in the 1930s by Joe Scanlon, a United Steel Worker official. It is a formalized suggestion system, involving considerable research, a very flexible productivity measurement system and a total organizational plan. Gainsharing is becoming what Scanlon intended for his own Plan - a very flexible, goal-oriented system with high involvement.

2.2.3 Rucker Plan

This was developed in the 1930s by Allen Rucker. It is always based on a value-added calculation (labour costs divided by value added; value added is sales minus outside purchases).
All or part of the organization participates and involvement is emphasized. The Plan is fairly common in Europe, because of European experience with value-added taxes, but the method of calculation is difficult to understand and it is currently being phased out.

2.2.4 Improshare

Improshare stands for Improving Productivity through Sharing. It follows a more traditional, industrial engineering approach (based on standards) and is applied at all staff levels. There is little involvement at the beginning but some firms introduce quality circles later. The system may be introduced by management or following a vote by the staff. There must be rules providing for “buyback” of products not meeting required quality standards. There is little research at present into the system, which is of fairly recent origin, being developed in the early 1970s. Licensing arrangements have been reached with various consulting firms, and many versions are used in practice.

***

As well as the above, many hybrid plans are in use today, ranging from very limited systems with short-run objectives to very broad plans, including the whole staff. The trend is toward more customized plans, and this has probably increased the success rate of Gainsharing.

Questions for discussion

1. What different types of Gainsharing systems are there?
2. What are their main advantages and disadvantages?
3. What are the major trends in Gainsharing development in your country?
4. What does “customization of Gainsharing” mean?
UNIT 3: TWO KEY ISSUES: INVOLVEMENT AND CALCULATION

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and explain the key issues involved in the design of Gainsharing systems.

2. Understand the relationship between methods of employee involvement and Gainsharing calculations.

3. Understand different Gainsharing systems and their calculations and relate them to specific company performance objectives.

4. Assess the success of a Gainsharing system.

UNIT 3: CONTENTS

3.1 Involvement issues

3.2 Different calculation options

3.3 Key calculation decisions in Gainsharing systems

3.4 Typical examples of Gainsharing calculations
UNIT 3: TWO KEY ISSUES: INVOLVEMENT AND CALCULATION

An analysis of many Gainsharing schemes indicates that, despite their differences, they all have two common features, i.e. the involvement of employees in decisions about the performance of their work, the calculation of the volume of gains and the pattern of distribution between those who create the gains. We shall discuss these issues in this unit.

3.1 Involvement issues

There are several involvement and communication methods, including teamwork, communications and recognition. They may be limited or wide-ranging (see figure 14.1).

**Figure 14.1: Methods of involvement**

<table>
<thead>
<tr>
<th>Limited</th>
<th>Wide-ranging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask questions</td>
<td>Steering committee</td>
</tr>
<tr>
<td>Report bonus</td>
<td>Developmental task force</td>
</tr>
<tr>
<td>No structure</td>
<td>Department/area teams</td>
</tr>
<tr>
<td></td>
<td>Council/plant-wide board</td>
</tr>
<tr>
<td></td>
<td>Meetings at least once a month</td>
</tr>
<tr>
<td></td>
<td>Self-managed teams</td>
</tr>
</tbody>
</table>

As can be seen, involvement ranges from relatively minor degrees of employee involvement when the management style is fairly autocratic or has limited, short-range objectives to significant involvement if the plan is based fairly broadly on a philosophy of participative management.

Below we suggest a somewhat elaborate but commonly found involvement system based on a parallel concept (i.e. management would still make day-to-day decisions); empowerment in this approach would still be somewhat limited. This is a fairly typical approach in an organization with fewer than 600 employees. Larger firms may add another level of involvement between the area teams and the council.

3.1.1 Steering committee

**Possible activities**
- Develop draft of plan (purpose/goals; involvement system; calculation; policies);
- obtain corporate approval; and
- normally temporary.

**Membership**
- Normally top management; could include union representatives in some situations if appropriate.
3.1.2 Development task force

Possible activities
- Finalize draft of plan;
- help to build identity;
- group would make presentation to other employees; and
- adjust the draft plan to reduced expectations after tentative corporate approval.

Membership
- Cross-section of entire organization.

3.1.3 Departmental or area teams

Possible activities
- Investigate suggestions;
- implement suggestions (if consensus exists and within spending limits - e.g. US$200-US$250);
- develop departmental goals;
- work on solving problems (communications, recognition); and
- meet at least once a month.

Membership
- Management/non-management representatives; and
- coordinators/advisors.

N.B. This kind of involvement results in considerable empowerment of employees, but is still a long way from self-managed workforces.

3.1.4 Gainsharing council

Possible activities
- Reviews economics;
- reviews bonus results;
- reviews team activities; and
- performs special studies.

Membership
- Non-management representatives from each team and top management.

N.B. Various references in the Bibliography at the end of the module cover these and other employee involvement systems in more detail. A larger organization may have three or four levels of employee involvement with different decision-making limits (empowerment) at each level.

It can therefore be seen that involvement is an important feature of a typical full-scale Gainsharing system, starting with a steering committee to develop a draft plan and obtain
approvals, and going on to a developmental task force, which is much larger and helps to refine and implement the system. After implementation, area teams are normally formed to help to implement ideas for improvement and monitor economic conditions and bonus results. Many companies have two or three levels of involvement. Numerous other systems are found in practice, including some based on quality circle orientation and more self-managed approaches. Today there is a more marked trend towards increased involvement and empowerment than during the past five years.

Before going on to the next section, discuss the following important issues of involvement and try to relate them to your own organization.

1. How will the organization’s philosophy and its reasons for installing Gainsharing affect the involvement system (e.g. an autocratic management style and/or limited objectives tend to reduce involvement)?
2. Indicate which possibilities are available for involvement and which are used in practice.
3. If systems already exist in an organization, could they be integrated as part of the involvement? If yes, how?

3.2 Different calculation options

These options may be classified into two major groups, as illustrated in figure 14.2.

![Figure 14.2: Calculation options](image)

<table>
<thead>
<tr>
<th>Narrow</th>
<th>Broad</th>
</tr>
</thead>
<tbody>
<tr>
<td>More physically based</td>
<td>More financially based</td>
</tr>
<tr>
<td>Normally standard based</td>
<td>Multicost, profit-oriented</td>
</tr>
</tbody>
</table>

Experience shows that the broader the calculation, the more involvement and education is necessary; otherwise, people will not change their behaviour because of their lack of knowledge and information about the parameters involved.

Table 14.1 shows the relationships between different calculation options and the time span for the system.

In practice, one can find a wide range of calculations, from physical measures of output (e.g. board feet of lumber, documents processed) as related to hours of labour input, to Return On Investment (ROI). The ultimate success of any calculation will depend on several common factors:

1. It must be perceived as fair by employees, the organization and customers/clients - it probably will not change behaviour unless this holds at least for the majority of those involved.
2. It must meet management’s objectives - just what is it trying to accomplish?
3. It must be understandable - not everyone will understand, but the key staff must. People may understand the variables that influence the calculation without knowing all of the details.
Table 14.1: Scope/time span for calculation alternatives

<table>
<thead>
<tr>
<th>Range of alternatives</th>
<th>Time-span orientation</th>
<th>Examples of measures</th>
<th>Targeted or past performance base</th>
<th>Desired long-term identity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Narrow/short time span</td>
<td>3-12 months</td>
<td>Specific item: (1) Quality, (2) Cost, (3) Efficiency - allowed versus actual time. Could be token awards</td>
<td>Normally target</td>
<td>Limited</td>
</tr>
<tr>
<td>(B) Narrow/longer time span</td>
<td>1-2 years</td>
<td>Similar to (A) above - more elaborate measurement in terms of developing a formal base period</td>
<td>Normally targeted or combination of target/past performance</td>
<td>Some</td>
</tr>
<tr>
<td>(C) Broader/medium to long time span</td>
<td>Over 2 years</td>
<td>Specific measurement: (1) Allowed versus actual labour hours (Improshare), (2) Specific cost(s) related to revenue, budget, (3) Labour related to output (single ratio), (4) Multiple pool</td>
<td>Normally past performance and sometimes targeted</td>
<td>Considerable</td>
</tr>
<tr>
<td>(D) Broad/long time</td>
<td>Over 2 years</td>
<td>Specific measurement: as (C) above, plus (1) Value added, (2) Broad multicost, (3) Profit, (4) ROI (profit/investment), (5) Multiple pool</td>
<td>Normally past performance, could be targeted</td>
<td>Major - requires long-term commitment</td>
</tr>
</tbody>
</table>

4. It must be easily administered - does it have to be constantly monitored and can it be completed with existing records?

5. It must be flexible to changing conditions - can it meet these without constant adjustment?

6. It must focus efforts on what is important - could it lead to a waste of other resources?

7. Overall: Is it fair to the unit's customers, employees and the organization itself?

3.3 Key calculation decisions in Gainsharing systems

Before starting to design any calculation system you must settle the following key issues:
- a measure of output and input must be developed;
- a historical base period or one based on expectations, or both, is needed;
- the percentage going to employees (between 10 and 75 per cent of improvement, with 30-50 per cent fairly common) must be determined;
- the frequency of payment (often monthly, with a certain amount being set aside for the end of the year to reinforce long-term attitudes) must be settled;
- how to distribute payments (percentage or some other method, which is a sensitive issue)
and legal considerations must be settled. In some countries, this may constrain payment methods;
- should payment be made according to time paid or time worked)?
- who should participate?
- adjustment procedures for capital, mix changes, etc., must be drawn up;
- should payment be made with a separate cheque? and
- the amount, if any, that is to be set aside to establish a year-end reserve (ranging from 10 to 50 per cent or more) must be decided.

We shall discuss the most important of these issues in detail.

### 3.3.1 Measures of output

The most difficult part of Gainsharing measurement is deciding on an output measure. These range from broad measures to much more specific ones. A partial listing of possible measures is given below:

- revenue;
- revenue + inventory change (many plans are production based, because employees were thought to identify more with this). In a manufacturing firm, inventories (normally only work in process and finished goods) can be a major source of problems. Service sector undertakings obviously have fewer problems in this area. This is a somewhat complex issue, and one which simulations will detect, because of the increased volatility of the bonus. Nevertheless, one must be consistent and base the measure on items related to production or sales;
- total standard cost of sales or standard cost of production;
- value added (sales minus all outside purchases such as materials);
- standard direct labour costs or standard direct labour time;
- board feet or scrap reduction;
- activity measures such as inspections made, meals served, tons produced, vouchers processed and tests completed. Be careful not just to maximize activities: that is, the activity should be a good measure of output, which is why standard time is often used; and
- goal-oriented output measures, which can include a multitude of items if the attempt is to reduce them against some target: for example, travel costs (actual or projected), scrap/materials, telephone expenses, supplies, on-time shipments and returned items.

### 3.3.2 Measures of input

One example of input is actual labour hours, which generally follow standard labour hours (i.e. pieces multiplied by allowed time per piece; the allowed time may be based on engineered standards, actual past times or a combination of the two). Other examples include labour cost; labour and fringe cost; labour, scrap, supplies; most costs; and all costs.

Base ratios are then calculated between inputs and outputs. For example, if labour costs were 25 per cent of sales in the base period, a bonus is earned in any period when actual labour costs are less than 25 per cent. Most calculations have traditionally been based on such an
approach, but there is a movement toward more goal-oriented calculations.

3.3.3 Base period of past performance or targeted performance

Traditionally, Gainsharing was based on past performance because the data are easier to accept and assess. The period of past performance could be as short as a couple of months or extend to several years. Some firms use the past three years. Obviously, an analysis helps to determine the best past performance level. Some organizations (perhaps 20 per cent) base their plans on targeted or goal-oriented performance, with another group combining past and targeted performance. This is especially true in organizations with poor or limited past data or those with limited short-term objectives. Goal-oriented performance does require considerable trust on the part of employees, however. All of the above has to be related to the objectives of the plan.

3.3.4 Percentage to employees

In practice, the percentage going to employees ranges from 15 to 100 per cent depending on goals, the broadness of the calculation, past performance and the amount of discretion/input employees have as against the capital investment by the employer, and how generous an organization is to its employees. Many plans advocate a 50/50 proportion.

3.3.5 Reserve or not

Many traditional Gainsharing plans, particularly those oriented towards Scanlon and Rucker, set aside some of the bonus for year-end payments (if you did a good job during the whole year, you would also receive a year-end bonus). This was to protect the organization against "spikes" in performance (i.e. paying large bonuses when everything went well but having the organization absorb losses in negative months) and to reinforce long-term attitudes. The standard Improshare plan does not normally establish a year-end reserve but rather uses a four-week moving average basis for paying bonuses. This has a tendency to smooth out the bonus. None the less, the reserve is not intended to pay bonuses in negative periods. This issue is again related to the objectives of a plan.

3.3.6 Frequency of payment

Payments are probably most commonly made every month. Improshare frequently pays weekly (four-week moving average). Once an organization ceases to measure activities according to standard labour time, the payment of bonuses more often than monthly becomes almost impossible. Bimonthly and quarterly plans are also commonly found. A few plans pay even less frequently, e.g. semi-annually or annually. Again, this is related to objectives (short versus long run, with the longer term probably emphasizing less frequent bonuses).
3.3.7 Percentage or other distribution method

This may be the most controversial area of Gainsharing. Many employees like the idea of a flat amount per hour of work, whereas others prefer the idea of paying the same amount to everyone, or a percentage. The United States Fair Labor Standards Act puts significant restraints on the payment of a flat amount per hour of work or the same amount to everyone, with the exception of profit-sharing bonuses. This has to do with the overtime provisions of the Act. For this reason, the vast majority of American organizations pay a percentage of wages (directly or indirectly as with Improshare); this includes an overtime premium also.

3.3.8 Caps on payments

Caps on the size of a bonus are the subject of lively discussions in many organizations. There are several types of cap:

- an absolute cap on the amount of the bonus;
- a cap on the maximum wage amount (e.g. only those earning up to US$2,000 per month may participate, for example); or
- a period cap, with any amount over this level (e.g. 5-10 per cent) going into the year-end reserve. Improshare typically has a period cap of 30 per cent. The decision is made under the corporate approval process and depends on the volatility of the bonus.

3.3.9 Adjustment procedures, if any

Almost all plans have some procedures for adjusting the calculation. They may range from specific measures (e.g. adjusting for 80 per cent of the saved time because of new equipment, as in the case of Improshare) to more general statements such as “the calculation may be changed as a result of changes in goals, standards, equipment, process, price, and so on”. A specific statement is needed, and should be complied with in order to maintain the creditability of the system. Goal-oriented systems are modified regularly. Most organizations have a constant base which is changed only for specific reasons (the traditional Gainsharing approach) but a sizeable percentage use some sort of moving base, such as a three-year moving average with an annual review for equitability encouraged.

3.3.10 Separate cheque or not?

Under many plans separate cheques are issued to differentiate the bonus from regular pay. This is difficult with systems that pay weekly, such as Improshare. Although separate cheques are normally desirable, the bank charges, etc., must also be taken into consideration: thus small bonuses are usually accumulated until they exceed a certain amount or percentage (e.g. 1 or 2 per cent).
3.3.11 Method of payment

The vast majority of plans are paid in cash. Other less common forms of payment include lotteries, time off and merchandise.

3.3.12 Basis for payment

This is a controversial area. Bonuses are normally calculated according to time paid or time worked, since this reinforces the performance/reward relationships, but compromises are frequently made.

3.3.13 Taxation

Bonuses such as those examined above are normally subject to withholding taxes.

3.4 Typical examples of Gainsharing calculations

Many types of calculation are in use today. In the past, the methods were fairly standard, but nowadays they are generally tailored to meet the needs of the organization. More companies are finding that one pool or calculation is insufficient to meet their needs, so may have several: for example, one based on labour productivity, one on quality and customer service variables, and one on other controllable expenses. Employees may earn a different percentage from one pool to another. Other firms have a separate focus pool for a specific period that may or may not be separate from other pools. We have seen one calculation based on 28 separate pools, all based on points. This trend is likely to continue. Some of the more common calculations that traditionally have been used in Gainsharing are given below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Period A (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Output (could be revenue, total standard cost, budget or some other measure)</td>
<td>1,000,000</td>
</tr>
<tr>
<td>2</td>
<td>Labour cost allowed (could be based on past performance - 25% or targeted, for example) (assume 25% of line 1)</td>
<td>250,000</td>
</tr>
<tr>
<td>3</td>
<td>Actual labour cost</td>
<td>220,000</td>
</tr>
<tr>
<td>4</td>
<td>Bonus pool (line 2 minus line 3)</td>
<td>30,000</td>
</tr>
<tr>
<td>5</td>
<td>Employee share (assume 50% of line 4)</td>
<td>15,000</td>
</tr>
<tr>
<td>6</td>
<td>Reserve for year end (1/3 of line 5)</td>
<td>5,000</td>
</tr>
<tr>
<td>7</td>
<td>Net bonus (line 5 minus line 6)</td>
<td>10,000</td>
</tr>
<tr>
<td>8</td>
<td>Participating payroll (all participating payroll excluding paid time off)</td>
<td>200,000</td>
</tr>
<tr>
<td>9</td>
<td>Bonus % (line 7 divided by line 8 or US$10,000 + US$200,000)</td>
<td>5%</td>
</tr>
<tr>
<td>10</td>
<td>Balance in reserve for Period A</td>
<td>5,000</td>
</tr>
</tbody>
</table>
3.4.1 Single ratio of labour bonus calculation

**Bonus payment (US$)**

<table>
<thead>
<tr>
<th>Employee</th>
<th>Gross normal wages</th>
<th>Overtime</th>
<th>Total</th>
<th>Bonus %</th>
<th>Bonus Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Doe</td>
<td>1 000</td>
<td>100</td>
<td>1 100</td>
<td>5%</td>
<td>55</td>
</tr>
</tbody>
</table>

Comments: Between broad and narrow orientation
Mix problems (used less today because of these)
Often associated with Scanlon plans

3.4.2 Multicost bonus calculation

1. Output (could be revenue, total standard cost, budget or some other measure)  
   *Period A (US$)*  
   1 000 000
2. Costs allowed (assume 80% of line 1, based on history)  
   800 000
3. Actual costs  
   770 000
4. Bonus pool (line 2 minus line 3)  
   30 000
5. Employee share (assume 50% of line 4)  
   15 000
6. Reserve for a year end (1/3 of line 5)  
   5 000
7. Net bonus (line 5 minus line 6)  
   10 000
8. Participating payroll (all participating payroll excluding paid time off)  
   200 000
9. Bonus % (line 7 divided by line 8 or US$10,000 ÷ US$200,000)  
   5%
10. Balance in reserve for Period A  
    5 000

Comments: Broadly oriented, if most costs are included
Requires major commitment to share all savings, regardless of source
Requires much disclosure
A common Gainsharing calculation
### 3.4.3 Value added calculation

<table>
<thead>
<tr>
<th></th>
<th>Period A (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Output (normally sales or value of production)</td>
<td>1,000,000</td>
</tr>
<tr>
<td>2. Less outside purchases</td>
<td>500,000</td>
</tr>
<tr>
<td>3. Value added</td>
<td>500,000</td>
</tr>
<tr>
<td>4. Allowed labour cost (assume 55% of value added from historical analysis)</td>
<td>275,000</td>
</tr>
<tr>
<td>5. Actual labour cost</td>
<td>250,000</td>
</tr>
<tr>
<td>6. Bonus pool (line 4 minus line 5)</td>
<td>25,000</td>
</tr>
<tr>
<td>7. Employee share (assume 50% of line 6)</td>
<td>12,500</td>
</tr>
<tr>
<td>8. Reserve for year end (30% of line 7)</td>
<td>3,750</td>
</tr>
<tr>
<td>9. Net bonus</td>
<td>8,750</td>
</tr>
<tr>
<td>10. Participating payroll</td>
<td>200,000</td>
</tr>
<tr>
<td>11. Bonus % (line 9 divided by line 10)</td>
<td>4.375%</td>
</tr>
<tr>
<td>12. Balance in reserve</td>
<td>3,750</td>
</tr>
</tbody>
</table>

Comments: Somewhat more complex mathematically
More common in Europe because of value added tax
Rucker plans used this calculation exclusively

### 3.4.4 Sample bonus calculation: Standards based

In this case, by “standards” we mean the predetermined time or quantity (e.g. of materials) needed to do a job or activity. It may be based on a “scientific” engineered estimate or on past or estimated performance. Examples include allowed times per operation or piece, time to pick an order at a warehouse or assemble a product, and materials or supplies allowed for assembling a product.

Costs can be added to quantity to yield total standard cost. An example could be the average wage rate in a company at some date which, when combined with standard time, would yield the total standard labour cost.

### 3.4.5 Allowed labour bonus calculation

Base Performance Factor (BPF):

\[
BPF = \frac{\text{Actual direct hours} + \text{Actual indirect hours}}{\text{Total standard hours}}
\]
Standard hours (SH):

- \( SH = \text{standard hours per unit} \times \text{number of units} \)
- Product A: 1,000 \( SH = 5 \text{ hours} \times 200 \text{ units} \)
- Product B: 800 \( SH = 2 \text{ hours} \times 400 \text{ units} \)
- Product C: 600 \( SH = 1 \text{ hour} \times 600 \text{ units} \)

Assume 60 direct and 50 indirect labour people.

Base Performance Factor (BPF):

\[
BPF = \frac{\left(60 \text{ direct people} \times 40 \text{ hours}\right) + \left(50 \text{ indirect people} \times 40 \text{ hours}\right)}{1000 + 800 + 600}
\]

\[
BPF = \frac{4400}{2400}
\]

\[
BPF = 1.83
\]

This would actually be calculated on an annualized period in order to develop a good base period. You also could have a different BPF for each product line.

### 3.4.6 Bonus calculation for a period

1. Output
   - Product A: 329 units
   - Product B: 300 units
   - Product C: 400 units

2. Allowed hours (units \times \text{allowed time} \times \text{BPF})
   - Product A (329 units \times 5 \text{ hours} \times 1.83) = 3,010 hours
   - Product B (300 units \times 2 \text{ hours} \times 1.83) = 1,098 hours
   - Product C (400 units \times 1 \text{ hour} \times 1.83) = 732 hours
   - Total = 4,840 hours

3. Actual hours = 4,400 hours

4. Performance improvement (total line 2 minus line 3) = 440 hours

5. Bonus hours for employees (50\% of line 4) = 220 hours

6. Total hours worked (110 employees \times 40 hours) = 4,400 hours

7. Bonus percentage (without reserve) (220 hours \div 4,400) for each hour worked per period = 5\%
Comments: Control or narrow oriented
- Standards or allowed times required
- Adjustment procedures need clarification (e.g. methods changes, new equipment, new products)
- Currency does not enter into the calculation
- Could be paid weekly
- No reserve in example given

3.4.7 Multiple pool calculation

Pool 1: Labour productivity

1. Efficiency improvement (previous calculation for allowed labour) \[5\%\] (US$)
2. Participating payroll (assume) \[100\,000\]
3. Net addition (line 1 x line 2) \[5\,000\]

Pool 2: Other costs or quality and customer service

4. Costs allowed as a % if revenue from history \[10\%\] (standard hours, standard cost)
   - Scrap
   - Overtime
   - Material quantity variance
   - Supplies
   - Travel
   \[(US\$)\]
5. Revenue \[1000\,000\]
6. Allowed costs (line 4 x line 5) \[100\,000\]
7. Actual costs \[90\,000\]
8. Net addition (line 6 minus line 7) \[10\,000\]
   - Pool 1 \[5\,000\]
   - Pool 2 \[10\,000\]
   - Total bonus pool \[15\,000\]

Comments: Decisions needed on sharing percentage, amount of reserve (if any)
- Could share different percentage of different pools
- Could have a variety of different pools based on objectives
- Could be based on a variety of outputs
- Common calculation
- Three pools are common, as are special focus pools
Other calculations can be based on a variety of approaches. Some of these are listed below:

- profit sharing - perhaps the most common of all;
- return on investment (ROI);
- a combination of the above calculations;
- range of goal-oriented systems such as customer service, reduction in labour and materials costs, increased turnover of receivables and inventories. Some firms develop a new set of goals each year;
- indexed systems: indexing makes it possible to combine financial and non-financial variables. Indexing is becoming much more common today;
- flexing formulas to adjust for volume fluctuations;
- moving averages to give consideration of poor past performance, changing business orientations or significant competitive pressures.

Questions for discussion

1. What are the two major issues underlying Gainsharing?
2. Is there any relationship between the involvement and the calculation systems?
3. What are the different ranges of calculations and how do they relate to productivity objectives?
4. What are the most important factors in evaluating calculations?
5. What do you think might be possible measures of performance for your organization?
UNIT 4: INSTALLING THE GAINSHARING SYSTEM

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the most important factors and conditions which facilitate or prevent the successful launching of the Gainsharing system.

2. Be aware of the most important steps in starting up the system.

3. Assess the initial reaction to Gainsharing and make decisions about any corrective steps needed.

UNIT 4: CONTENTS

4.1 How to start the Gainsharing system

4.2 Deciding whether to proceed or stop

4.3 Case studies: Introduction and presentation of Gainsharing, group analyses and discussion

Annex: Answers to case studies

Bibliography
UNIT 4: INSTALLING THE GAINSHARING SYSTEM

4.1 How to start the Gainsharing system

Perhaps the most common approach is to introduce the Gainsharing system with a presentation for top management, and then to form a steering committee involving higher management and perhaps union officials, if appropriate, to:

- evaluate the different plans;
- visit locations and read background materials;
- decide whether it is necessary to bring in outside consultants;
- develop a draft plan;
  - purpose and goals;
  - involvement system;
  - calculation; and
  - policy issues;
- decide on the timing of union involvement, if applicable (sometimes the union may be represented on the steering committee); and
- draw up a corporate approval process.

Many other issues need to be considered, depending on the complexity of the system being installed, especially as regards involvement. Some of these are discussed below.

Management commitment. This may include willingness to share, ensuring that meetings and educational classes are held as planned, making the commitment part of the reward system for managers, attending meetings as needed, and holding regular meetings with employees about Gainsharing.

Team activities and how these affect decision-making. Will there be any limits on decision-making, such as hiring people, choosing vendors, union activities, pay, and so on? Some plans have limitations and some do not.
Union commitment. This can be more of a major problem in some companies and countries than in others. The more Gainsharing is tied into a union contract, the more likely it is that problems may arise. Gainsharing cannot be installed if the union opposes it. Cooperation with unions has generally improved in recent years throughout the world, probably because of competitive pressures.

Coordinator selection/development. The larger and more sophisticated the system regarding the employees' involvement and the change process, the greater the need for a good coordinator/facilitator. The coordinator monitors and assists the teams, makes sure that schedules are observed and that communication is good. A good coordinator/facilitator can significantly increase the chances of long-term success.

Participation policies. These could include participation in any bonus payments, and also the involvement process. Will a team include everyone, or a representative? How will management and unions become involved?
Approval process. This can be very simple or long and drawn out. A possible outline of a proposal might cover the following points:

- what is Gainsharing?
- what do we want from it?
- what studies have been done?
- what is our involvement system?
- what are our calculations, including simulations?
- what needs to be done?
- what is our time schedule?
- what education and communications are needed?
- what are the possible problems?

More detailed calculation simulations and a draft plan document could be included in appendices.

Training and education. The greater the change process, the greater the educational requirements. Much early education is directed towards employee involvement and teamwork, but later the emphasis should be on more technical aspects.

Time requirements. It is likely to take a considerable time to install a Gainsharing system. In fact, a year of preparation is not unusual; but the key is how much employee involvement is expected. Although the calculations are the first major bottleneck, employee involvement in this exercise is really what takes the most time.

***

Again, it is very important also to consider situational factors if the system is to be successful. These include the level of top management commitment, interaction, cooperation and communication, management’s willingness to examine suggestions, the availability of information on production and costs, employees’ commitment and industrial relations.

It is also of critical importance to assess the first reactions to Gainsharing. Some typical reactions (positive and negative) are given below.

1. Top management:
   - better than in the past;
   - more participative in general;
   - believes more in sharing, but would still rather have improvements without payment;
   - frustrated by lack of employee commitment; and
   - concerned about the ability of management to handle the system.

2. Middle management:
   - often undermine many such systems, feeling that their status may be lessened;
   - often not actively involved;
   - do not always share; and
   - could be advisors to teams.
3. Supervisors:
- more actively involved;
- little experience in participation: some take to it very well, but others do not;
- have to be helped with education and assistance;
- should participate in bonus; and
- try not to undermine authority.

4. Non-supervisory employees:
- many distrust management in the light of past experiences;
- subject to “herd” leadership - both good and bad;
- like the idea of a bonus but many do not participate; and
- need to be taught teamwork and creativity.

5. Technical/professional:
- not as actively involved as they should be in many situations;
- somewhat elitist attitude;
- feel their status may be eroded; and
- must become actively involved.

6. Union:
- some enthusiastically endorse the system while others resist it;
- some fear that they will lose influence;
- some fear that management may substitute a bonus for equitable wages;
- attitudes toward involvement have improved in recent years;
- actively participate in the beginning (visits, task forces), but then frequently draw back after implementation; and
- some national officers endorse the system, but others oppose it or are neutral.

4.2 Deciding whether to proceed or stop

After analysing the reactions from different parts of an organization you may be able to decide whether to proceed with Gainsharing or stop. To make the final decision, try to answer these questions.

1. Why would a firm want to continue to explore Gainsharing?
   What benefits could accrue to it?
   Your answers:
2. Why would a firm not continue to explore Gainsharing?
   Your answers:

3. What problems would have to be overcome before installation?
   Your answers:

Normally, at this point, one of the following actions takes place:
- a steering committee is set up to explore Gainsharing further;
- a consultant is engaged to make a complete study; or
- Gainsharing is dropped.

If a decision to proceed is taken, a wide range of activities can occur at this point, ranging from a limited application to full implementation. Surveys are frequently made to assess the need to change. What follows is a typical “systems” approach to implementation. All the material we have dealt with so far helps with these steps (see figure 14.3).
Form a steering committee to undertake the following tasks:

<table>
<thead>
<tr>
<th>Assess organization's need for Gainsharing (surveys and interviews)</th>
<th>Assess involvement/communication systems</th>
<th>Assess different calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate policy decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop draft of plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approval processes by union and management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduce to all employees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish developmental task force to help with implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduce implementation, education, involvement systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor teams and progress</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3 Case studies: Introduction and presentation of Gainsharing.

Group analyses and discussion

To introduce you to the range of Gainsharing situations, two case studies are presented below. Please form groups of from three to six members each, with a discussion leader and reporter. After reviewing the situation, try to answer the questions presented. The primary purpose of this exercise is to enable the participants to understand the issues and complexities of installing Gainsharing systems in a variety of situations.
Case 1

A company employs 75 people and has a major problem: it is falling further and further behind in processing repair orders every week. The activities could be subcontracted outside if necessary. Labour relations are acceptable but little effort is made by the fairly traditional management regarding employee involvement or communications. The work is fairly non-routine and standards are not easily established.

1. On the basis of the limited information given, what might be the goal(s) if a Gainsharing plan were installed in such a situation?
2. Can you think of any possible measures of performance that might be developed?
3. How sophisticated a “system” would be likely/desirable in such a situation (i.e., time span for implementation and operation, commitment of time and resources from various levels of management, requirements from union, etc.)?
4. Would this company be a good candidate for Gainsharing, on the basis of the limited information given? If so, in what form; if not, why not?
5. What additional information would be useful before proceeding further?

Case 2

A storage warehouse has 400 employees, with excellent labour relations. Some light assembly and repacking work are also done. A variety of employee involvement systems are currently in operation, including some formalized employee involvement teams. Monthly meetings with all employees are held in all areas and some supervisors have short daily meetings with their employees. Well engineered standards are used to monitor departmental performance, and superiors are involved with cost control in their specific areas. Interdependencies between areas are significant. Performance is good in most areas. The amount of work being performed is likely to grow in the future.

1. On the basis of the limited information given, what might be the goal(s) if a Gainsharing plan were installed in such a situation?
2. Can you think of any possible measures of performance that might be developed?
3. How sophisticated a “system” would be likely/desirable in such a situation (i.e., time span for implementation and operation, commitment of time and resources from various levels of management, requirements from union, etc.?)
4. Would this be a good candidate for Gainsharing based on the limited information. If so, on what basis; if not, why not.
5. What additional information would be useful before proceeding further?
Summary questions on the case studies

Discuss the case studies and say how the two situations differ in regard to:

- possible objectives;
- likely time span for installation and operation;
- "size of system" (i.e. complexity as related to measurement, employee involvement, etc.);
- required commitment of various participants and likely ease of obtaining such commitment;
- ease of developing measurement;
- problems likely to be encountered; and
- probable outcomes.

The answer to these case studies are given in the Annex to this unit.

Questions for discussion

1. What are some of the key policy decisions that have to be made when installing a Gainsharing system?
2. What would be the ideal situation in which to install Gainsharing?
3. What are most common reactions of various groups to Gainsharing?
4. What are the main steps for installing Gainsharing?
5. Why does Gainsharing work?
ANNEX

ANSWERS TO CASE STUDIES

Case 1

1. Most limited goals - reduce the time for processing orders; most refined goals - a major change in philosophy if appropriate; and objectives could be short- or long-term.

2. The time from obtaining the order to completing cost per order, i.e. if the time is reduced, costs will also be reduced. These are simple, short-term measures, which may have to be target-oriented, i.e. "If you do this, you will receive this."

3. Management would probably take a short-term approach in this case.

4. Introducing Gainsharing could result in major improvement with little effort or cost. If this were the goal, the improvement might be only short-term, however.

5. It would be useful to know whether what is desired is a short-term system with limited objectives or more of a long-term plan. This can be ascertained through surveys, interviews and other approaches.

Case 2

1. The continuation of the management style already in place. In this case, Gainsharing might raise the organizational change process to much higher levels.

2. Standard versus actual time, single ratio of labour, goal-oriented systems.

3. Merely a continuation of what is currently being done; not a major change.

4. Yes; it meets some of the factors identified in this unit.

5. It would be useful to know how much commitment really exists, how a calculation is decided upon, and what is the corporate approval process.

Summary questions on the case studies


Likely time span for installation and operation. Case 1 - short time span on both installation and operation. Case 2 - longer time span on both considerations.

"Size of system" (i.e. complexity as related to measurement, employee involvement, etc.). Case 1 - limited in both measurement and involvement. Case 2 - longer term and more complex.

Required commitment of various participants and likely ease of obtaining such commitment.
Case 1 - may have limited impact. Case 2 - process would continue onward to a higher level.

*Ease of developing measurement.* Case 1 - probably easy if objectives are limited. Case 2 - probably more complex.

*Problems likely to be encountered.* Case 1 - limited objectives and problems; problems in the long term. Case 2 - none in the long term.

*Probable outcomes.* Case 1 - positive in the short run, little long-term impact. Case 2 - positive in both the short and the long term; see unit 1 for long-term benefits.
BIBLIOGRAPHY

Doyle, R.J.: Gainsharing and productivity: A guide to planning, implementation and development (New York, AMACOM, 1983).

Fein, Mitchell: Improshare (Norcross, Georgia, Institute of Industrial Engineers, 1982).


Institute of Industrial Engineers: Gainsharing: A collection of papers (Norcross, Georgia, 1983).


O’Dell, Carla S.: People, performance and pay (Houston, Texas, American Productivity and Quality Center, 1987).
MODULE 15
INDUSTRIAL RELATIONS AND
PARTICIPATION FOR PRODUCTIVITY
IMPROVEMENT
MODULE 15: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand the different dimensions of industrial relations that have a bearing on productivity.

2. Appreciate the changing environment that affects both industrial relations and productivity.

3. Understand the essence of collective bargaining and its impact on productivity improvement and the sharing of productivity gains.

4. Understand the different forms of employee participation in promoting productivity.

5. Understand the role and responsibilities of trade unions in productivity and know how to develop positive responses from trade unions.

MODULE 15: CONTENTS

UNIT 1: The concept of industrial relations and productivity

UNIT 2: Employee relations issues related to productivity

UNIT 3: Collective bargaining for productivity

UNIT 4: Joint consultation and employee participation

UNIT 5: Developing the unions’ cooperation in productivity improvement

Bibliography
UNIT 1: THE CONCEPT OF INDUSTRIAL RELATIONS AND PRODUCTIVITY

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the concept, scope and objectives of industrial relations and their impact on productivity.
2. Understand what constitutes positive industrial relations and the role of the employers/management and trade unions.
3. Understand the changing economic, technological and business environment and public policy and their implications for industrial relations and productivity improvement.

UNIT 1: CONTENTS

1.1 Definition and scope of industrial relations
1.2 Developing positive industrial relations
1.3 Basic perceptions of and approaches to productivity
UNIT 1: THE CONCEPT OF INDUSTRIAL RELATIONS AND PRODUCTIVITY

The management of productivity in general and of industrial relations and employee participation in particular are largely country specific and culture oriented. Hence, this module needs to be seen by trainers from different countries in the light of the national cultural parameters of industrial relations. However, the basic concepts used in the module remain universal. These concepts include industrial relations, trade unionism, employee participation, productivity, production, collective bargaining, etc. Some of these concepts have both a narrower and a wider connotation and employ synonymous terms for industrial relations, productivity and employee participation, for instance.

The term “employee participation” is interpreted in different ways. For some it means joint consultation; for others it is collective bargaining, or information sharing, or sharing some areas of administration, or joint decision-making, or codetermination, or self-management, and so on. Hence, to lay down rigid lines of action on any aspect of industrial relations, particularly in the context of productivity improvement to be applied in different economic and cultural conditions, is a hazardous task.

Therefore, this module, instead of providing reading materials, merely seeks to provide a broad framework within which the complexities of industrial relations governing productivity improvement may be seen. The contents of the module must be examined in the light of the specific situations prevailing in organizations, enterprises, a particular industry or region and the economy. So it is the responsibility of the trainers and participants to expand the module by studying the suggested literature and other country-specific materials relevant to the subject.

1.1 Definition and scope of industrial relations

The ultimate aim of any human activity at the socio-economic level should be the minimal use of available resources in achieving the maximum economic and social results, i.e. to be increasingly productive. The productivity of capital, machines and resources other than human resources can be improved in various ways. But improving the productivity of human resources is a complex and onerous task, for the simple reason that “labour” stands for both an individual human being and a group of individuals with different perceptions about productivity, motivation and attitudes, and with different needs. In organizations, individuals do not operate in isolation. They interact and react collectively to various issues in which management has an interest, including productivity. Thus productivity improvement extends beyond the domain of the management of workers and becomes a labour-management or industrial relations issue to be negotiated, settled and implemented jointly by the management and the union. Productivity improvement as an industrial relations issue thus acquires a greater significance in all enterprises where the employees are organized.

“Industrial relations” broadly means the relations arising out of employment. In this broad sense it covers the area of personnel management or human resources management and labour-management relations or labour relations. In its narrower sense it refers only to the relations between management and the unions. And in its popular usage it refers only to labour-management relations.
Industrial relations in organizations is the sum total of the management’s attitude to labour and of labour’s attitude to management’s policies and practices that affect the interests of the employees. Industrial relations are, basically, interactions between management and union(s). They involve continuous dialogue between the two sides on various issues of common interest; through such dialogues, the two sides shape each other’s attitudes. The approach, methods, strategies and techniques, etc., of management in achieving the desired objectives vary from one organization to another. This is especially true in regard to productivity improvement through industrial relations. It is, therefore, primarily the responsibility of managements to develop industrial relations with workers and the unions so as to promote productivity on a continuing basis.

1.1.1 Why link industrial relations with productivity?

Of all the types of productivity, labour productivity has gained importance for the following reasons:

1. Labour is a human factor that interacts with, reacts with and controls the productivity of other factors. Labour is not a commodity.
2. It is one of the important factors of production and is universally used in all production and distribution processes.
3. It is a relatively simple concept of the ratio of output to the input of labour.
4. Labour time utilized in the production process is quantifiable and measurable.
5. Every other factor of production can be converted into its labour equivalent (past and present labour).
6. The labour productivity index is composite, for in the final analysis it reflects the realisation of many other economic objectives, such as reduction in the cost of production, advantageous location of the industry, degree of specialization, effectiveness of capital investment, use of basic funds, etc.
7. Unit labour requirements, expressed in terms of work-hours needed to produce a defined good, can be directly added or subtracted.
8. Inter-firm comparisons of productivity changes over a period of time are possible.
9. Labour embodied in man has a dual role - as the purpose of production as well as a means of production, i.e. a worker is both a producer and a consumer.
10. Labour productivity can be a helpful device in linking wages with productivity which in turn promotes good industrial relations.

Productivity improvement through employees and the unions is not a simple task, since unions and their members are not a resource under the complete control of managements. Managements must strive to build an industrial relations climate to motivate unions and union members to cooperate and collaborate with them and to make them understand that both labour and management have common interests and objectives that can be realized only if they work together and continuously enlarge the cake to be shared.

Hence, productivity improvement puts the emphasis on educating the employees and creating productivity awareness and consciousness among them, on involving and consulting the union in developing norms of work and behaviour, on creating opportunities for employee participation in decision-making processes, on negotiating productivity improvements and sharing...
the gains of productivity, and on understanding together the policies of the State that affect the productivity and profitability of the organization. The management also has a responsibility to develop a technically qualified workforce, train, retrain and improve their potential, make them responsive to the needs of the organization and extend their cooperation and support to productivity improvement. Productivity improvement through industrial relations and employee participation also calls for the presence of a union that is strong, stable, representative and democratic, and responsive to the employees’ and management’s needs.

Productivity improvement through industrial relations calls for a different form of industrial relations, in which the usual conflict-oriented adversarial kind is replaced by cooperation and collaboration. The objective of such relations is not merely the maintenance of working relationships but the achievement of cost-effective productivity on a continuing basis. For this purpose management and unions need to create a permanent structure for ensuring cooperative and collaborative relations - a structure wherein both sides work together towards a common goal. Such a structure could be a joint negotiating committee or a joint labour-management consultation system.

It is the responsibility of both management and unions to develop industrial relations that facilitate productivity improvement. In this process new patterns of collective bargaining, such as integrative bargaining, productivity bargaining, concession bargaining and sectionalized bargaining, may be adopted and put into practice by organizations at different times. Collective bargaining becomes a truly bipartite joint decision-making process where productivity-linked issues are negotiated and settled.

The two sides also need to have an effective tailor-made forum for employee participation in order to achieve productivity improvement and identify the issues for discussion in the forum.

The involvement of the unions in productivity improvement is as vital as productivity improvement itself. Hence, an understanding of the changing nature of trade unions, the issues in which unions are interested, their demands and their responses to management demands is a basic requirement. It is also vital that the management consciously endeavours to help to develop committed trade unions at the enterprise level by recognizing and accepting their institutional role. This will involve regular information sharing and consultation on productivity-related issues and other common concerns, and also the cooperation of the union in educating and training the workers.

The concept of tripartism in productivity improvement also requires that the State, especially in the Third World countries, should play an important role in productivity improvement. It is the State that lays down the policy and legal framework within which union(s) and management have to work. The productivity of enterprises is also affected by state policies on economic, fiscal, trade and industrial matters. Hence, it is necessary to understand the parameters of these policies, which influence industrial relations, employment and non-employment, employee training, working conditions, wages and social security, and the legislative measures that might affect the productivity of organizations.

Keeping in view these dimensions of industrial relations that have a bearing on productivity improvement, we shall now discuss these issues in detail.
1.2 Developing positive industrial relations

First of all, of the most important objectives of good industrial relations, the most frequently cited are:

- high or improved individual and group performance;
- cost effectiveness;
- productivity improvement;
- improvement in the quality of life and work satisfaction; and
- the development of human potential and its full realization.

To assess or judge the quality of industrial relations, some indices of good industrial relations are suggested below:

- harmonious industrial relations as a corporate objective and philosophy.
- tripartite relations and a problem-solving approach (the third part - the State - is represented through legislation).
- management’s recognition of the right of workers to freedom of association and to form a strong, stable and democratic union.
- transparency, openness and honesty in management policies and practices, information sharing and effective communication.
- uniformity and consistency in organizational policies, procedures and behavioural norms.
- integrated systems and policies.
- positive and informal human resources management practices.
- consultation by management of workers and unions in decision-making on all issues of mutual concern and interest.
- to achieve industrial relations of this quality, it is necessary for organizations, their management and their employees to have certain prerequisites. The most important of these are:
  - professional management;
  - an educated, self-disciplined and cooperative workforce;
  - a responsible, responsive and representative but democratic union;
  - acceptance by management of unions, union officials and workers;
  - industrial relations goals that are shared by management and the union(s);
  - developed and mature collective bargaining relationships and procedures;
  - recognition by management and the union of the institutional roles of each other;
  - management’s genuine interest in the employees and their problems;
  - system of joint consultation and decision-making in areas affecting productivity and relevant issues; and
  - bipartite committees and participative forums to develop and promote cooperative and collaborative labour-management relations;

These prerequisites should be considered and analysed in the country-specific context of the technological, industrial, economic, business, socio-cultural, political and legal environment.

To identify the main bottleneck and barriers in industrial relations in any given company or industry it is essential to undertake some analyses before deciding on the action to be taken:
- analysis of the nature of trade unionism in a specific context;
- analysis of collective bargaining relations in industry and the trends as regards the issues arising and the settlements reached;
- analysis of industrial conflicts resulting in work stoppages and lost workdays affecting production;
- analysis of the preferences and approaches of managements and unions in dispute settlements; and
- analysis of the legislative and other normative approaches of the State to the problems of labour-management relations.

1.3 Basic perceptions of and approaches to productivity

Productivity in the broad sense is a measure of how efficiently and effectively resources are used as inputs to produce the outputs of products and services needed by society (bought by markets) in the long term. Productivity improvement implies the elimination of waste in all its forms. Total (not only labour) productivity improvement is thus one very effective strategy towards ensuring sustainable economic and social development.

From the point of view of labour-management cooperation focused on productivity, it would be very interesting to consider the most commonly found perceptions of different groups on the subject:

- employers'/management's perceptions: higher productivity to gain the competitive edge in the product market; to expand business and maximize profits;
- workers' perceptions: higher workload, need to acquire new skills; suspicion about sharing the gains of higher productivity; feeling of insecurity; an aversion to change in the methods and techniques of work; job reduction or loss;
- unions' perceptions: exploitation of labour; loss of jobs, with fewer or no job opportunities for the jobseekers; fear of union losing power and influence; and
- government's perceptions: economic and industrial growth; creation of wealth; greater industrialization, creation of employment opportunities for the unemployed; overall economic and social development of the country.

A discussion of these perceptions makes it clear that a well organized and intensive educational and awareness-raising campaign is necessary in order to change the prevailing attitudes towards productivity before taking the next action-oriented steps. And one aspect of this campaign would be to secure the active cooperation of all the major players in productivity improvement. How can they be involved? Below is a checklist of the most important roles played by workers and employers and their organizations in productivity improvement in the most successful companies.

1.3.1 The role of employers and management

- Adopting well defined policies on productivity, wages and human resources management and communicating them to the workers and union(s);
- developing a culture of productivity and quality in the enterprise;
- continuously upgrading the technology and production methods;
- carrying out continuous training and development of workers and managers;
- maintaining a regular dialogue with the most representative union of the employees, and directly with workers;
- instituting joint decision-making forums and creating a conducive environment for them;
- empowering employees to make more decisions about the way they are doing their jobs;
- encouraging innovative suggestions from employees;
- communicating with the union on issues other than collective bargaining; and
- creating productivity awareness and consciousness among the workers and the union officials through communication, information sharing, consultation, etc.

1.3.2 The role of employers' organizations

- disseminating information and knowledge about new technology, new methods of production, market conditions, government policies and regulations, etc.;
- acting as a liaison between the employers and the government in matters affecting the interests of the member employers;
- helping the member employers in negotiations with the unions about productivity improvement; and
- ensuring that member employers cooperate in matters of productivity and quality management.

1.3.3 The role of workers

- To acquire better knowledge and multi-trade skills and continuously upgrade them;
- to develop cooperative attitudes and team spirit;
- to be quality and cost conscious;
- to be innovative and resourceful in job- and employment-related matters;
- to be self-disciplined;
- to participate in decision-making processes;
- to respond to shop-floor problems and the concerns of fellow-employees.

1.3.4 The role of trade unions

- To ensure internal democracy in the union and leadership among the employees;
- to make reasonable demands and be willing to negotiate the management's demands;
- to develop integrative and co-operative bargaining relationships with the management;
- to help the management in identifying the areas for cost reduction;
- to motivate employees to be quality and productivity conscious and help them to acquire multi-trade skills and continually upgrade them;
- to create, develop and adopt positive attitudes among the workers and union officials toward modernization and rationalization for productivity improvement;
- to develop jointly with the management the programmes of worker involvement in productivity improvement and decision-making and to ensure employee participation at all levels;
- to recognize the rights and responsibilities of the management in the adjustment of
manpower (sectors, jobs, skills, positions, responsibility, attitudes, etc.) with a view to productivity improvement;
- to avoid work stoppages and other negative tactics that affect productivity until all other means of settling disputes have been tried; and
- to avoid introducing political issues into industrial relations.

Read the following case carefully, discuss it in groups or with a colleague and try to provide answers to the questions.

Case: A matter of technology change

The Automative Parts Manufacturing Co. is a medium-sized firm with 750 employees. It has a fairly good industrial relations history. Its (mostly domestic) market share had been stable, but lately, because of competition from newer manufacturers using advanced technology and benefiting from a liberalized state import policy, its market has been reduced. On studying the feasibility of entering the export market, the firm found that foreign customers insisted on high anti-pollution standards for motor vehicle components and that these standards could not be met through the traditional manual techniques that the firm had been using.

It was decided to diversity into electronics, and a small subsidiary unit with 100 employees and highly sophisticated production processes was set up. The company ordered the latest technology and equipment from abroad to manufacture motor vehicle components with the required higher quality standards.

The employees of both units are represented by a single union, which has been quite cooperative in adopting the latest technology. Human relations practices such as yoga exercises for the employees and management, the compulsory wearing of uniforms and safety equipment, etc., are enforced with the cooperation of the union.

The personnel manager has been informed that the new technology will be introduced in three areas within 15 days. He also realizes that the technology will lead to redundancy for certain workers who have been with the company for a number of years. He wonders what the reaction of the union will be in this matter. He wants your advice on the following points:

1. What kind of reaction is to be expected from the workers in departments where the new technology is being implemented?
2. What will be the union’s attitude?
3. How should the management deal with this issue?
4. What are the steps to be taken to minimize the problems that may arise?

Please give your advice.
Questions for discussion

1. In the context of productivity improvement, what is meant by industrial relations?
2. What are the features and prerequisites of positive or good industrial relations?
3. What are the perceptions of employers, workers and the government as regards productivity improvement? How can you explain them?
4. What is the role of employers/management, employers’ associations, workers, trade unions and the State in productivity improvement?
UNIT 2: EMPLOYEE RELATIONS ISSUES RELATED TO PRODUCTIVITY

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Perceive the importance of employee relations issues such as changing job profiles, employee discipline and manpower adjustments.

2. Understand and utilize the human resources development interventions that are relevant to productivity improvement.

3. Understand the compensation and reward systems that stimulate productivity improvement.

4. Understand the ways and means of creating productivity awareness and consciousness among the employees.

UNIT 2: CONTENTS

2.1 Employees’ profiles conducive to productivity

2.2 Financial and non-financial motivation
UNIT 2: EMPLOYEE RELATIONS ISSUES RELATED TO PRODUCTIVITY

### 2.1 Employees’ profiles conducive to productivity

It is of critical importance in productivity improvement to achieve a certain workforce structure with regard to education, expectations, dynamism, attitudes, etc., which will be responsive to a company’s development and productivity improvement efforts. It is absolutely essential to identify such employees’ profiles and to understand them in order to plan an effective human resource development and productivity drive.

Of course, these profiles may differ according to country, culture, industry, employees’ aspirations, leadership styles, etc.

Some of the main elements in the analysis of employees’ profiles are shown below. One should look for:

- young, educated and technically qualified employees;
- employees with an inquiring mind;
- a democratic outlook and a desire to participate in decision-making;
- a desire for more freedom on the job and minimum supervision;
- a desire to be a leader;
- leadership qualities;
- innovativeness and creativity;
- a preference for more job challenges and higher compensation; and
- an aptitude for team orientation and cooperation with others.

The employees should also be receptive to training and motivated for development. With such people, human resources development interventions such as training, career planning, performance appraisal, etc., will give rise to a very positive response.

### 2.2 Financial and non-financial motivation

We have already discussed Gainsharing and motivation as an important productivity improvement factor (see Module 14). Here we shall briefly review some of the basic motivational influences. Please discuss them in groups and relate them to the development of positive industrial relations:

- individual-based, group-based and performance-based reward systems;
- wages, salaries, incentives and bonuses;
- linking of wages, incentives, bonuses, etc., to productivity;
- wage incentives and performance bonuses for non-direct workers;
- non-financial rewards: recognition; responsibility assignment; growth opportunities; and quality of working life;
- suggestions scheme and rewards for suggestions;
- fringe benefits (cafeteria, etc.);
- sharing in gains from productivity improvement;
team spirit among the employees; and
recognition and appreciation of the efforts and merit of individual employees.

Besides financial and other motivators, discipline at the workplace is of crucial importance
to productivity improvement in most cases. Without discipline the implementation of more
sophisticated productivity approaches can often fail. Please discuss some of the important
prerequisites of positive discipline:

- proper induction of employees;
- effective communication;
- fairness in dealings;
- harmony of objectives of company and employees;
- careful training of employees;
- consistency in the administration of discipline;
- help in building up a team spirit among employees;
- development of high morale among employees;
- setting of high but achievable standards of performance;
- provision of examples of self-discipline; and
- involvement of employees in framing rules and regulations.

An important factor in developing positive employee attitude to productivity lies in trying
to provide job security, which may be threatened as a result of productivity improvement. Here,
the following manpower adjustment instruments could be used:

- retraining and redeployment of surplus labour;
- training of employees for multi-trade skills and their utilization;
- voluntary retirement;
- retrenchment of surplus labour through collective agreements; and
- lay-offs for short periods.

Finally, an important means of developing a long-term positive attitude by employees to-
wards productivity is through building up productivity awareness and consciousness through the
following systematic measures:

- explaining the organization’s mission and philosophy to all the employees;
- continuously sharing information about the organization’s competitive position in the prod-
  uct market and its profit-earning capacity, in both good and bad times;
- educating the workers so as to remove their misconceptions about productivity improve-
  ment and explaining to them the benefits of productivity improvement;
- setting goals jointly and having the workers participate in productivity actions.

2.2.1 Positive discipline

A particularly important issue is the development of positive discipline. This involves the
creation of an attitude and an organizational climate wherein the employees willingly conform
to the established rules and regulations. It is achieved when the management applies the
principles of positive motivation, when sound leadership is exercised by supervisors, and when
the entire organization is managed efficiently.

Positive discipline, which is often called constructive discipline, consists of that type of supervisory leadership that develops a willing observance of the necessary rules and regulations of the organization. The employees, both as individuals and as a group, observe the desired standards of behaviour because they understand, believe in and support them.

Make sure that all your employees share the following beliefs and assumptions about productivity improvement:

1. It will be difficult to achieve an improvement in productivity in the absence of a cordial working relationship between labour and management. It must also involve labour participation in the work process so that all those elements which contribute to increasing efficiency are accepted and implemented.
2. Productivity is not merely the ratio of output to input: rather it involves, in a substantial way, the human element.
3. The positive involvement of labour and the unions is essential for the success of productivity activities.

Three guiding principles emerge from the third assumption:

1. Labour-management cooperation is a prerequisite for increasing productivity.
2. A fair distribution of productivity gains between management and labour is basic to continued productivity improvement.
3. In the long run, productivity improvement will lead to an increase in employment.

Questions for discussion

1. What are the changing profiles of the employees and their impact on productivity?
2. What human resources development interventions have a bearing on productivity and how do you make use of these techniques?
3. Discuss the various forms of financial and non-financial compensation and rewards and explain their impact on productivity.
4. How do you create productivity awareness and consciousness among your employees?
5. What are the manpower adjustment mechanisms and procedures that have a bearing on productivity?
UNIT 3: COLLECTIVE BARGAINING FOR PRODUCTIVITY

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the changing patterns of collective bargaining that lead to productivity improvement, and the skills needed for negotiating productivity agreements, productivity-linked reward systems and the introduction of change.

2. Identify, negotiate and eliminate wasteful and restrictive work practices.

3. Ensure the effective administration of productivity settlements through developing positive responses from workers and unions.

UNIT 3: CONTENTS

3.1 Concept and scope of collective bargaining

3.2 Collective bargaining focused on productivity
UNIT 3: COLLECTIVE BARGAINING FOR PRODUCTIVITY

3.1 Concept and scope of collective bargaining

Under the legislations of most countries, employees have the right to self-organization and to bargain collectively through representatives of their own choosing.

The objective of collective bargaining is to negotiate an agreement which will meet the need of the company to remain competitive and profitable, while at the same time being creatively responsive to the individual interests, situations and concerns of employees. Thus, collective bargaining is an adaptive institution in industrial relations drawing heavily on the experiences of the negotiators and involving continuous dialogue with the other side at the bargaining table. These dialogues are largely based on the data gathered by the negotiators from different sources. As such, negotiating productivity agreements, etc., requires the continuous compilation of productivity data and their utilization by the negotiators. The data need to be compiled regularly through measurement, observation and production records and a survey of the collective agreements negotiated in the industry and the region.

The process and scope of collective bargaining, its negotiation techniques, the strategies and skills of the participating sides, the conclusion of agreements and their enforcement - all these are important dimensions of collective bargaining. Our aim here, however, is merely to provide an overview of the role of collective bargaining in productivity improvement and of the importance of labour-management cooperation in this task. None the less, we should like to emphasize the following highly important prerequisites of collective bargaining:

- a favourable political climate;
- freedom of association and the stability of organizations;
- the recognition of parties as bargaining agents;
- the duty to bargain in good faith;
- permanent negotiating machinery; and
- well developed, but not rigid, labour legislation.

The following major patterns of collective bargaining directly or indirectly promote productivity improvement.

3.1.1 Integrative bargaining

This is the process by which labour and management attempt to increase the size of the joint gain without respect to the division of profits. It is instrumental in the attainment of objectives which are not in fundamental conflict with those of the other party and which therefore can be integrated to some degree. Such objectives are said to define an area of common concern, a problem. Integrative bargaining implies a change in attitude of the parties from an offensive-defensive position to a genuine interest in and concern for the joint exploration of problems, gathering facts and solving problems.

The important steps in integrative bargaining are as follows:
Module 15
Unit 3

- the identification of problems of common concern and their definition, involving the maximum exchange of information about the problems;
- searching for alternative solutions and their consequences; and
- preferential ordering of solutions and the choice of a course of action.

Please discuss the case in the box showing how integrative bargaining in an Italian enterprise influenced the cooperation between trade union and management in the training and development of employees following the introduction of new technology.

Case: An example of integrative bargaining

Collective bargaining in the undertaking is the major source of regulation of labour-management relations. In the enterprise in question, the major directives for the formulation of training and retraining schemes were laid down in two agreements in 1981 and 1982 (which were also concerned with the general orientation of enterprise restructuring and its consequences on the organization of labour and working conditions). In the 1981 agreement, the parties had already recognized that the enterprise's long-term development programmes (which involved the accelerated introduction of new technology and consequent changes in work organization and work positions) increased internal mobility and called for the joint definition of adequate large-scale training and retraining schemes for a considerable number of employees.

The agreement laid down tentative guidelines for a medium- to long-term training and retraining plan covering two main areas: technological change as such, and the resultant reorganization of work. The bargaining agents were the factory committee, composed of elected delegates. Given the importance of the group, the committee was assisted in the negotiations and in some other respects by external trade union representatives (provincial and sometimes national).

On the other hand, the peculiar nature of negotiations relating to training and retraining, which imply technical and continuous monitoring, made it advisable that a specialized "technical committee" should be set up, composed of an equal number of representatives of management and trade unions. The committee has the task of overseeing the day-to-day administration of the agreement with respect to all aspects of training and retraining (training needs, programmes, teaching techniques, selection of employees, etc.).

3.1.2 Concession bargaining

This is an explicit exchange, setting moderation in labour costs against improvements in job security and productivity. It refers to contract changes that reduce labour costs in an effort to improve the productivity of the enterprise as well as employment prospects.

3.1.3 Sectionalized bargaining

This is a method of negotiation for determining the workload and wages of workers in a shop/section/department/occupation as and when necessitated by the phased rationalization and
modernization of industrial organizations. It facilitates the phased modernization of the organizations and helps management to redefine the work norms under the new work situations. It implies the cooperation of the workers and their unions in maximizing production and wages without loss of jobs. It is similar to productivity bargaining.

3.2 Collective bargaining focused on productivity

Productivity bargaining is another major form of collective bargaining and merits a section of its own. Productivity is the process of optimizing or maximizing the economic utilization of all available resources, as well as creating new resources for different activities. Qualitatively, productivity means the full, proper and efficient utilization of all the available resources; the reduction of waste in all its forms and in all resources; and obtaining the greatest yield/value for the least cost. It is a constant adaptation of individual and production systems to changing conditions in economic and social life.

This means that the aim of productivity bargaining is to reach an agreement on productivity under which workers agree to make a change or a number of changes in working practices that will lead to more effective production; in return, the employer agrees to provide a higher level of pay or other benefits, including Gainsharing.

The most common productivity-linked issues and demands of union and management are as follows:

- workload and work norms; manning production levels;
- quality and quantity of products;
- wages, allowances and fringe benefits and their links to production/productivity;
- bonus and compensation issues;
- changes in technology and work methods;
- elimination of wasteful and restrictive work practices;
- manpower adjustments - retrenchment, voluntary retirement, redeployment, retraining, etc.; and
- sharing the gains of productivity.

The most essential features of productivity bargaining may be classified into three groups, as follows:

1. Productivity bargaining is a part of the total concept of the firm. It involves the whole management team and is a part of the process of deploying human resources optimally.
2. Management assumes an active role in identifying the areas for cost reduction and productivity improvement, and makes plans for achieving the targeted improvement. This necessitates intensive management communication with unions, workers and various levels of management.
3. Productivity bargaining is used for eliminating restrictive and unproductive work practices. Economic concessions are related to the savings in costs. The offer of economic concessions motivates acceptance of the changes.

The typical issues for negotiation in productivity bargaining are:
Negative issues: Progressive elimination of restrictive and wasteful work practices, namely arriving late; idling; non-utilization of man/machine hours; extension of tea and lunch intervals; absenteeism during working hours for personal reasons; claiming overtime work as a matter of right; resistance to change in production methods, job mobility, transfers, etc.; refusal to do ancillary work and to work without helpers; refusal to do lower-skill jobs, such as loading and unloading, etc.; working to rule, going slow, etc.; wastage of raw materials beyond the permissible limits, etc.

Positive issues: Changes in working practices and methods; regular measurement of efficiency and communication of its results to the workers; realistic calculation of relevant costs; wage systems and pay grades based on job evaluation, work study and skill differences; payment by results; spreadover of wage increase; job flexibility and enlargement; working intensively; reduction of prices benefiting the consumers.

The analysis of collective bargaining practices provides the following most frequently cited implications of productivity bargaining both management and unions:

1. Implications of productivity bargaining for management:
   - opportunities to structure the industrial relations situation more and more on the basis of factual information, cost analysis and analytical data on organization and production;
   - effective utilization of resources by plugging cost leakages;
   - employee participation in decision-making and a problem-solving approach to areas of conflict;
   - creation of a more positive and motivated work organization; and
   - structuring of adequate control and supporting services to monitor and ensure progress in productivity.

2. Implications for trade unions:
   - continuing education and training, improved status and authority for employee representatives in the joint regulation of the employment situation;
   - better development of internal leadership and promotion of union growth;
   - an improved role for the union in the growth and prosperity of the organization; and
   - provision to union representatives of factual information that can be used to negotiate an equitable share for employees in the future.

Now discuss the case below with a colleague or in a group:
Case: Extra hours

The Shakti Sri Tin Works is a medium-sized unit employing 52 women and 48 men. Following a general boom in the market, the demand for the unit’s products went up. The company management thought it prudent not to increase the number of employees but to make better use of the existing staff.

So, with the concurrence of the employees’ union, the unit began making each employee work four hours extra, over and above his or her normal working day of seven-and-a-half hours. It was agreed that the employees would be paid one-and-a-half hours wages for each hour of extra work.

The management also agreed with the union to donate a generous amount for building the union office. Since it was the first time that all the employees were earning extra money for work, the employees were happy.

After about six months, the demand for the company’s product fell. The management informed the union that the practice of working extra hours would be discontinued.

The employees and the union are very unhappy. They want the extra work to continue. The management is worried. Please discuss the following points:

- Was the management right in trying to increase production without increasing manpower?
- What steps might the employees and the union take to put the pressure on the management if the extra hours were discontinued?
- How should the management deal with the situation?

Questions for discussion

1. What is collective bargaining and what are its scope and objectives?
2. Discuss the main prerequisites of collective bargaining.
3. What are the most important productivity-linked issues and demands of the unions and management?
4. What is the concept of productivity bargaining, and what are its implications and advantages for negotiating productivity agreements for (a) the management; (b) the employees?
5. Name some typical wasteful and restrictive work practices. How can they be eliminated in order to improve the productivity of employees and enterprises?
UNIT 4:  JOINT CONSULTATION AND EMPLOYEE PARTICIPATION

UNIT 4:  LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the concept of employee participation.
2. Understand different forms of employee participation and direct the concept towards improving productivity.
3. Ensure the effective administration of employee participation and institutionalize the system.

UNIT 4:  CONTENTS

4.1 Concept and scope
4.2 Forms of joint consultation and employee participation
UNIT 4: JOINT CONSULTATION AND EMPLOYEE PARTICIPATION

4.1 Concept and scope

The term "participation" refers to the influence in decision-making exerted through a process of interaction between workers and managers that is based on information sharing.

Participative management is the process of involving subordinates in decision-making, stressing the active involvement of people at work. It uses their experience and creativity in solving important managerial problems. It rests on the concept of shared authority, which holds that managers share their managerial authority with their subordinates in the important decision-making processes of the organization, and not just in tangential problems or concerns.

The main objective of employee participation is to increase productivity for the benefit of the employees, the enterprise and the community, to give employees a better understanding of their role in the production process and to satisfy the workers' urge for self-expression, thus leading to industrial peace, better relations and an increase in effectiveness and efficiency.

The most important prerequisites of participation and participative management are:

- management's commitment to participative management;
- a supportive but non-interventionist labour policy;
- a fairly high level of industrialization of the economy and technology;
- a growing professionalization on the part of the managers;
- an educated and technically trained workforce;
- an increasing emphasis on human resources management and development;
- a strong but not aggressive trade union movement;
- a favourable political and conducive industrial relations environment; and
- a social and cultural milieu where democratic ideals and processes are accepted and practised.

A higher degree of employee participation is an important condition for moving towards a higher, more sophisticated level of industrial relations and labour-management consultation. The latter is a continuous dialogue between labour and management representatives about improving business strategies, introducing new technology, company restructuring, introducing the best work practices, and improving working conditions and job security and the general quality of working life. The main difference between labour-management consultation and collective bargaining is that, if the latter is built around sharing the results of production between labour and employers, the former is focused on creating greater wealth, income, profit and productivity. Their distribution is of secondary importance, and is agreed upon in advance according to specific formulas, which do not change often.

The most important issues and subjects relating to joint consultation and employee participation are normally work-related issues, employee-related problems and the identification of the characteristics of effective employee participation for developing a system that is suited to the specific organization.
Now please discuss this case with a colleague or a group.

**Case: Whose fault?**

Mr. Roberts joined the Empy Containers Company as personnel officer a year and a half ago. One day, the general manager called him to his office and told him that the works manager had complained that Mr. Roberts was very slow in taking disciplinary action against workers, although the foreman had submitted written reports on their conduct.

"Sir, did he tell you of any particular case?" Roberts asked. "Yes, about the case of the oiling department worker, Kensington. It seems that he deliberately did not follow the agreed procedure regarding changing the oil, in spite of being reminded by the supervisor. The maintenance engineer's report, with the works manager's recommendation that Kensington should be suspended pending inquiry, has been with you for over a week without anything being done about it," said the general manager.

"Oh, that case, sir! I have not forgotten it. I was making some preliminary investigations. The union secretary told me about a month ago that the supervisor would settle the matter somehow. Kensington is a hardworking employee with years of service. Apparently, some time ago there was a lot of talk about heavy oil consumption by the oiling department. Kensington was concerned about it; it appears that he had thought about the problem. He had then suggested a change in the oiling method, so that the oil wastage could be minimized. The machining department foreman had thought this a good idea, when Kensington had casually mentioned it to him. Kensington mentioned it to his supervisor and a few fellow-workers. The supervisor told him that he had to talk with his boss and only then would it be tried out. Nothing happened for about three months. Kensington tried to change the method on one machine without the supervisor's knowledge, for which he got a written warning. Kensington then approached the union secretary, who told him that he would take it up with the management. The union secretary spoke to the maintenance department head, who promised to look into the matter.

In the meantime, the works manager had planned to inspect the oiling department; hearing this, Kensington had used the changed method of oiling on a machine, to demonstrate it to the works manager. Unfortunately, the works manager could not visit the department. But the maintenance department head, who had gone round the oiling department, was told of Kensington's action. He was annoyed and sent a strong complaint to the works manager, who has now forwarded it to me with his remarks. Should I suspend Kensington, sir?" asked Roberts. The general manager is wondering how such a situation could have been avoided. He also is thinking about who was at fault - Kensington, Roberts or the oiling department? What is your advice?

**4.2 Forms of joint consultation and employee participation**

The most important method of developing joint consultation and worker participation is codetermination. This is the process of joint decision-making by the representatives of the shareholders and the employees, based on the principles of parity of representation and complete information-sharing on all matters that affect the interests of the employees and the enterprise.
The common forms of employee participation and joint consultation derive from the active use of the various kinds of small group activities and mechanisms, such as:

- employee stock-ownership plans;
- joint management councils;
- Lernstatt (see box below);
- Quality Control Circles;
- works councils/committees, etc.;
- suggestions schemes;
- grievance procedures and machinery;
- safety committees; and
- employee welfare committees.

Most of these, as well as some others, have already been discussed in other modules, e.g. Module 7, “Organizing a Company Productivity and Quality (P & Q) Movement”, Module 9, “Total Quality Management”, Module 14, “Productivity Motivation and Gainsharing”, etc. However, here we should like to describe the Lernstatt system, which is not often mentioned in the literature but deserves particular attention since it integrates social and productivity concerns in its activities (see box).

**Lernstatt**

The term Lernstatt is derived from two German words, Lernen and Werkststatt, which mean “learning” and “workshop”. The most important element of the system is the Lernstatt group, consisting of ten to 12 workers who usually meet for about 50 minutes once a fortnight. Each group is led by two moderators.

This is a small group activity about learning to work better through teamwork, and about problem solving. It seeks to realize full human potential through teamwork by learning with and from each other. It helps to improve employee participation, promote teamwork, strengthen working and interpersonal relationships, increase employee satisfaction and education, improve communication, motivation and quality, make employees aware of the latest technology, and infuse a problem-preventing attitude, safety awareness and cost consciousness. It is a process that helps to enhance the competence of employees by increasing their knowledge regarding the products, the workplace and the working environment, the company, the market situation and the competition. Employees are encouraged to take the initiative in developing new ideas and overcoming problems.

To develop an effective system for employee participation in productivity improvement, the following elements should be presented in any productivity improvement programme:

- consult with and involve employees and trade unions in designing the structure and contents of the participative management mechanisms;
- train employees in the participative processes;
- train supervisors and middle-level managers in the consultative and decision-making processes;
- have a regular review of the functioning of the participative forums by the top management;
- implement the decisions taken by the participative forums and provide feedback on implementation to the employees; and
- gradually expand the scope of participative management forums and employee representation.

Please read the following case very carefully and discuss its relevance to your own country’s experience:
Case: Germany

In Germany industrial relations at the plant level are regulated by the Works Constitution Act. This law provides the works council with a variety of different-level rights to codetermination, consultation, and information on social and personnel matters, in questions pertaining to the organization of work and vocational training, and with respect to so-called “economic matters”.

However, this legislation imposes limitations not only on the manoeuvrability of management, but also on the scope of the works council. Thus the latter is bound by the “peace obligation” - that is, the works council is not allowed to take industrial action but has to refer conflictual matters to arbitration or appeal to the labour court. Its threatening potential thus is limited. Moreover, the works council can break off cooperation with management. If it is true that the works council is in a position to set limits to the latitude of management, it is also true that management is able to gauge the behaviour of works councillors. There is no asymmetry of power. The requirement to observe the peace obligation formally applies to both sides, but materially almost exclusively affects the works council (and the workforce). The legitimacy of these regulations is unquestioned among the representatives of the interested parties.

The works council is an institution fully accepted by the company director and the entire company management. However, the position of the works council in the firm is dependent on the specific function assigned to it by the company management. This function consists of the works council performing subtasks of a staff division concerned with “company order and social matters”. A major task of the works council is to “get things straight” concerning the issues arising in the firm’s day-to-day functioning. It thus complements and in part even replaces the personnel department. The assignment of such regulative functions to the works council requires a high degree of consensus to exist with respect to the use of labour and the general company objectives. The works council also assumes the functions of an “ombudsman” and “trouble-shooter”. Thus, the works council is expected to make manageable personnel conflicts (e.g. grievances, complaints) that may arise at the department or workplace levels through taking action in terms of securing reasonable company management.

The adoption of these functions provides the works council with an unchallenged “managerial position” regarding the everyday problems arising in the firm. Production manager and works council chairman often sit together to discuss, and often immediately resolve, problems of labour utilization as they arise.

Apart from his participation in the settlement of the firm’s day-to-day problems, the chairman of the works council is involved in another institution which, next to the authority of the company director, is the major decision-making body in the firm. This institution performs the function of an in-house “centre for social matters” and is composed of the production manager, the personnel manager and the works council chairman. This “tripartite board” takes action in cases of transfers, displacements, or requests for upgrading and the like. Although the company director has reserved for himself the right to take the final decision on any issue, this tripartite board is to be seen as an important instrument of overall company management.

Questions for discussion

1. What is the concept of employee participation in management and/or decision-making and what are its scope, objectives and prerequisites?
2. Discuss different forms of employee participation and identify the features that have contributed to their success in productivity improvement and industrial relations.
3. What is the significance of small group activities for promoting employee participation and productivity improvement?
UNIT 5: DEVELOPING THE UNIONS’ COOPERATION IN PRODUCTIVITY IMPROVEMENT

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Recognize the changing dimensions of trade unionism that have a bearing on the productivity of workers and enterprises.

2. Understand the role of trade unions in productivity improvement.

3. Assist in developing responsive trade unionism for productivity improvement.

UNIT 5: CONTENTS

5.1 Responsive unionism

5.2 Developing trade unions’ responsiveness to productivity
UNIT 5: DEVELOPING THE UNIONS’ COOPERATION IN PRODUCTIVITY IMPROVEMENT

5.1 Responsive unionism

Responsive unionism refers to the activities which are planned, designed and carried out by the representative trade unions in response to the members and management of organizations or to the overall welfare of the organization without sacrificing their institutional roles of protecting and promoting the members’ interests.

A responsive union believes in shared industrial relations goals within the larger interests of the enterprise.

There have been significant changes in the profiles, objectives and methods of activity of unions in various parts of the world. This is not the place to discuss them: however, a few such developments, such as the expanding range of trade union interests and their impact on productivity, should be mentioned. The major role of trade unions in productivity improvement may thus be summarized as follows:

- to ensure internal democracy in the union and to provide leadership for the employees;
- to make reasonable demands and be willing to consider the management’s requests;
- to develop integrative and cooperative bargaining relationships with the management in their endeavours to improve productivity both of the employees and of the enterprise;
- to help the management in identifying areas for cost reduction;
- to motivate the employees to be conscious of quality and productivity and jointly with the management to help them to acquire multi-trade skills and continually upgrade them;
- to create, develop and adopt positive attitudes among the workers and trade union officials toward modernization and rationalization for productivity improvement;
- to develop jointly with the management the programmes of worker involvement in productivity improvement and decision-making and to ensure active employee participation;
- to accept the rights and responsibilities of the management in matters of adjustment of manpower; and
- to avoid work stoppages and other negative tactics that affect productivity of the enterprise as well as to avoid the politicization of industrial relations.

The basis for this role of the unions in productivity improvement is the development of the cooperative bargaining approach. This implies that labour and management both accept that they have common interests to pursue rather than divergent ones. The two parties approach the negotiations with an understanding that the better the individual performance, the better the collective performance, with advantages to both employers and workers. The basis for cooperative bargaining is the belief that there is mutual dependence on the part of both the parties, and that neither party can achieve its objectives more effectively without winning the confidence and support of the other. Cooperative bargaining implies a basic change in the attitudes and approaches of the parties to negotiations and mutual relations. A prerequisite of cooperative bargaining is the existence of enlightened labour unions and managements, both of which are willing to go beyond the boundaries of conventional wage and effort bargaining.
5.2 Developing trade unions' responsiveness to productivity

To develop this kind of cooperation it is important for managers to know and understand the most frequent responses of different unions to their potential involvement in productivity drives. Some typical responses are:

- expecting the management to involve the workers and the unions in formulating technological and productivity plans and changes;
- showing a preference for incremental changes in productivity by tapping the creativity and potential of the employees through small group activities;
- maintaining the belief that the responsibility for motivating employees rests largely with the management;
- expecting the management to meet the aspirations of workers;
- expecting and demanding job security;
- expecting that the message of productivity will percolate down to the shop-floor level through training;
- insisting on the right to information sharing;
- expecting the management to create conditions of mutual trust, confidence, belief and understanding between the employees and the management; and
- expecting that management will negotiate only with the representatives of the recognized union.

Developing trade unions responsive to productivity improvement is possible only through information sharing, consultation on all issues of mutual concern, joint decision-making, recognizing the institutional role of the union and ensuring that union members enjoy security - and, more importantly, recognizing the representative (majority) union and strengthening it.

Thus, to develop responsive trade unionism, managements have to:

- recognize the union and its institutional role;
- regularly consult and involve the union in decision-making processes;
- share information on all matters of business policies and management;
- help the union in educating the workers; and
- ensure union security and strength.

The State also plays an important role in union involvement in productivity drives through its policies on employment, wages, social security, industrial relations and other employee-related issues, and, particularly, through legislation on working conditions and industrial relations.

Questions for discussion

1. How do the philosophy, policies, objectives and activities of trade unions affect the productivity of employees and enterprises?
2. What role should the unions play in improving the productivity of employees and enterprises?
3. What are the responses of unions to the efforts of management to improve productivity and
how do you shape and exploit those responses to the advantage of the organization?

4. Discuss the ways and means of developing responsive trade unionism in organizations with respect to productivity improvement.
BIBLIOGRAPHY


India, National Productivity Council: Labour-management cooperation on productivity and technology change (New Delhi, 1987).


Monga, R.C.: Case studies in labour-management cooperation for productivity improvement (Bangkok, ILO, 1988).


MODULE 16

INNOVATION MANAGEMENT AND NEW TECHNOLOGIES
MODULE 16: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand and appreciate the importance of innovation in development and perceive the main phases of the innovation process.

2. Distinguish an innovative from a non-innovative organization, and describe the main features of an innovative organization.

3. Appreciate the importance of the project management approach in innovation and technological development and be aware of its main characteristics and management methods.

4. Understand the most important leadership skills for running an innovative organization and how to develop innovation managers.

MODULE 16: CONTENTS

UNIT 1: A model for the innovation process

UNIT 2: Profile of an innovative organization

UNIT 3: Project management for innovation and technology transfer

UNIT 4: Leadership in technological innovation

Bibliography
UNIT 1:  A MODEL FOR THE INNOVATION PROCESS

UNIT 1:  LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and define the innovation process and its main components, distinguish innovation from other traditional activities and developments, and indicate the main types of innovation.

3. Describe the main characteristics of a good innovation management system and the managerial role with regard to innovations.

4. Outline the four phases of the innovation process.

5. Understand and explain a contingency model of the innovation process.

UNIT 1:  CONTENTS

1.1 Introduction to innovation and innovation management

1.2 Images of technological innovation and its components

1.3 A few hints on managing innovation

1.4 Checklist for judging alternative methods in product or process innovation
UNIT 1: A MODEL FOR THE INNOVATION PROCESS

1.1 Introduction to innovation and innovation management

Innovation is a creative process. It may be defined as a process of introduction, beginning with an invention, a new idea or new application, and then bringing that invention into general use. For example, if the computer was an invention, the application of that invention to handle the information needs of the organization was an innovation.

Innovation may be applied in many areas - new product development, a new production process, distribution, management - in fact, any kind of human activity. Some specialists rightly consider innovation as the process of persuading people to adopt an invention.

Another interesting insight into the management of innovations can be had by contrasting innovation with maintenance, or the sustaining of operations. If maintenance is the sustaining of operations today, innovation is concerned with tomorrow - with making sure that there is a continuing improvement in profitability and productivity, or an improvement in social results.

If the outcome of maintenance operations is more predictable, innovation is a highly creative, highly qualitative and highly unstructured process, and is far riskier.

By definition, innovation challenges existing knowledge regarding process contents. But innovation has some remarkably stable characteristics regarding process form. While a technologist focuses on the content of specific innovation processes, a technology manager concentrates on process form and its nature. The innovation management approach enables technologists to acquire the necessary new outlook and understanding to enter the field of technology and innovation management. Innovation can be thought of as a discontinuous change in the combination of three factors: technology, the environment (market) and the organization. The innovation process can be initiated through any of these three factors.

Management plays a crucial role in initiating the innovation process. The foremost task is to create conditions conducive to generating new ideas and to trying them out and perfecting them. At the same time, management must create an equilibrium between promoting new developments and maintaining existing operations. A clear vision about the strategy of the organization is essential in attaining this equilibrium. By following up these tasks in the right way, management is creating and maintaining a creative organization. Innovation management is more than the management of separate innovation projects.

Successful innovation management systems should have at least the following characteristics:

- An open structure that encourages the creative process. This openness is consistent with the personality and style of those people - entrepreneurs - who must be supported by the innovative organization.
- Separation from maintenance responsibilities. If the maintenance organization is linked with an innovative one, the immediacy of maintenance problems will drive out the concern for building for the future.
Module 16
Unit 1

- An interdisciplinary rather than a functional structure. This requires the simultaneous improvement of all relevant disciplines so that each problem in the innovative process is considered and solved in the broadest context.

- Top management commitment. Top management must believe in the importance of innovation in shaping the future of the organization, accept the risks of innovation, and participate in the management of the innovation process.

- Acceptance of qualitative control built into the Total Quality Maintenance (TQM) system.

- Pressure for progress. This has to be created and maintained in innovative organizations. The ability to make timely decisions is an important incentive to the innovative group and an important measure of its productivity.

- A successful innovation management system. This must attract entrepreneurs - professionals who are able to accept the risks of the market place and who are committed to successful introduction. The system must contain incentives that will attract these extremely rare, yet highly prized, innovators.

- Strong leadership that will motivate, encourage and push the professional innovators.

- Strong consumer orientation. The innovative process must begin with the consumer and work back to the drawing-board to generate ideas or applications that will solve a real problem.

There are no standard paths to success in innovation. Fortunately, a manager can learn a lot about innovation that enables him or her to make better decisions. This is true for general strategic decisions, such as the allocation of resources for innovations activities as well as for their execution. Successes from the past can sometimes be a guideline for decisions but should not be a blueprint for future activities. History teaches us that pioneers of new technology do not always appreciate in time the importance of the next technological breakthrough. A good example is Anthony Fokker, who in the early 1930s secured a leading position for his aircraft in the world market. However, he neglected the importance of metal construction and as a consequence his company lost its predominant position in just a few years.

Despite the fact that innovations can cover any area of organizational activity, in this module we shall concentrate mainly on technological innovations. It is therefore important for a manager to understand the peculiarities of technological innovations and to take these as the basis for decision-making. Consequently, images or models of innovation are useful decision tools.

1.2 Images of technological innovation and its component

Strange as it may seem, one of the first questions to be answered in decision-making on innovation is “Are we or are we not looking at an innovation?” The following example shows that the answer is not always straightforward but does have far-reaching consequences.

1.2.1 The case of the laminating machine

A manufacturer of blockboard decides to buy new laminating equipment. The production manager is requested to make a proposal. While evaluating the different machines he takes into consideration the possibility of making some process improvements. The choice is made to buy
a machine that is capable of laminating rounded corners. Until now they have only produced blockboard with square corners. According to the production manager the new machine will result in only a marginal improvement of the current process. After the green light has been given by the company director the new machines are ordered. At this stage the production manager creates a plan for the layout of the new machines. Some of the existing machines will have to be moved.

Meanwhile, the rumour that new machines have been ordered has circulated in the factory. In the monthly review meeting the foreman of the laminating section seeks clarification of the situation. He has had a lot of questions from his people to which he has no answer. Will there be consequences for the workers in production? Will the job requirements stay the same? What will be the influence on the reward system? When will the change-over take place? Will there be any changes for the technical support section? Are we finally going to use a different kind of glue so that we no longer have to throw away 20 per cent of the production?

The foreman is calmed down: in due course he will receive all the information he needs, but first a few technical puzzles have to be solved. This ritual will recur several times. Finally, a year after the planned implementation date, the new line is operating reasonably free of disturbances. Meanwhile, the company has lost several clients because of late deliveries and poor quality. There were a few spontaneous stoppages in production.

After a short work stoppage during the start-up a working group was set up to define the new work method and its job requirements and the resulting training plan. A few improvements in the working environment could still be made with some adjustments to the machine. Mistrust and resistance disappeared quickly after the intentions were clarified and possibilities were created for participation and personal input. The training programme was a direct result of this approach.

The most important changes for the organization were:

- maintenance group and operators: learning how to work with computer-controlled machines;
- purchasing: wider responsibilities in judging the capability of suppliers to meet the tougher requirements on raw board materials;
- sales: stricter specifications resulting from the new process; and
- training: specialized training for new personnel.

At the end of the project the whole process was evaluated and the following learning points were highlighted:

- At the start the innovation project was seen as a routine replacement investment, not as an innovation. The extent of the change and its adaptation to the organization were essentially underestimated.
- Since the innovative nature was not recognized, the project was assigned to the technically oriented production manager who executed it as a purely technical project.
- Too optimistic an approach in the introduction of new technology resulted in unrealistic project planning and external commitments that could not be met.
- Since the lack of familiarity with the new machines was underestimated, the operators were
involved in the decision-making process at too late a stage.
- Resistance among the personnel resulted mainly from lack of information and not from the changes themselves.
- Making use of the creativity and practical insight of production workers eliminates many practical problems.
- The effect of technological innovation does not stop in the production department. Other departments such as purchasing, sales and personnel also have to adapt. Decisions should be evaluated for their effect on other departments at the top management level.

Exercise:

Discuss this case in your group and answer the questions:

1. Which innovation roles do you recognize in this case?
2. What were the major problems in implementing this innovation?

1.2.2 Technological innovation is more than solving a technical problem

On the basis of many studies of innovation projects, a general model of innovation processes has been developed. The model is an important tool in guiding innovation decision-making. According to the model, innovation consists of three interdependent, simultaneous processes: problem solving, internal diffusion and organizational change (During, 1986).

Problem solving. The main activities of problem solving are:

- determining the direction of innovation (manufacturing and also process design);
- determining the innovation objectives (in the case above, a laminating machine for producing rounded corners);
- developing methods to implement objectives (automation of feeding into the machine); and
- determining and implementing the application of the innovation (fitting the new laminating machine into the existing process).

Each activity is performed in a cyclic process consisting of four phases:

1. The creative phase (finding and describing the innovation problem).
   One approach: looking at the problem from a new angle.

2. The selection phase (choice of the problem that will be actively tackled and for which possible solutions are further elaborated). A provisional model to be followed and the criteria for the expected results are developed.
   One approach: decide which ideas should be developed in detail. Concrete activities may include defining the selection criteria for the ideas generated; setting priorities; collecting information on possible solutions; judging alternatives; and choosing alternatives for further study.

3. The design phase (the selected strategies for solving the innovation problem are worked out, until a possible application is found to be a realistic one).
   One approach: reshape suggested possibilities into concrete actions that can be
implemented. Concrete activities may include working out solutions; drawing up the approach or work method; setting up trials and tests; drafting operational norms; and drafting user specifications.

4. The implementation phase (the suggested solutions are put into practice. Plans are executed and new experience is acquired. Observation and evaluation are the input for starting a new cycle).

One approach: testing solutions. Concrete activities may include executing action plans; reporting on their execution; introducing a new work method; instructing users; and providing resources.

**Internal diffusion** is a process related to the dissemination of innovation between organizations (Rogers, 1983). In his model Rogers indicates that diffusion is a necessary part of the process of introducing an innovation. Of prime importance is the dissemination of the innovation. Important aspects of this process are information, interaction, and motivation and enthusiasm on the part of all persons involved. In the initial phase of an innovation process the number of people involved is small but it steadily increases as the process evolves. This implies that communication about whether or not the innovation is accepted becomes increasingly important.

**Organizational change** resulting from innovation is necessary to make problem solving and diffusion possible, for example through setting up an innovation group. It is also possible that a selected solution cannot be implemented without adapting the organization. The qualitative and quantitative changes in the organization also concern people, resources, processes and organizational rules.

**Figure 16.1: A contingency model of the innovation process**

![Contingency model of the innovation process](image)

Source: During, 1984.
It is characteristic of the three interrelated processes that their interdependence and interaction determine the evolution of the innovation process (see figure 16.1). Besides the characteristics of the organization, there are other contingency factors such as the nature of the innovation (degree of novelty, kind of innovation, etc.) and environmental characteristics which will influence the course of the innovation process (Boer and During, 1987).

According to the contingency model, the general conditions for successful innovation management are:

1. The different processes (problem solving, internal diffusion, organizational change) must be integrated with each other and with the contingency factors. For example, by receiving information on the innovation objectives the persons involved are motivated to contribute to a potential innovation. The innovation must suit the working style of the organization; if it does not, changes in the organization must be made.

2. Key roles must be assigned to specific persons, such as those of idea generator, champion, sponsor, gate-keeper, project manager, etc. (see Roberts and Fusfeld, 1981). During (1986) identifies the following roles:
   - The integrator. Since in innovation management the different processes are tackled simultaneously, it is important to balance them. The task of the integrator is to optimize these activities so as to improve productivity.
   - The scout. The role of the scout is information gathering on a well defined but insufficiently known area. This role is in contrast with the role of the gate-keeper who gathers information in an unstructured manner.
   - The ambassador. The ambassador conveys the policy with respect to innovation goals and activities to the people who will be involved. He or she also passes on to the problem solvers information on the attitude of the people concerned towards the innovation. The ambassador makes suggestions for adapting the methods of communication or the solution of problems.
   - The reorganizer. The reorganizer pays attention at an early stage to necessary changes. This role demands the initiation, realization and consolidation of changes in the organization (people, resources, processes and procedures) with respect to innovation processes.

3. The working style must provide the freedom for introducing innovation.

4. Innovation should be set up as a learning process for the whole organization. Not everything that starts well ends well. The following points should be taken into account:
   - Reserve time, money and human resources for failures. Determine the “learning fee” the organization is prepared to pay.
   - Foresee the changes to the existing way of working. Who will be involved, what will be the effect on existing commitments, job requirements, etc.?
   - Provide information on the planned changes. Being informed is a prerequisite for involvement.
   - Coordinate decision-making on innovation at the general management level. Weighing decisions, authorizing activities or spending outside existing authorized limits and readjusting the goals inevitably accompany innovation.

1.2.3 Different types of technological innovation

Apart from the general guidelines for innovation management, each type of innovation has
its own specific demands. In many cases the immediate cause for process innovation is the need to replace machines and technology. It is often necessary to make organizational changes also (training, redefining tasks, responsibilities and authorizations, levels of communication). The most important learning points resulting from the study of innovation processes are:

- Do not look at the technological problems only. A project group should not consist exclusively of technical people.
- When evaluating possible solutions, make use of management and assessment techniques that are appropriate for innovative investment. Classical rentability calculations often fail owing to the uncertain nature of the innovation.
- Specifications should be regularly adjusted. Because of the duration of the problem-solving process, market forecasts change, with consequences for production capacity.
- The project team should continue to operate for some time after the implementation of the innovation, since it is only after implementation that the technical and organizational bottlenecks appear, which can obviously be more easily solved by the project team members.

Our research shows that in most cases the trigger for product innovation is the replacement of existing products or need for adaptation to a new user market. The most important learning points for directing the process of product innovation in these cases are:

- Goals and product specifications should be specific and complete. The specification should cover a group of users and not be applicable for one client only.
- Product innovation is a continuing process. There should be enough leeway to keep the learning process going: for instance, it is often possible to revive a stagnating innovation process by adapting the design or market approach. A regular planned analysis of delays and "failures" often points the way to an alternative.
- Subprojects should be carried out in parallel. A long waiting time reduces motivation for the innovation process. It so happened that a cosmetics manufacturer wanted to add a sterilizing lotion to its "personal care" product line. The legally required permission was requested only after the market research was finished. The procedure took almost a year. By that time the sales force that had been involved in the early stages of the innovation had lost all belief in the realization of the innovation, nearly causing a disaster when the product was finally introduced.

1.3 A few hints on managing innovation

"The image of innovation defines the way of management"

This image of innovation can be summarized into three core statements:
1. Innovation occurs more frequently than you think.
2. Technological innovation is more than a process of technical development. It essentially consists of three independent processes: problem solving, organizational change and internal diffusion.
3. There are several innovation processes that require a specific management technique.

The following learning points are based on this image:
Module 16
Unit 1

- Check if a technical development process is in fact an innovation process.
- Aim the innovation at specific goals.
- Create a complete specification paying attention to all parts of the organization concerned.
- Design the innovation process as the learning process.
- Make use of decision-making techniques suitable for the innovation process.
- Balance and integrate the three processes.
- Assign key roles to specific persons.
- Integrate the activities at the general management level.
- Devote sufficient time to communication.
- Do not wind up the innovation team until after the introduction of the innovation.

On the basis of these guidelines every manager can make use of decision-making processes and techniques that suit the organization and thus create a operational control system for innovation.

1.4 Checklist for judging alternative methods in product or process innovation

Discerning characteristics (strong positive correlation). This factor indicates the extent to which an alternative method is advantageous to the internal or external user. In relation to competitive alternatives this includes aspects such as price, useful capacity and reliability.

Appropriateness of the alternative method in relation to company characteristics (strong positive correlation). The available resources of the company, such as management skills, technical and marketing know-how, development facilities and financial resources, are compared with the resources required for the successful realization of the alternative method.

Scope of and need for potential application (positive correlation). What are the real needs of the users for the alternative method? The scope and eventual growth of the application should also be taken into consideration.

Advantages for the user (positive correlation). This factor indicates the extent to which users can achieve their goals. This might take into account such items as cost reduction, increase in market share or complying with the law (environment).

Novelty for the company (weak negative correlation). As the alternative method becomes less comparable to existing products, production methods, sales channels, and so on, the chances of success are reduced.

Competitiveness of the market (weak negative correlation). This factor is important for product innovation. As the competition increases (number, aggressiveness), the chances of success are reduced.

Specialization (weak positive correlation). When the alternative method is based upon users’ ideas and offers a standard solution for a relatively large number of users, the chances of success are higher.

---

1 Adapted from Cooper (1980) and Bronnengen (1987).
Questions for discussion

1. What is an innovation and how does it differ from normal technical development?
2. What are the different roles in the innovation process?
3. What are the main parts of the innovation process?
4. Can communication be treated as a separate process from innovation?
5. Innovation is sometimes called a learning process. Can you recognize this viewpoint in the model of the innovation process given above, and if so how?
UNIT 2: PROFILE OF AN INNOVATIVE ORGANIZATION

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Identify and describe the profile of an innovative organization.

2. Appreciate the importance of integrating the cultural and structural dimensions of innovative organizations and their impact on the management process.

3. Understand the essence of assessing innovative performance and use the results for decision-making.

4. Relate different management tasks and styles to the relevant stages of innovation processes.

UNIT 2: CONTENTS

2.1 Historical background

2.2 The cultural approach

2.3 The structural approach

2.4 Innovative performance: Assessment for making decisions

2.5 Three stages and three tasks for management
UNIT 2: PROFILE OF AN INNOVATIVE ORGANIZATION

To explain why one firm is more innovative than another, two major sets of answers are provided. The first deals with the innovative climate. The second can be found by examining organizational measures specially designed to develop and manage new ideas. These organizational entities are called "innovative mechanisms". Genuine innovation is most likely to occur when there is a proper balance between innovative climate and innovative mechanisms.

2.1 Historical background

In 1961, Burns and Stalker published a study on British electronic firms in which they described the culture and the structure of some successful and unsuccessful companies after the Second World War. They named the successful ones "organic". We now call them "innovative". The unsuccessful companies they named "mechanistic". Burns and Stalker described the organic organization as having 12 characteristics varying from "Individual tasks derived from a realistic situation" to "More lateral than vertical communication". Their description of the mechanistic organization contains ten characteristics varying from "Specialized differentiation of functional tasks" to "Hierarchical structure". Burns and Stalker's study has been repeated over the years by several authors with the same results. One of the most famous of these is In search of excellence (Peters and Waterman, 1982), in which the "excellent" company is described in eight characteristics or "lessons" (see table 16.1).

<table>
<thead>
<tr>
<th>Table 16.1: Eight characteristics of excellent companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A bias for action</td>
</tr>
<tr>
<td>2. Staying close to the customer</td>
</tr>
<tr>
<td>3. Autonomy and entrepreneurship</td>
</tr>
<tr>
<td>4. Productivity through people</td>
</tr>
<tr>
<td>5. Value-driven decision</td>
</tr>
<tr>
<td>6. Stick to the knitting</td>
</tr>
<tr>
<td>7. Simple form, lean staff</td>
</tr>
<tr>
<td>8. Simultaneous loose/tight properties</td>
</tr>
</tbody>
</table>


The resemblance between the excellent company and the organic company is clear. Excellent companies are organic; but not all organic companies are excellent. The excellent company is a subtype of the organic company: a very successful organization with an organic regime and high coherence based on a specific cultural pattern.

2.2 The cultural approach

Many authors and practitioners emphasize the importance of creating a cultural climate favourable to innovation. A climate is a set of values, attitudes and beliefs as reflected in day-to-day decisions and actions. Peters and Waterman observed a strong team spirit in the companies
they surveyed. There was a specific strong company culture in which new employees were thoroughly immersed. The cultural characteristics they mention are a bias for action, a need to experiment, short communication lines and the predictability of leaders.

This results in a simple and clear organization with a relatively small staff. When necessary, this organization is split up into more flexible units. The family feeling guarantees simultaneous loose/tight properties. A sense of freedom is needed, as shown for instance by a tolerant attitude towards mistakes, and new speculative ideas are not dismissed out of hand. In this kind of organization, non-conformist behaviour is tolerated and appreciated.

A good example of an innovative climate is provided by the French company Club Med. In this tourist firm the emphasis is on personal and social qualities and the diversity of talent and background. With the Club Med the management of the holiday villages changes every six months and the rest of the employees change tasks frequently (of course, not without appropriate training). Within a week of the end of this holiday the customers of the Club Med receive a short questionnaire asking for criticisms and suggestions. The responses are not used to provide statistics but are sent directly to the villages concerned.

The above-mentioned authors are not alone in placing strong emphasis on the climate in innovative firms. Most authors - amongst them well-known names such as Mintzberg and Mosskanter - describe the innovative organization as one emphasizing the cultural aspect.

2.3 The structural approach

But the climate is not the only facet of innovative management. The organizational design of the company can also be totally or partially directed to innovation. A classical approach in the structural design of innovation is the departmental approach, in which the innovation process is split into stages which are connected with the functional departments of the company. A simple example of this approach is given in figure 16.2. In this sense the innovative firm is based upon the “technology push” function of a good R & D department and the “market pull” function of a good marketing department.

![Figure 16.2: Example of a departmental approach in innovation](image)

Nevertheless, innovation is not only the excellent performance of single functional departments but also the joint cooperative effort of all the functions. The innovative firm is characterized in this vision by the linking of the R & D and marketing functions and the synergy between the two. The way in which this integration takes place is normally organized in a multidisciplinary group - for instance, the Philips organization operates with so-called multidisciplinary “product teams”.

16 - 13
At the same time, besides departments or groups, the role of dedicated individuals is seen as crucial for the success of innovation. Much has been written on the role of the so-called (product) champion. The champion is the driving force behind an innovation. This person is strongly activated by the innovative concept and is thus able both to motivate others within the organization and to gather the required resources. In their study on great breakthrough innovations, Ketteringham and Ranganath Nayak (1986) found one or more champions behind the success of all these innovations. The innovative firm is normally capable of breeding champions and nourishing them.

A more systematic survey on the organization of innovation was conducted by the American consulting firm Arthur D. Little (1985a). In this survey the term “enabling mechanisms” is used, by which is meant organizational entities to promote the development and management of new ideas. In table 16.2 international comparisons of the most important elements of these mechanisms and the frequency of their use are indicated. The result of the survey in this table provides an excellent insight into these elements of the innovation mechanisms favoured by the most innovative companies.

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>North America n = 417</th>
<th>Europe n = 446</th>
<th>Japan n = 88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated individuals or organizational units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual champion</td>
<td>49</td>
<td>38</td>
<td>7</td>
</tr>
<tr>
<td>Task force</td>
<td>69</td>
<td>53</td>
<td>55</td>
</tr>
<tr>
<td>Venture team</td>
<td>18</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>“Skunkworks”</td>
<td>9</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>New venture division</td>
<td>16</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>New business start-up</td>
<td>18</td>
<td>22</td>
<td>47</td>
</tr>
<tr>
<td>Acquisitions/divestitures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed investment (less than 10%)</td>
<td>19</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Enabling acquisition (10% to 100%)</td>
<td>42</td>
<td>39</td>
<td>10</td>
</tr>
<tr>
<td>Partial spin-off</td>
<td>8</td>
<td>7</td>
<td>50</td>
</tr>
<tr>
<td>100% spin-off</td>
<td>8</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Financial mechanisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate venture capital group</td>
<td>20</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>R &amp; D limited partnership</td>
<td>8</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>Licensing</td>
<td>24</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Special partnerships</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint venture</td>
<td>46</td>
<td>36</td>
<td>43</td>
</tr>
<tr>
<td>Supplier partnership</td>
<td>13</td>
<td>15</td>
<td>41</td>
</tr>
<tr>
<td>Customer partnership</td>
<td>18</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>Union partnership</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Government-supported venture</td>
<td>8</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Corporate governance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside advisory group</td>
<td>10</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Special board-level committee</td>
<td>11</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Appointed innovation tsar</td>
<td>6</td>
<td>17</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: Arthur D. Little, 1985a.
2.4 Innovative performance: Assessment for making decisions

The innovative climate and the innovation mechanisms present the structural and the cultural dimensions of the innovativeness of a company and thus form a matrix in which the innovative performance can be represented (see figure 16.3). In this matrix two styles of innovativeness are described. Natural innovators rely on their innovative climate and systematic innovators emphasize the use of innovation mechanisms. The previously mentioned Club Med is an example of a natural innovator.

**Figure 16.3: Innovativeness in two dimensions**

![Innovativeness in two dimensions diagram]

2.4.1 The measurement and modification of the innovative climate

On the basis of a number of previously mentioned studies, a fairly accurate set of innovation-stimulating factors can be derived. In table 16.3, 11 important factors are listed. On the left side are the factors commonly quoted as being not in favour of innovation and on the right side are the factors that are in favour of innovation.
Table 16.3: Some aspects of the innovative climate

<table>
<thead>
<tr>
<th>Negative</th>
<th>Factor</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>horizon</td>
<td>long</td>
</tr>
<tr>
<td>kept out</td>
<td>maverick</td>
<td>accepted</td>
</tr>
<tr>
<td>punished</td>
<td>failures</td>
<td>tolerated</td>
</tr>
<tr>
<td>formal</td>
<td>communication</td>
<td>informal</td>
</tr>
<tr>
<td>kept out</td>
<td>uncertainty</td>
<td>accepted</td>
</tr>
<tr>
<td>analyses</td>
<td>planning</td>
<td>action</td>
</tr>
<tr>
<td>means</td>
<td>planning</td>
<td>opportunities</td>
</tr>
<tr>
<td>closed</td>
<td>external cooperation</td>
<td>open</td>
</tr>
<tr>
<td>autocratic</td>
<td>decision-making</td>
<td>participative</td>
</tr>
<tr>
<td>internal</td>
<td>orientation</td>
<td>customer</td>
</tr>
<tr>
<td>vague</td>
<td>strategy</td>
<td>clear</td>
</tr>
</tbody>
</table>

These factors cannot be considered as absolute. For instance, a long planning horizon is known to favour innovation, but to determine the exact place and capacity of a phone-operating system ten years ahead proves to be too rigid. The acceptance of some mavericks in the organization favours innovation. However, too many mavericks will lead to unmanageable situations. Some degree of tolerance for failures is positive, but only up to a certain level.

It is therefore impossible to measure the innovative climate of a company in an absolute sense. To judge the climate we therefore use the “Ideal - Actual” method. First the actual situation is determined, and then the ideal or desirable situation. The magnitude of the gap between the two is a measure of the innovative climate. Large gaps between the actual and the ideal situation are leverage points for modification. This approach is illustrated in figure 16.4.

**Figure 16.4: Leverage points for modification of the innovative climate**

(○ = actual; ⋅ = ideal)

<table>
<thead>
<tr>
<th>Planning horizon</th>
<th>○</th>
<th>⋅</th>
<th>- Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>○</td>
<td>⋅</td>
<td>- Business planning</td>
</tr>
<tr>
<td>Strategy</td>
<td>○</td>
<td>⋅</td>
<td></td>
</tr>
<tr>
<td>Tolerance</td>
<td>○</td>
<td>⋅</td>
<td></td>
</tr>
<tr>
<td></td>
<td>○</td>
<td>⋅</td>
<td></td>
</tr>
<tr>
<td></td>
<td>○</td>
<td>⋅</td>
<td></td>
</tr>
<tr>
<td>Customer orientation</td>
<td>○</td>
<td>⋅</td>
<td>- Multidisciplinary task forces</td>
</tr>
</tbody>
</table>
2.4.2 Assessing and using innovative mechanisms

The use of innovative mechanisms can be measured in the absolute sense. Most companies use only a limited number of them. They draw on mechanisms that fit the culture and tradition of the company whether or not the mechanism is suited for the purpose. It seems wiser to use a range of mechanisms and choose those that fit the purpose as well. Assuming that a particular idea has emerged and appears to have merit, three important guidelines should be observed for choosing the appropriate enabling mechanisms:

- Determine how closely the idea relates to the company’s existing business and capabilities.
- Compare the resources required, in terms of talent and money, with those that are available.
- Determine how much time is available from the moment the opportunity is identified until it must be successfully introduced into the market place.

To assess how closely the idea relates to a company’s existing business is a critical consideration. To this end we can use the well-known market/technology familiarity matrix (see figure 16.5). If the innovative project is close to the present technology and market, internal task forces and venture teams are good mechanisms. Cooperation with other organizations can be considered for innovations of moderate risk, i.e. in the middle of the matrix. For very new and thus risky projects, financial mechanisms such as venture capital and (minority) participation seem appropriate.

**Figure 16.5: Relationship between market/technology familiarity and the appropriate innovation mechanism**

<table>
<thead>
<tr>
<th>Known</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate venture capital</td>
<td>Seed investment</td>
</tr>
<tr>
<td></td>
<td>R &amp; D sponsorship</td>
</tr>
<tr>
<td></td>
<td>Skunkworks</td>
</tr>
<tr>
<td></td>
<td>Government support venture</td>
</tr>
<tr>
<td></td>
<td>Enabling acquisition</td>
</tr>
<tr>
<td></td>
<td>Joint venture</td>
</tr>
<tr>
<td></td>
<td>Business start-up</td>
</tr>
<tr>
<td></td>
<td>R &amp; D partnership</td>
</tr>
<tr>
<td></td>
<td>New venture division</td>
</tr>
<tr>
<td></td>
<td>Supplier partnership</td>
</tr>
<tr>
<td></td>
<td>Spin-in</td>
</tr>
<tr>
<td></td>
<td>Venture team</td>
</tr>
<tr>
<td></td>
<td>Task force</td>
</tr>
</tbody>
</table>

The second criterion for choosing appropriate enabling mechanisms is the type and amount of resources available compared with those required, in terms of experience, availability of personnel and finance. Although many companies are capital constrained, the greatest barrier to innovation seems to be a lack of management resources, as existing managers are preoccupied
with current operations and short-term problems and have limited time available to run a new venture. Companies in this position are often obliged to attract new talent from outside, with all the associated uncertainties that this brings.

The amount of time available from the moment the opportunity is identified until it must be successfully introduced is called the "window of opportunity". The choice of an enabling mechanism will obviously be conditioned by the amount of time that management has to seize the opportunity. If enough time is available, it may make more sense to develop the required skills and capability in-house. If time is limited, a joint venture or acquisition may be more appropriate. Innovative companies usually understand the importance of using a broad range of enabling mechanisms to foster innovation; they also have a good understanding of which mechanism to use for which type of innovation.

2.5 Three stages and three tasks for management

It is useful to break down the innovation process into three distinct stages:

- the concept stage in which new ideas are found: the stage of "invention" and free creativity;
- the development stage in which ideas are transformed into projects; and
- the introduction stage in which projects are turned into new business.

The task of management is different in each stage (see figure 16.6.). In the concept stage the task of management is to create a climate favourable to innovation. The development stage requires that management establish the correct enabling mechanism to nurse the projects. The last stage, the introduction, needs a more classical management approach: planning, action, control. The complete innovation process calls for the integration of all three tasks of management in one innovative process. Management of innovation is really managing paradoxes. This emphasizes again the need for top management’s involvement in innovation. Only top management can set the balance between a good climate to allow ideas to come up and enough structure to get ideas to the market without confusing the innovation process and the routine production cycle.

Figure 16.6: The tasks of management by stages
Questions for discussion

1. What is meant by an innovative organization? What is its main distinctive characteristic?
2. How do companies organize their innovation? How can line management influence the innovation process? Is there a best way of doing this?
3. What is the reason for making a distinction between innovative culture and innovative mechanisms?
4. What are the main criteria for assessing innovative performance?
5. Discuss the linkages between innovation stages and managerial tasks.
UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand what factors influence the project process and the project management concept, and the main differences between this and the normal line management of routine production operations.

2. Be aware of the main project process phases and their major tasks, and also relate management styles to specific phases.

3. Understand and involve the project “users” in the project identification and definition phases.

4. Appreciate the importance of the project organization in having the project designed and implemented.

UNIT 3: CONTENTS

3.1 Why project management?

3.2 What is project management?

3.3 Areas for application

3.4 Major areas for development
UNIT 3: PROJECT MANAGEMENT FOR INNOVATION AND TECHNOLOGY TRANSFER

In innovation management or technology transfer, project management is normally used to meet objectives in time. In this unit, several issues and problem areas of project management for innovation will be discussed. Particular attention will be paid to delivering products and services with speed and quality. Special emphasis will be placed on the importance of the project "users" and how project management involves them. Besides project phasing, the different "tools of project management", such as project quality, planning/scheduling, financial management, project organization, documentation control and communication, will be discussed in some detail.

3.1 Why project management?

Among the many reasons that push companies to use more and more project approaches in innovation management, the following two are of particular importance:

- the global acceleration of innovation and related competition; and
- shortening the innovation lead-time and reducing risks.

The following three aspects will be emphasized in this unit:

- the development of new technology;
- the introduction of existing technology; and
- technological strategy development.

Although it is not always wise to be the first to innovate, once the decision is taken, the required lead-time to implementation will have to be shorter than previously accepted. There are two reasons why this is necessary. One is cutting costs; but a more important reason is reaching the market earlier than the competitor, and thus creating income when the customer’s willingness to pay high prices for new and innovative functions is greater than average. Furthermore, the product/service should of course meet the customer’s needs. Again, the strategic issues are speed and quality.

In order to meet these crucial objectives, professional project start-up processes per project phase have proven to be essential. "A good start is half the work" is a Dutch saying. Sections 3.3 and 3.4 will elaborate on this issue. The key term here is prevention of failures.

3.1.1 Selecting line or project management

In the production type of organizations especially, managers frequently believe that projects can best be run through the established line organization structure, using the normal consultation processes. Project management is a profession, however, comprising the needed skills that are lacking in the line organization. The main differences between "general" (line) management and project management are:
- the difference between short-term (production) goals and long-term (project) objectives;
- project management involves managing uncertainty and risks;
- the speed and quality of the decision-making process are higher in project management;
- project management requires a phased approach with rapidly changing organizational set-ups and leadership approaches during the life of the project; and
- project and line managers have different career objectives and motives.

### 3.2 What is project management?

A project is an organized programme of investigation and activity carried out to reach a defined goal, often of a non-recurring nature, with a specific terminal point. A project goal might be the introduction of new technology, R & D, social programmes, etc. A few important points of project management are discussed below.

### 3.2.1 The importance of the project users

At the beginning of any technological innovation, it is of crucial importance to identify the possible users by category (see below) and ask their opinions, before going directly from problems to solutions. A professional project manager will have had project specifications drawn up by the different users. Since often they do not have identical objectives, the first project phase is one of negotiation.

The following user categories can be identified:

*The end users.* These are the people who are using the final products (or services) of the project. They constitute the “project market”.

The system users. These people keep the product/service available and in good order during the entire product life cycle. They work in business areas such as manufacturing and logistics, sales and distribution, packaging and storing, product maintenance and service, and supply. These system users normally develop requirements to be implemented during the project.

*The intermediate users.* These people “develop” the project throughout the business. They also have skills in R & D and engineering, advertising and market development, manufacturing and logistics, training for sales and service, manual preparation (user, service, installation), etc.

*The environment.* The last important group consists of people who are not directly visible or engaged in the project but who are interested in project developments and in the end product. They may represent the government, regulating such aspects as safety, the environment, export, fiscal matters, working conditions, licences, etc.; social groups, seeking influence on issues such as job security, the working environment, etc.; the internal power structure and competition; and external competition.

### 3.2.2 Project phasing and risk control

The project process is shown in figure 16.7. Project phasing is important for checking on progress at predetermined moments of the project life cycle and for bringing management up to date with progress. The most important phases are:
1. **Orientation.** Problems are identified and supporting research is conducted. This phase ends with the maxim: “Provide me with a project plan.”

2. **Definition.** The project requirements are specified and a plan is drawn up with the users. This phase is terminated by a “go/no-go” decision.

3. **Development phase(s).** Creative solutions are generated to fit the plan. Depending on the plan’s complexity, there may be two or more phases. This phase ends with a decision to implement the chosen technology.

4. **Implementation.** The product/service becomes operational in all management areas. This phase ends with the so-called “commissioning” and operations can start thereafter.

5. **Use and maintenance.** This phase sometimes lasts for many years.

The above phases are managed using a standard set of management tools as described in figure 16.7.

1. **Project quality.** There are two major areas of concern in project quality control. The first relates to the quality of the project plan, which is verified by checking whether the users have been consulted properly. If the plan is well defined, the second area of concern - quality assurance - is examined, with all development actions and decisions being tested.
against the project plan and its specifications.

2. **Scheduling.** This is generally carried out at two levels. First, an overall phased life-cycle plan is established in order to see the major phase transitions and decision moments. This exercise is a process analysis. At the same time a detailed action plan is developed for the next phase in order to manage and control the work in progress. Techniques used are based on activities and their lead-times. The detailed scheduling exercise is repeated during each project phase, the maximum planning horizon being approximately three months. The best way to control progress thereafter is to ask project workers “How much time and effort do you need to finish the activity?” rather than “How much have you finished so far?”. In this way you know what is likely to happen.

3. **Project finance.** Financial management recognizes three levels of uncertainties:
   - a preliminary estimate during the orientation phase, representing a first assessment of possible costs and benefits;
   - a final estimate at the end of the definition phase, being part of the information needed for the “go/no-go” decision. The accuracy may be + 30 per cent. Money is to be allocated but not yet used (except for the definition phase budget); and
   - the allocation of target-oriented budgets based on specific activities and on external spending for materials, consultancy, etc. In most control systems, budget and scheduling information are linked to check progress and estimate “efforts to complete”.

4. **Project organization.** Setting up a good project organization is very important. The type of organization and leadership differs from phase to phase.

   During the orientation and definition phases people with vision and conceptual qualities are needed - people with experience and business, commercial and sometimes political skills. Task-oriented leadership is not necessary at this stage. The project organization should be one of coalition and discussion among equals. Problems and future project requirements will have to be brought into focus.

   The phase of development or finding solutions, based on defined requirements, calls for more task-oriented leadership. The project and subprojects are allocated and the jobs to be carried out are relatively clear. Commitment is the key word. Mostly this phase is executed in a matrix type of environment, which needs tough project management in getting support from the line management resources. Authority in executing the project is very important. It is therefore crucial that the project be connected to the top level in the organization, where conflicts can be solved and decisions taken.

   Commissioning, or the transition to the implementation phase, involves the participation of other teams. It is not only technology that will have to be transferred, but also knowledge, management, a new organization, new jobs, etc. This phase requires task-oriented leadership.

   The use and maintenance phase brings the project back into the line organization, with its clear subdivisions, responsibilities and hierarchy.

5. **Information control and communication.** This has three components, i.e. standardization and identification of information carriers, distribution to information users, including
decision-makers, and change control. Standardization (document identification) enhances communication between the parties in the project. It forces people to communicate within an agreed framework, thus contributing to efficiency and effectiveness. Standards should be adopted and observed for the layout of assignments, changes and progress control information. When distributing information, it is useful to consider “who needs what and when”. This means maintaining a selective distribution list of information users. Change control means making agreements on the change management process at the start. It has three levels:

- changes on the performance of the final product/service and interfaces between sub-projects. These are the most problematic and should be dealt with at the top project level;
- changes within sub-projects. These should be dealt with at their own level, provided that they do not interfere with total performance, overall schedules and cost targets; and
- lower-level changes. These should always be recorded but not brought in at the project level. They may, however, influence maintenance and user manuals.

3.3 Areas for application

There are several areas for application in connection with technology management. These are R & D for new technology; the implementation of existing technology; and the strategic development and implementation of technology.

R & D for new technology. In many parts of the world there is great pressure to shorten lead-times for innovation projects and to make them more reliable. The best way to do this is to adopt the professional method for product-market development and management, consisting of simultaneously providing the following:

- business-level professional project start-up processes;
- co-development (= co-makership), i.e. involving suppliers directly at the start of the project;
- project management by experienced and trained personnel; and
- adequate project authority.

Implementation of existing technology. Most organizations underestimate their ability and willingness to accept change. The effort and cost needed to bring about the required changes are often higher than the cost of the technology itself. Moreover, project implementation requires special skills such as organization and management development, cultural change and training. Do not leave project implementation to the “technology-driven” employees.

Strategic development. At the strategic level, it is advisable to apply project management as well. As soon as long-term objectives are agreed upon, a phased process to achieve them is the logical step. Increasingly, organizations are recognizing that this is the right way to proceed.

3.4 Major areas for development

Major areas for the development of project management are a professional project start-up;
project process quality; and co-making/co-development.

**Professional project start-up.** Assistance in professional project start-up is available on the consulting market today, for example through the Europe-based International Project Management Association. The value of such help is shown by the fact that the professional approach to project start-up business-wide and involving all users has resulted in lead-times being shortened by between 30 and 60 per cent.

**Project process quality.** The ISO 9000 Quality Series (especially ISO 9002) represent a first attempt to systematize project quality assurance. By using this document it is possible to audit the (project) organization with regard to project management skills and mandatory improvements. Respect for the users, both external and internal, remains an important aspect during audits.

**Co-making/co-development.** Another powerful development is co-makership, which is especially important in a technologically advanced environment. The idea is that, instead of contracting suppliers after the first project phases are finished, suppliers (of products or knowledge) are brought in during the very first stages of the project definition and/or design planning phases. Their knowledge helps to speed up project development. Sometimes strategic alliances are made for longer-lasting cooperation.

**Questions for discussion**

1. What are the most important project phases and why is phasing needed? Describe the objectives and general contents of the different project phases.
2. Name the most important management tools used in project management. Describe their objectives and general contents.
3. What type of implementation models are used to implement project management in organizations?
4. What user categories should be involved during project start-up?
5. Discuss some major application areas of project management.
UNIT 4: LEADERSHIP IN TECHNOLOGICAL INNOVATION

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and appreciate the nature of leadership in technological innovation and differentiate it from the management of production processes.

2. Outline the principles and specifics of human resource management in innovative organizations.

3. Understand the differences between management and technological specialists’ functions and skill profiles, and appreciate their complementarity.

4. Explain how to design and run an innovative organization.

5. Appreciate the need for innovative leadership development and advise on ways of achieving this.

UNIT 4: CONTENTS

4.1 The nature of leadership

4.2 Leading in a technological environment

4.3 The development of leadership

4.4 Towards an innovative organization
UNIT 4: LEADERSHIP IN TECHNOLOGICAL INNOVATION

4.1 The nature of leadership

From analyses of innovative organizations it appears that, on the whole, their managers display an open and inspiring leadership style. In addition to controlling and commanding (management in the narrow sense), the innovative manager is required to pay especial attention to motivating and stimulating his employees. Put differently, there is a great demand for leadership (Zaleznik, 1989). Within this process the direct contacts between manager and staff are of great importance. But the structure of the organization matters too, especially the structuring of tasks and responsibilities, rewards and career perspectives, as well as the culture of the organization. Thus, human resources have acquired a central place in the consciousness of the manager.

In innovative organizations, human resource management has become an integral part of management, including top-level management. The same may be said of the management of technology. Particularly in innovative companies, both human resources and technology are increasingly becoming part of the manager’s job and of the culture of the company. Therefore, many innovative companies pay particular attention to the integration of management functions in the fields of human resources and technology. Figure 16.9 illustrates this development. Among other things, the integration of human resource and technology is apparent in the way in which problems of staffing are handled. This concerns career planning, job rotation, the structuring of individual tasks, cooperative networks, and so on. Now discuss the following case:

Figure 16.9: Management functions in relation to innovation

<table>
<thead>
<tr>
<th>Leadership</th>
<th>Human resources</th>
<th>Technology</th>
</tr>
</thead>
</table>

Organization structure - culture

Case: Technology and human resources at Porsche

A few years ago, the then general manager of Porsche described how he, a newcomer in the car factory, asked his people what the most important race was in which they took part, and whether they stood a chance of winning it. The answers were “The 24-hour race of Le Mans” and “No”. They participated only to test the reliability of their cars. The manager’s reaction was that as long as he was general manager, Porsche would participate for one reason only and that was to win. He told his team to come back the next day with a victory formula. The result was a first place for Porsche!

The story has a sequel. The specifications for the cars for the following year’s race were changed in such a way that Porsche in particular was forced partly to redesign its cars. This could not prevent Porsche from winning again. The manager’s explanation for this was succinct: “We were forced to change the cars, but the team stayed the same.”
Point out the links between the new objective, new technology and human resource management.

### 4.1.1 Forms of control

There are several ways in which the work can be organized and controlled in innovative organizations. The following types of control are often mentioned (see Storm, 1981):

- individual self-control on the basis of abilities and commitment;
- impersonal control in the form of rules, agreements, guidelines, etc.;
- collective (self-)control by the team (cooperation, team spirit, etc.); and
- leadership.

The control mechanism that is emphasized and implemented depends upon the type of organization. A bureaucracy, for example, will be characterized by a high degree of impersonal control. In a professional organization (e.g. a research laboratory) individual self-control will be highly developed. It is also important for the control mechanisms to be in harmony and appropriate to the situation. Composing the right mix of control mechanisms is a part of leadership. But what is the distinction between “management” and “leadership”?

### 4.1.2 Management and leadership

With the aid of structures and procedures, management systems and instruments, managers are expected fully to control any situation. Leadership is distinguished from management by its emphasis on the sociodynamic processes of cooperation. Leaders focus more on the culture of the organization, on stimulating commitment through consultation and participation. Leaders are also characterized by a distinct strategic orientation: they concentrate on achieving the principal management objectives and creating the settings and conditions that make employees aware that their contribution to the company is valuable and meaningful. Figure 16.10 illustrates these relationships.

**Figure 16.10: The management/leadership matrix**

<table>
<thead>
<tr>
<th>Type of leadership</th>
<th>Structure- and instrument-oriented</th>
<th>Process-oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation-oriented</td>
<td>Management techniques and systems</td>
<td>Consultation</td>
</tr>
<tr>
<td></td>
<td>THE MANAGER</td>
<td>Participation</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Motivation</td>
</tr>
<tr>
<td>Strategy-oriented</td>
<td>Planning</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Budgeting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Policy formulation</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>THE LEADER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organization culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Policy development</td>
</tr>
</tbody>
</table>
Even though leadership is focused on process-oriented control with a strong emphasis on the strategic angle, managing innovative organizations requires paying sufficient attention to each of the four quadrants. In practice, this means the following:

- The documentation, reporting and accounting required within the framework of an innovative project will have to fit in with the strategic terms of reference provided by policy-making, budgeting and planning (an example of harmonizing quadrants 1 and 3).

- Policy development at top-management level cannot and should not be isolated from the contribution made by the lower-level staff of the organization, in order to develop better participation (an example of harmonizing quadrants 2 and 4).

- Specific policies should be the expression of a continuous, “living” process of policy development (an example of harmonizing quadrants 3 and 4).

Structuring and guarding this consistency is the important leadership function essential to innovative organizations. Now discuss this case.

### Case: Reorganization at Thomassen & Drijver-Verblifa

A good example of reorganization and complete reorientation to improve employee motivation at all company levels is Thomassen & Drijver-Verblifa in Leeuwarden (Netherlands).

The Leeuwarden branch of the TDV company has been given a relatively independent position: it is a Business Unit. A drastic reorganization has taken place within this branch. A production-oriented organization structure has been set up, which closely involves employees in the drafting of their own, new, job specifications. To a considerable degree, this seems to have solved many of the frequently occurring problems in the production departments, such as poor motivation, poor quality of the work done, and a high percentage of absence through illness. At the task-structuring level, all the dimensions discussed (variety, identity, significance, autonomy, feedback) showed improvement.

The change at TDV-Leeuwarden, however, is not only a matter of designing a different organizational and task structure. Even more crucial may be the implementation and the change process itself. One of the important factors proved to be the attitude of the management. On the one hand, the management clearly indicated what they wanted to achieve (a profitable company), and how this was to be achieved (among other things, through a production-oriented organization, no forced redundancies, improvement of working conditions). On the other hand, the management closely involved the employees in the entire change process, with the concomitant risk of delays and other drawbacks. The result of the whole reorganization is not just a different structure, but a thorough change in the organization culture. Not only has the dedication of the employees increased, but their commitment and loyalty as well.

In discussing the case, pay attention to the following questions:

- Which innovation roles do you recognize in the case?
- Were all roles fulfilled at the start of the project?
- Is it possible for one person to combine different roles?
- If roles could be combined, which are in your view compatible and which are not?
- How would you establish the innovative character of an investment project?

4.2 Leading in a technological environment

4.2.1 Professionalization of management

In the past, the top position in a technology management function was usually assigned to a technologist. This state of affairs has changed a great deal. In recent years we have witnessed the rise of people who do not have much technological training, but who do possess management skills and experience. As a result, technology is often being neglected and left to the lower-level staff in the hierarchy. The professionalization of management resulted in management being "pulled out" of the shop-floor and from technological issues.

Often, professional managers have no feeling for technology, and are too reluctant to occupy themselves with the primary process of production and product development. They lack specialist knowledge, but above all the affinity with the shop-floor, and it is only natural that they have communication problems with specialists.

However, it is a fact that the technological function has become so complex that it needs its own management. For example, not only will new manufacturing equipment (robots, for instance) have to be installed, but the organization will have to be adjusted to it at the same time (e.g. a different allocation of tasks). At the strategic level, technology increasingly becomes also the subject of management decision-making. The complexity of technology makes strategic control indispensable. At this level, management makes overall assessments and fundamentally considers the pros and cons. Is it technologically feasible? Is the market ready for it? Do we have the necessary funds? Do we have the right experts?

Such complexity calls for specific organization and management techniques in more specific areas also. In this way, project management, quality management and service management have been developed, and are still being developed further. If the professionalization of technology management requires greater differentiation at the top levels of control and the various component areas, this differentiation should be accompanied at the same time by integration.

4.2.2 Technology in the context of the enterprise

Technology in its various forms (products, production facilities, knowledge and experience) is one of the most important resources of companies and they should be able to determine their own position in relation to their competitors in terms of their technological strengths and weaknesses: in which areas of technology the company is leading rather than lagging behind, and the
(possible) consequences of this state of affairs.

In this regard, management is continuously faced with the following questions:

- Which technologies do we apply in our products and manufacturing?
- Which technologies do we stimulate; which do we invest in?
- What is the extent and direction of our R & D efforts?
- What are the consequences if we invest in a particular technology, or refrain from doing so? What knowledge do we purchase; what do we develop ourselves; which fields of collaboration should we enter?
- How do we realize our training policy, career policy, etc.?
- What timetable do we envisage for the decision-making process and the implementation of all this?

The information provided by technological specialists is relevant to all these questions, and is as decisive as is information about the market, the competitors and the financial, personnel and organizational resources. It is also important that managements assess the risks, and show the ability and willingness to face and justify these risks, as do any entrepreneurial managers.

4.2.3 Complementarity of management and technological specialists

Specialists claim an autonomy of their own; they constitute a subculture with its own language, customs, manners and, where possible, their own privileges, skills and norms. To some extent, their subculture can be characterized as follows:

- The “toy” culture. Technical specialists often indulge in developing products which testify to their creativity: if the work and the results are intrinsically amusing and challenging, this is perfectly in order. Functional arguments presented by outsiders (management, clients) are often considered just a nuisance.

- The “perfection” culture. Specialists are often extremely sensitive to imperfections, a trait which can be very expensive. Clients do not always ask for a “perfect” product; they often prefer a lower price and a shorter delivery time.

- The “demonstration” culture. Specialists gladly demonstrate their products to anyone who is interested. It is not always a coincidence that company secrets leak out in this way.

- The “my-baby” culture. Technical specialists consider their field and the results they obtain as their own property. They like to set their seal on it by keeping trade secrets, just as cooks do. In this way, and often unnecessarily, companies become dependent on the inventor or developer. Such a “my-baby” culture becomes especially apparent when the results of their work are to be transferred to another department or a client. This transfer then meets with much resistance, and quite often problems occur.

In the case of complex technological matters, the attitude of many managers is complementary to that of many specialists. In this case, the managers accept the relatively high degree of autonomy of the specialists and perform the important role of facilitator. It is also an important
task to ensure smooth communication and the sharing of objectives between managers and technological specialists. This requires much interface between them.

4.2.4 Organization and management of the technological function

Managers, both at top and at middle levels, are faced with the task of organizing the technological function. Production and service processes must be designed, maintained and renewed. Organization implies that a structure should be found in which the functions of a company are assigned their proper place, and in which tasks, responsibilities and authorities are delegated to the proper units, groups or individuals, and so on. The management is faced with the task of structuring technology in such a way that it fits into the organization, and serves as one of its pillars.

There is no obvious, clearly mapped path for the management that guarantees success in this area. Managers are constantly confronted with tensions and dilemmas, particularly in the field of technology. Some of them are:

- a general organization culture versus specialists’ subcultures;
- short-term versus long-term orientation;
- being in the forefront of developments as against following them;
- purchasing knowledge, machinery and products as against developing them;
- giving technical specialists autonomy as against letting them function within strict limits;
- involving specialists in strategic decision-making as against letting line management decide;
- stability versus flexibility;
- inward-looking (doing your work according to plan) versus outward-looking (adjusting plans to the changing markets) attitudes; and
- openness to the technological-scientific environment versus organizational closure.

There is no recipe stating how to deal with technology dilemmas. It is not always possible to learn this from manuals, or training programmes. Dealing with technological and innovative dilemmas requires some specific attitudes on the part of managers, such as:

- Managers should accept that the origin and interplay of phenomena (for example, technical and social implications) are more complex than technologists are usually willing to believe.
- Managers should have a better feeling for the ambiguity of reality than the average technologist.
- Managers should be able to recognize recurrent problems, while technologists are used to solving problems once and for all.
- Managers should know how to deal with people, how to inspire them and achieve results, etc.

4.3 The development of leadership

The management of innovation requires a constant focus on the innovation of leadership. Where new technologies, new product applications or new product/market combinations are
being developed, the organization will usually have to be adapted as well. An important component of this adaptation should be the adaptation and development of the leadership function. It is the company line management that is responsible for the development of both innovation and its leadership.

To develop innovation leadership it is necessary to examine the most important functions or tasks used in innovation management. Some of them are:

- formulating a clear, well understood and easily communicable strategy, a company perspective which the members of the organization can share. Everyone should perceive their job as a contribution towards realizing this perspective and be able to identify with it;
- monitoring and controlling the production/service processes, as well as the overall company management;
- stimulating and motivating employees. On the basis of employee commitment, the management has to create the favourable material and social conditions for the employees to contribute to the company’s objectives;
- management should have a clear picture of the present and future situation and the organizational changes needed to adapt the business process and innovation to future demands;
- in innovative organizations it is the job of management to keep in touch with external developments in technology, markets, government regulations, etc., to disseminate this information and to use it for further development;
- the management is the prime representative of the company and should be able to give the company a proper “external image” and identity;
- setting a good example. A manager’s behaviour also should make clear what he or she means and how seriously the instructions issued are followed and controlled; and
- making decisions. In most cases this aspect of leadership involves facilitating the collective and individual decision-making processes and confirming their outcomes.

These functions and tasks constitute what we should like to call the contents of leadership.

As to the organizational aspects of leadership, i.e. assigning the various tasks to the different positions within the organization, this involves at least the following aspects:

- differentiation according to hierarchical levels. Incidentally, an innovative organization should keep the number of levels low. Tasks, competences and responsibilities should be coordinated, so that there are no grey areas or overlaps, or a lack of authority. In an innovative organization it is not important who fulfils a particular function, but whether it is fulfilled at all; and
- differentiation according to functional areas. In addition to general management, such functional areas as marketing, production, R & D, human resources, etc., also need to be coordinated and managed. These areas require more technical, specialized skills from the leaders.

In addition to this functional, professional development, the personality of the leaders is also a very important part of “leadership development”.

Leadership development involves a good deal of learning from practical experience, not just attending training courses. The situation which confronts managers is often so unique that the available conceptual knowledge cannot be used directly without proper adaptation.
Managers should have practical experience, and should know how to reflect on that experience. To help them learn to reflect on their experiences, it is very important that they have a discussion partner, a mentor, a “scratch-post” to rub against.

In this way, knowledge and experience must become two sides of the same coin in the leader’s personality. The leadership learning process is presented graphically in figure 16.11.

**Figure 16.11: The leadership learning cycle**

4.4 Towards an innovative organization

An important feature of an innovative organization is consistency and robustness.

4.4.1 Consistency in design and organization

Developers of new products are increasingly making explicit efforts to tailor these products to clients’ demands about specifications, cost, life span, etc. It is a matter of quality. We can also use the term “external integrity” (see Clark and Figge, 1990) or “external consistency”, when the parts of the product itself form a consistent whole. It is useless, for example, to put a car engine with a very long life in a body that will soon deteriorate. Many examples can be given of products whose parts do not match up or whose exterior does not fit their function. In such cases, the requirement of internal integrity or consistency has not been satisfied.

In the same way as the requirement of internal and external consistency applies to product design, it applies to the organization as well. All parts of the organization should be adjusted to the environment. The organization should also conform to the nature of its product. In an R & D department this product is new technologies. To the extent that these technologies require research of a more fundamental nature — the course and results of which cannot be easily predicted — a less rigid organization is needed, where conformity with standard methods is not the priority. Consistency of design and consistency of organization cannot be viewed in isolation. An internally and externally consistent design requires adequate coordination and input from representatives of various functional departments, each with its own competencies and demands. Coordination with suppliers is also necessary. If they are involved in the earlier
specification phase, a consensus can be reached more easily in the realization phase.

Organizational consistency in a company means that there should be frequent coordination and adjustment. The most important prerequisite here is that the strategic orientation should be clear. The common goals and shared interests should be clear and everybody must understand and be committed to his or her task. Consistency does not mean that the company structure and culture should be uniform. On the contrary, production departments call for forms of management and social relationships, organizational arrangements and incentives patterns that are different from those of an R & D department.

4.4.2 Robustness in design and organization

It appears that there are major differences in the extent to which a basic design lends itself to adjustment, variations and redesign for products such as cars, aeroplanes, electronic devices, and so on. Sometimes a product has to be completely redesigned as a result of changes in market demands over the years, sometimes the basic design need not be changed for a long time. If the latter is the case we call the design "robust". "A robust design is one that has sufficient inherent design flexibility or 'technological slack' to enable it to evolve into a significant 'design family' of 'variants'" (Rothwell and Gardiner, 1988, p. 9). Examples of such robust designs are the Volkswagen "Beetle" and the Boeing 747. These designs had so much "slack", so much "elasticity", that a whole family of varieties could evolve from the basic design, which thus turned out to be useful for many years. The first hovercrafts may be mentioned as an example of a product with hardly any or no design flexibility at all, thus a less robust design. In terms of technology, robustness may entail the introduction of technological innovations at the level of subsystems or components without a complete redesign being necessary. It may also give scope for adapting the product to other markets by means of relatively few adjustments: the process of design and redesign.

By analogy with robustness in product design, we can also speak of the robustness of an organization. This indicates the flexibility that is built into an organization, a flexibility which leaves room for differences in the structure and culture of departments and for changes and adjustments. Often, temporary project organizations or ad hoc discussion groups should be set up, employees will have to function in more than one team, relationships are formed which cut across existing lines of command, etc., etc. A company that is able to generate such forms of organizations geared to specific situations ("consistency"), without creating a general vagueness or necessitating a total reorganization, may be called robust. Seen in this light, robustness is the opposite of rigidity. The main objectives and principles may be formulated, but the organization is capable of much adjustment and change within the boundaries set by them.

The question is now how robustness and consistency can be achieved in product design and in the product design organization. The next section provides some guidelines for doing so.
4.4.3 Guidelines for achieving robustness and consistency

Management displays commitment and leadership. Firstly, there is the need for commitment on the part of top-level management to implement strategically the processes of product and manufacturing development. The two processes should be implemented jointly to the extent possible. The classic pattern of the development of new products is that the process design always follows the product design, i.e. a sequential process. The necessary coherence, however, requires a parallel development of product and process. Such a parallel development may be realized in different ways: by consultation, by joint participation in project teams, by a systematic exchange of information, by shared premises which stimulate informal contacts, and — undoubtedly the most important aspect — by making someone responsible for the entire project. In their discussion of experiences in the Japanese and American motor car industries, Womack et al. (1990) emphasize that the individual responsible for the project should have the status not of coordinator but of leader. That way, a project manager has not only the responsibility that comes with the job, but the authority as well. What comes to mind here is the manager’s authority to bring personal views to bear, budgetary leeway, the authority to recruit people from the organization and to commit them to his or her project team for a longer period of time, etc. If necessary, suppliers should be involved in this process immediately (“co-makership” and “co-design”).

Broad market orientation. The design need not be tailored to one particular application. From the start, several product/market combinations should be pursued. This implies that the company should not communicate with a single market (one particular type of customer or a single buyer) to have a clear idea of the programme of demands and specifications. Various applications and contexts for use should be incorporated in the development process from the start. This too may be defined as parallel development, but now in the sense of the synchronous development of applications for different market sectors. A prime example is the motor car industry (particularly in Japan), where a vehicle’s basic design allows easy further development into family car, sports car, van, and so on.

Adequate structuring of projects. Innovative projects should be adequately divided into sub-projects. An important principle of this structuring is that the constituent projects should deal with relatively autonomous subsystems of the product as a whole. Specifications drawn up for these subsystems to ensure that they fit in with the whole product demarcate the boundaries for this part of the overall design. Naturally, constant adjustments are necessary, but still the result is an overall design consisting of relatively autonomous modules. What applies to the entire project also applies to the constituent projects, i.e. there should be a project leader who has relatively wide powers and responsibilities.

Autonomy and clear demarcation of tasks. An innovative project, in particular in basic R & D, requires a certain degree of autonomy, in accordance with the nature of the project and the people in it. This is also true of other professional organizations, e.g. in the health service. R & D departments and researchers are not unique in this respect. Nevertheless, autonomy is often confused with absolute freedom, unstructured approaches and isolation. It appears that a large degree of autonomy and a clear demarcation of tasks can go together within the scope of a large project. Jelinek and Schoonhoven (1990) show that the organic structure, with the associated autonomy, is characterized by vague hierarchical relationships, responsibilities and report

---

1 Source: Adapted from Rothwell and Gardiner, 1988; Jelinek and Schoonhoven, 1990; Womack et al., 1990.
structures, which could be an effective framework for innovations.

Case: Stability and change in the high-tech electronics industry

The investigation conducted by Jelinek and Schoonhoven (1990) in five high-tech electronics companies shows that in actual practice there are very explicit and clear relationships within companies. People clearly know who their superiors are, who their subordinates are, and what they should report to whom. Formal structures do exist, and they are very important, but they are not frozen. Constant adaptation and reorganization takes place. Periods of stability alternate with periods of change.

If both the stable situation and the changes are formally and clearly defined, a dynamic tension (as Jelinek and Schoonhoven have labelled it) is created within the organization. A clear organization is necessary to provide the necessary grip on reality and predictability, so that employees can cope with the changes within and outside the company.

Questions for discussion

1. What are leadership and management? What are their main common and different features? Relate them to managing an innovative organization.
2. How does the quality of human resource management influence the effectiveness of innovative organizations? What should be different or distinctive in an innovative company?
3. Why do we need professionalization in management and specialization in technological functions? What are the differences between professional managers and technical (functional) specialists? Is there any complementarity?
4. What does leadership development mean? What are the main and best ways to develop a leader of an innovative organization?
5. What are robustness and consistency? Relate these meanings to innovative organizations.
BIBLIOGRAPHY


During, W.E.: Innovatieprobleme in kleine industriële bedrijven, doctoral thesis (Twente, Netherlands, University of Twente, 1984).


MODULE 17

WORK ORGANIZATION AND DESIGN
MODULE 17: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand the main principles and approaches to work organization and design.
2. Identify different work situations and find areas where work organization methods could improve productivity.
3. Set up guidelines for individual work design.
4. Analyse different production models and suggest ways to improve the objectiveness of work structures.
5. Recognize the criteria for an effective business system.
6. Develop effective working time models.

MODULE 17: CONTENTS

UNIT 1: Introduction to work organization
UNIT 2: Design of individual work roles
UNIT 3: Design of the work group
UNIT 4: Organization design
UNIT 5: Working time models for high productivity
UNIT 6: Criteria for an effective work organization

Bibliography
UNIT 1: INTRODUCTION TO WORK ORGANIZATION

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the essence and the role of work organization.
2. See linkages and complementarity between business ideas, business systems and work organization, and understand integrated business systems.
3. Apply the work study approach to job analysis and design.

UNIT 1: CONTENTS

1.1 Business idea - business system - work organization
1.2 Systematic design work and everyday development
1.3 From work task to business system
UNIT 1:  INTRODUCTION TO WORK ORGANIZATION

The conditions under which organizations carry out their activities today are entirely different from those of ten years ago. Greater demands for flexibility and competitiveness make it necessary for a dynamic organization to find constructive ways to improve productivity and thereby raise profitability.

Philip Kotler expresses this idea as follows: "There are three kinds of companies: those that make things happen, those that watch things happen and those that wonder what happened." In this unit we will look at different ideas about how an organization can increase awareness of where to start change, and about how it can structure its activities to create a more efficient work environment.

We will start by discussing the concepts of business idea, business system and work organization, considering how these must be coordinated so that changes can be made in a meaningful way. Work methods are developed for each specific task as well as for the overall business system. The structure of the organization is based on the interaction between subsystems. Before describing work organization and the conditions that affect it, we need to clarify its relationship to the central business concepts of organization.

1.1 Business idea - business system - work organization

The point of departure for a commercial activity is an expressed and coherent business idea of what the organization wishes to achieve through its activities. In far too many cases the definition of the business idea is so hazy that both customers and employees see the company as just one producer among many others.

An operative business idea is thoroughly implemented and is known throughout the organization. It describes the strategic advantages in relation to competitors on the market. This will help the organization to progress towards the goals that have been defined for its activities, since there will be no doubts about what the aim is.

The business system includes all the activities which are needed to fulfill the business idea in the best possible way. In other words, the production units, the sales department and the supplier sections should not be considered as separate entities, but as interacting parts of a larger entity. The stronger the links between these parts, the better the cooperation and the effect on productivity. If there is a symbiosis between customers, suppliers and employees, it will be easier to define what means are needed to achieve the stated goals.

Work organization refers to the way in which employees are assigned throughout the business system, the resources that are available to them and the way in which the work should be performed. As will become apparent, it is mainly work organization that is responsible for job design.
1.2 Systematic design work and everyday development

Work study has become an effective tool in improving enterprise performance since modern work study techniques were introduced at the beginning of the century. The underlying principles of these methods will, for the foreseeable future, continue to be of immense importance in the great majority of enterprises, regardless of their size or area of economic activity.

Let us briefly summarize the basic significance of systematic work study for the development of better methods of work.

Figure 17.1: Work study procedure
Methods: systematic versus haphazard

The first rule of work study is that each task must be systematically analysed in advance and the ways of carrying it out must be thought through. If the task in question is to be carried out only once, perhaps this preliminary analysis is of no great importance - indeed, there might be no point in paying too much attention to it. But if the task is to be carried out repeatedly, then clearly there is much to be gained by carefully scrutinizing the manner in which the task is executed. Every movement that can be eliminated or improved, every time span that can be shortened will produce economies - and if each task is repeated many times, as happens with mass production or long runs, the saving of even tiny movements or of a few seconds here and there can be of crucial economic significance. If systematic analyses of this kind are not carried out, preferably before production begins, inefficiency will in effect be built into the job.

Systematic analyses of work organization which are carried out before an activity starts may thus mean considerable cost savings through the development of methods and working practices. However, it is important that such developments should be brought about in day-to-day activities by the people who actually perform the work, using their knowledge and experience to improve working methods continuously. To encourage this situation, it is important to stimulate interest in productivity improvements among all employees, and to promote such improvements by a variety of means.

Work analysis: step-by-step examination

An important feature of work study is therefore the systematic analysis of the job, that is, the division of a task into its various constituent parts followed by a careful examination and discussion of each part. By thus breaking down a complex problem into its underlying elements, a clearer and more readily understandable picture of the task can be obtained, and a good method of carrying it out can be deduced.

Pre-set times for various movements

One of the most important features of modern work study is that it is possible to determine in advance, with moderate margins of error, the amount of time necessary to carry out particular movements. There are many different methods of doing this, ranging from summary estimates to highly refined predetermined time systems (PTS). One point that these methods have in common, however, is that they all contain a more or less established method of determining, on the basis of the characteristics of the work in question, the “normal” time that a task should require.

This process of pre-setting times for various tasks is of overwhelming importance in production management because it makes it possible to test alternative methods and combinations of methods of performing a certain job and to determine which alternative is the most time-saving. Furthermore, with the help of these systematic time guidelines, it becomes feasible to distribute work assignments among different individuals and groups in order to plan production more efficiently; it also provides a foundation for discussing production-linked wages and similar incentives. This is an element of modern work study that is virtually indispensable in normal industrial activities. Without the help of work-study methods and systematic time formulae, the determination of guidelines would be pure guesswork.
The latest role of work study: from analysis to synthesis

So far we have discussed the basic role of work study in the design of individual jobs and of work organization. Before we go into more detail, it should be emphasized that the development of method study and work measurement has been continuous, so that it is now possible to apply work study to any kind of activity. Furthermore, the understanding and active involvement of workers in work study has increased rapidly. Over the past few years we have seen many examples of companies providing extensive training in work analysis, job simplification and work study methods, so that all employees will be able to employ systematic methods to improve productivity.

This experience and information make it possible to use the results of work study, not only for breaking the job down into small operations and components, but also to build up (synthesize) a new job.

1.3 From work task to business system

As already stated, work study activities consist of a series of steps which must be followed if an acceptable standard is to be achieved. The whole is broken down into its components, which are measured, analysed and reassembled in a more functional form. You see the whole and study the parts. (You can see the wood and study the trees.)

In a conventional work study the central issue is to ensure that each task is performed as efficiently as possible. The consequence of this approach could, of course, be counter-productive if the parts are not considered in their proper context. Therefore, successful companies have developed the ability to think at different levels, as a means of achieving a work design that reflects the total business idea.

The basic level is the study of individual tasks which are combined into a job. A number of jobs and their activities can be combined in a work group. Group work can be used for a sequence of operations in a flow, for jobs that are performed in physical proximity to each other, or for jobs that require special skills.

A number of work groups are combined to form a product shop, where the entire product or a complex product component is produced from beginning to end. The production system is incorporated with other elements such as product design and marketing, into a business system where all the parts interact with each other.
Questions for discussion

1. What is work organization, its roles and main elements?
2. What is your company's business idea? How would you relate it to your production structure and work organization?
3. What is work study? Discuss its two dimensions - identifying new actions to cut costs and creating interest and commitment among the personnel.
4. What are the analysing and synthetizing functions of work study?
UNIT 2: DESIGN OF INDIVIDUAL WORK ROLES

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Apply general guidelines for task and job design and take all the relevant factors into consideration.

2. Appreciate those factors in job design which could increase job satisfaction at the same time as improving performance.

3. Recognize the major methods of decoupling operators from machines.

UNIT 2: CONTENTS

2.1 Task and job design: Some guidelines

2.2 Variety at work

2.3 Decoupling man/machine systems

2.4 Integrating production and auxiliary tasks
UNIT 2: DESIGN OF INDIVIDUAL WORK ROLES

In order to create an efficient work organization, each work activity must be carefully analysed and evaluated so that it may be seen in the larger context of fulfilling the quantitative and qualitative requirements for the finished product. It should also be technically and financially justifiable.

2.1 Task and job design: Some guidelines

With the aid of work studies and work evaluation it is possible to quantify each individual work phase and determine how the work method or resource utilization might be adjusted. Situations might be found where it is questionable whether the task should be performed with existing technology. Of course, the longer the production series, the greater the value of task design.

Work phases should be simplified and automated to the greatest possible extent, since this increases capacity and reduces the vulnerability of the system. The process involves looking at the design of the product itself to see if it can be modified without reducing its value added: simplification of the manufacturing process usually has a favourable effect on quality.

One important part of task design, however, is performed by the operator who continually improves the task and tries to anticipate possible disturbances in the production process. Results from Japanese car factories have shown continuous improvement at several levels thanks to the implementation of this method (Kaizen). Ideas for improving production methods which are generated by individual workers are based upon the specific work situation to achieve the overall goal.

This requires a high degree of commitment among operators (the work group) and management. No suggestions for improvement will be generated unless the operators know that their suggestions will be tried and evaluated and that they will be informed about the results. Another central issue is who is to be responsible for implementation.

There are a number of criteria which serve as guidelines for satisfactory job design. Most important are the economic aspects. With the help of systematic work study the constituent parts of a task are put together in such a way that the minimum time is required to carry it out. However, the design of individual work roles is too complex to be effected with the aid of a single criterion - that is, what appears on paper to be the shortest time needed to carry out a task. In practice, numerous different factors must be considered.

Some of these are purely practical considerations, such as the need for different types of machinery, the nature of the different components of each job, and so on. For example, if it takes ten minutes to carry out a particular part of the task and if this operation is repeated 1,000 times within a 50-strong work group, it is easy to see that the results of this study must be combined with other information about the work situation in order to arrive at a reasonable division of the task among the various members of the group. This example is given merely to indicate the problem, which we shall not examine here. There is, however, one special group of factors that we must look at more closely: namely, the employees' needs and preferences, their
Module 17  
Unit 2

experience of the work and their reaction to different kinds of work organization. This is a new and important dimension, since it implies the need to adapt work design to the individual’s wishes and capacities, to create jobs in industry that offer a reasonable challenge, and to provide employees with the chance of working in a climate that offers some degree of job satisfaction. Here we can identify three important factors that can lead to improved job performance and increased job satisfaction:

- a moderate amount of variety in the work done;
- decoupling of man/machine processes, that is, not being tied to a machine during the entire working day;
- the opportunity to integrate various services and auxiliary tasks into a production job.

These three topics will be treated separately in the sections below.

2.2. Variety at work

If work is to be done well, there must be a reasonable match between the job and the person doing that job. A job that consists of only a few simple movements and takes only a few seconds to do is certainly easy to learn. At first sight, it may seem that this is an efficient way of organizing the work. But this type of job is hardly efficient from a more practical viewpoint. It will rapidly become monotonous and tiring, and such extreme specialization requires long runs, plus a degree of structural stability and production volume that is not often found in reality. It is much better to create work roles that display a reasonable amount of variety, that require something from the employee in terms of learning and that are adapted to reality in terms of the true length of runs, a stable product mix and production disturbances.

There is no comprehensive, clear answer to the problem of designing a task cycle that gives just the right amount of variety. However, a study of the following factors will offer some guidance on improvements:

- the basic structure of the technical system;
- the pattern of the physical load;
- the information content of the task;
- the balance between physical and intellectual task components;
- the demand for learning and the need for individual development opportunities.

In many production technologies the basic structure of the technical system is an important determining factor. By way of example, we can consider final assembly in a car factory. In such systems, the content of an individual operative’s work cycle is often determined by the technical system. If 500 cars are to be assembled in 500 minutes, the work cycle at each individual workstation must be one minute long. The most usual arrangement in European and American car factories has been to allocate a work volume of approximately one minute to each workstation, and to have one assembly worker at each station. With such an arrangement, all employees at their allotted workstation will perform assembly work equivalent to approximately one minute, and this will be repeated over and over again hundreds of times a day. To ensure that everyone will have time for a complete work cycle each time, it is impossible to allot a volume of work to each station equivalent to a full minute, and a safety margin of 10-15 per cent is often allowed.
Since the assembly line runs at a fixed speed, any operation which is not completed at a particular workstation will result in the finished car suffering from quality defects.

In Japanese car factories (not only in Japan but also in transplants in Europe and the USA) a rather different work organization has been put into practice at the machine-controlled assembly lines. In these plants, a group of assembly workers is jointly responsible for one part of the assembly work, and within such a group one particular worker accompanies the car through a sequence of workstations. This lengthens the job cycle even though the technical system keeps the material moving at a certain rate. In these Japanese assembly plants, it is also normal for each worker to be able to stop the whole of the assembly system by pressing a “red button” if something goes wrong.

Assembly lines in car factories and similar systems for assembly in long series are an area where the choice of work organization has often been discussed, and where several different solutions have been tested. However, the best solution in each case will depend on the specific circumstances at that plant.

The fixed-speed assembly line is not the only technological system that affects the time cycle. Short-cycle man/machine operations, such as those carried out with eccentric shaft presses, offer another example of the need to reshape the entire technical system in order to apply time cycles that are of a comfortable length for the operative.

It should be emphasized that variety in the time cycle is primarily subjective and therefore cannot be precisely defined, either technically or mathematically. However, it is more or less closely related to such factors as:

- length of the time cycle;
- size of the run;
- frequency of recurrence of a product (that is, the time that passes before the same product is worked on again);
- amount and distribution, in respective jobs, of non-repetitive tasks;
- differences in work structure and job content between different series.

An example In an enterprise manufacturing electrical circuit breakers, two alternatives were identified for organizing the work. The first would require assembly to be done in four separate jobs, each carried out at a specially built and equipped workstation. Assembly is completed and the product is inspected at the last workstation. In this type of arrangement the cycles are about ten seconds in length. Variations within cycles are virtually non-existent. The second alternative would require the entire circuit breaker assembly to be done at each workstation (one job at each workstation), which would mean a complete reorganization of the material supply system. By planning the work in this way the cycle would be lengthened to 40 seconds and opportunities for varying the cycles would increase markedly.

After analysis of the practical consequences of the two choices, the second alternative was chosen. The decision is significant, since it exemplifies the efforts that have been made in recent years to make jobs less monotonous and to achieve a practical balance of working conditions.

One important point in an analysis of this kind is the fact that people are different. At any
one time the people at the same workplace will present quite different characteristics. And if we study the same people at different times during their working life, we will find significant differences in their performance. This is a fundamental element in the design of individual work roles. Jobs should be different, and should present different degrees of difficulty to those who execute them. Then different people can find a work role and a level of difficulty to match their own aptitudes and preferences. In addition, an individual can begin working in a job with a particular level of difficulty, and then move on to more challenging jobs.

2.3 Decoupling man/machine systems

The constraints on workers in a man/machine system may be due to several factors. People can be tied to the workplace in a geographical sense - it may be impossible to leave the workstation for even a short time. They can also be tied by the method - it may be impossible to vary the sequence in which operations are carried out. And they can be tied in terms of time - they may be required to carry out certain operations at fixed times.

The degree of rigidity with which workers are tied can be “planned” - that is, the man and the machine are consciously and deliberately integrated in a man/machine system - but in many cases the rigidity is “unplanned”. In some cases unplanned rigidity arises from a fault in the technical system; the operational stability of the machines may be so poor that they must be continuously tended, usually with only simple movements. Unplanned rigidity can, however, be reduced through the use of more reliable technology.

Three different types of solution may reduce the problem of rigid man/machine links:

- complete decoupling through increased mechanization;
- use of technical auxiliary equipment to free the operative from the machine;
- decoupling through contact and cooperation among operatives.

Let us examine each of these three choices more closely.

Complete decoupling through mechanization

Decoupling of this kind requires heavy capital investment. Therefore, production processes that are to be handled in this way must be characterized by mass production, extremely short operation cycles and severe rigidity and monotony. In such cases mechanization means the complete elimination of all human intervention. New technology has markedly increased the range of jobs which may be automated. In particular, the much improved resetting features of machines and handling equipment have made it possible to automate even short series production. It might be said that it has become possible to employ mass production methods on a small scale.

One example of this is the industrial robot. Automated handling of workpieces in production equipment at earlier stages of industrial development took the form of advanced mechanical systems designed specifically for the equipment and the products that were to be handled. These installations were unable to cope with variations in products, and the high cost of such installations made very long series necessary. The industrial robot, on the other hand, is a flexible piece
of equipment, and it can be reprogrammed relatively easily for new movements, new objects or new grips. Thus, production equipment served by an industrial robot can deal with considerable variations within a product range, and the series length for each variation within the range need not be especially great.

The industrial robot has therefore opened up promising new automation potential, both within production (such as grinding, polishing and spot welding) and for materials handling. In the same way, modern information technology has influenced the development of production and handling equipment in many areas, and the potential for automation in mixed production has greatly increased. In general, this development has meant that the role of the worker is becoming more and more supervisory in character.

Even actual assembly work, which is perhaps the most difficult area, has been mechanized to some extent. To date, this is mostly a matter of certain simple tasks, such as positioning and tightening of screws. However, progress is relatively rapid, and new opportunities are constantly being opened up as a result of technological advances. “Seeing” robots, which are now being brought into industrial applications, are greatly expanding the potential areas of use since the objects which are to be handled no longer need to be positioned in exactly the same location each time; the robot can “see” where the object is.

**Technical auxiliary equipment for the operator**

This principle can be put into effect by establishing buffers and magazines in an integrated man/machine system in order to reduce dependence between men and machines. (A buffer is a waiting point located between two consecutive operations in the production flow; a magazine is a point of accumulation located within an operation and providing automatic feeding of material to the machine.) The key is to create processes that can accept variations in the speed at which different sections of the line move.

Both buffers and magazines are characterized by an “accumulation of products for continued processing” which can be completely identical in their technical design. Since buffers and magazines are placed at different points in the man/machine system, their characteristics as accumulators of time are influenced by different types of time gaps in the process. The different types of buffer are illustrated in figure 17.3.
Figure 17.3: Some examples of buffer stocks in manufacturing operations

(a) Typical magazine

(b) Work station with a simple sliding rack or storage space

(c) High-stacking machine used as a buffer

(d) Buffering rack
A buffer makes it possible to accumulate:

(a) the waiting times created when two operators on opposite sides of the buffer work at different speeds; and
(b) the waiting times created because the quantities of work done at two stations are not absolutely identical.

A magazine makes it possible to accumulate:

(a) waiting times created because an operator works at a different speed from the overall speed of the technical process; and
(b) waiting times created because an operator is forced to wait while a machine does its part of the work.

**Decoupling through job enlargement**

Finally, decoupling can be achieved if, in agreement with management, workers are able to interchange tasks and assignments. What we usually call job enlargement takes place through job rotation and mutual cooperation.

### 2.4 Integrating production and auxiliary tasks

In the design of individual work roles it can often be advantageous to include service and auxiliary tasks in production jobs. This leads to greater variety for the individual worker. Auxiliary tasks that are most often combined in this way are:

- maintenance of machines and tools;
- setting up of machines;
- handling of materials near the workstation;
- inventory work;
- quality control.

When we speak of maintenance in production positions, we are referring to measures that can be taken to reduce the number and extent of production errors. Maintenance can include regular inspection of the system in order to find errors and take remedial measures. It can also include repair of parts necessary to achieve the precision norms required in production. In addition, it can include a statistical follow up in order to improve the capacity utilization of equipment.

The possibility of including machine setup and similar preparatory functions in the ordinary operative’s role depends on a number of factors, among which are the following:

- degree of difficulty and time available for the setting-up operation;
- frequency of setting-up operations;
- degree of rigidity in other production tasks;
- need for special auxiliary equipment to undertake this work.
An example A metalworking enterprise conducts its operations with the help of advanced computer-controlled equipment. In one department the operative was trained to programme the computer equipment himself. He was thus able to handle the traditional job as well as programme the machine tool computer equipment. He therefore works both as a programmer and as a machine operator. This example shows that even moderately difficult and specialized tasks can sometimes be integrated into a normal production job.

Regarding the possible integration of materials handling near the workstation, the following factors have to be considered:

- nature of the product;
- volume of materials to be handled;
- design of the transport system;
- degree of rigidity in the production operation.

Quality activities can also be integrated to a greater or lesser extent into the production organization. This applies to both inspection and measurement tasks as well as to action to correct any faulty products that might be manufactured. Recently in industry we have seen a dramatic upswing in interest in developing quality-mindedness on the part of all employees in the production organization and in involving all employees in efforts to produce fault-free products. Known as zero-defect strategies, these are an important aspect of current management thinking in this field. This affects work organization in that the separate functions of quality inspection after production and correcting faults are now being reduced, and quality work is being integrated into production.

These are some examples showing how production jobs can be supplemented with a variety of auxiliary and service tasks. There are no simple, standard solutions in this area; each case must be examined in the light of its specific characteristics. However, the guiding principle in making these decisions is that a practical and smoothly functioning arrangement must be feasible, that jobs can be broadened sufficiently to include day-to-day variations and that they must not be unduly monotonous.

Questions for discussion

1. Why do we need to match job design with the individual characteristics of operators?
2. What are the differences between job design and task design?
3. What are the most important factors to be considered in job design?
4. What are the most common ways of making operators less dependent on equipment?
UNIT 3: DESIGN OF THE WORK GROUP

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the essence and the role of the work group in the production process.

2. Distinguish between the seven production system models, understand their advantages and disadvantages and advise on their proper selection.

UNIT 3: CONTENTS

3.1 Advantages of group work

3.2 Seven production system models

3.3 Flow groups in assembly work: some trends and examples
UNIT 3: DESIGN OF THE WORK GROUP

So far we have concentrated on different approaches and methods for developing individual jobs. In this unit we will deal with the ways in which jobs can be combined to form work groups in the production process.

3.1 Advantages of group work

Once individual jobs have been designed, the next logical step is to coordinate them. One method of coordination that has attracted increasing interest in recent years is the tying together of individual jobs into work groups. Organizational descriptions of a complete work group specify which roles are included in the group and the principles according to which these roles should be coordinated. Group work in production can have many advantages. Here we shall touch only on the more important ones.

The most important advantage is the way in which the objectives are established and the results measured. It is much easier to formulate appropriate objectives for a group than for an individual job, and this is a significant advantage. Another advantage is that the scope for variation in each individual’s activities increases and that a stronger sense of participation in the larger process can be experienced than when each person is tied to a limited individual task. People working in a group have a better chance to cooperate continuously in improving methods and eliminating unnecessary work. Attitudes can change as team spirit develops. A further merit of group work is that the organization’s built-in capacity to adapt itself to change increases.

These are some of the most important reasons why group work in production has been gaining ground in the design of work organization. But group work is not suitable everywhere. In certain types of production systems it is an excellent concept, while in others it is completely unworkable. Let us look at some models of production systems and see how group work might fit with specific working conditions.

3.2 Seven production system models

Let us start with a brief review of these seven production systems (see table 17.1).
Table 17.1: Characteristics of the main production systems

<table>
<thead>
<tr>
<th>Production system model</th>
<th>Characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>The machine-paced line</td>
<td>Work pace and materials flow controlled by machines</td>
<td>Feels monotonous and unstimulating. Sensitive to disturbances. Good control over materials and work-in-progress. Effective use of space</td>
</tr>
<tr>
<td>The worker-paced line</td>
<td>Conveyor belt principle with built-in material buffer stocks</td>
<td>Adaptable and suitable for production groups. Risk of work-in-progress building up</td>
</tr>
<tr>
<td>The automated process</td>
<td>Materials flow and processing controlled entirely by machines</td>
<td>Work characterized by supervision and systems maintenance. High quality of work content. Physical isolation of workstations may occur</td>
</tr>
<tr>
<td>The concentrated operation</td>
<td>Related tasks combined in one communal work space - batch production</td>
<td>Low degree of identification with other production phases. Risk of suboptimizing tendencies. Suitable for long production series with several product versions. Capital intensive at low capacity utilization</td>
</tr>
<tr>
<td>The diversified line group</td>
<td>Combined flow and batch production</td>
<td>Adaptable to different production requirements. Requires group cooperation to achieve high efficiency</td>
</tr>
<tr>
<td>The service group</td>
<td>Support functions</td>
<td>Requires high flexibility. Difficult to plan</td>
</tr>
<tr>
<td>The construction group</td>
<td>Work is concentrated on one product</td>
<td>High demands for coordination and interaction between groups</td>
</tr>
</tbody>
</table>

The machine-paced line

This type of arrangement is most often found in situations where materials handling occupies a dominant role. The classic example of this type is the motor car factory’s final assembly on a constant-speed assembly line (see figure 17.4).
In this type of production system a high degree of mechanized handling is chosen. The flow of materials and the organization of work are therefore completely under the control of the technical system. Until only a few years ago this was the only assembly arrangement used in situations where a high volume of materials was the rule.

In this system the individual's work role tends to be strictly limited and the pace of the work is in all essentials controlled by the technology. The most important disadvantage of such production systems is the way in which the operatives experience their work. Other disadvantages include the extreme sensitivity of such production lines to disturbances. A promising approach to overcoming this sensitivity can be seen in those methods, often applied in Japan, which permit any operative to stop the assembly line. Experience shows that the number of times the systems are stopped is still low. Since everyone is aware of the drastic effects of stopping the entire system, they do everything within their power to avoid having to press their “red button”. But production systems of this type nevertheless always remain sensitive to disturbances. Moreover, it is difficult to make changes in such production lines.

The advantages are short throughput times, efficient utilization of space, machines and auxiliary equipment and, consequently, the efficient operation that is achieved through an extreme division of work. This far-reaching specialization also makes it worthwhile to push the development of methods and tools as far as possible. Specialization also creates the best possible conditions for automation of tasks, whereas a work organization in which the tasks are varied makes automation more difficult.

During recent years, a considerable number of attempts to “loosen up” the assembly line have been made with the help of different innovative arrangements - a point to which we shall return later.

The worker-paced line

If we imagine an assembly line from which we have removed mechanized control and flow speed and introduced some buffer stocks between workstations, we have a type of functional
arrangement that is common in many companies (in the clothing and metalworking industries, for example).

**Figure 17.5: The worker-paced line**

![Diagram of the worker-paced line]

In this sort of production system control is less rigorous and the existence of buffers makes it possible to adapt the individual pace of work in a completely different way from work on an assembly line. In such a system, an organization based on production groups is an excellent arrangement. Within a group made up of individual work roles, operatives can help each other, take care of work disturbances, even out peaks and valleys in the work flow and pull together to achieve a good result.

However, it is necessary to be aware that there is a risk of the volume of work-in-progress increasing so that the overall financial equation is less favourable.

**The automated process**

If it were possible to mechanize all the manually executed tasks on a conventional assembly line, the result would be a kind of process line where the individual would be concerned primarily with supervision and control. Process lines of this type are extensively used, particularly in the steel, chemical, and paper and pulp industries.

On a process line the possibilities of creating group work are often excellent. Operatives rely greatly on one another and possess a common goal; working together to attain this goal is a clear necessity. One factor that may sometimes make group cooperation difficult is an excessive distance between group members. A key question with this type of production system is the relationship between direct production tasks and maintenance tasks executed in the work organization. The higher the degree of mechanization, the fewer production workers there are; but the number of maintenance workers normally increases at almost the same rate as the number of production workers decreases.
The concentrated operation (functional layout)

A constant element in the three systems that we have discussed so far is the grouping together of equipment along the production flow so that different types of machine are placed in the correct order. However, if we group the machines in such a way that all machines of a certain type are concentrated in one department, all machines of another type in another department, and so on, we obtain a concentration of each type of operation in one place (this is the "functional layout"). In this layout the product to be worked is sent through the various departments in turn - the drilling department, the turning department, the milling department, and so forth. Concentrated operations of this type are often found in batch production, where series are short and the products varied. In this type of production system it is extremely difficult to organize meaningful work groups. As all employees are bound to their own individual job and workstation, it is virtually impossible to create a genuine work group with spontaneous interaction between different roles and role occupants.

For several decades, this work organization represented the predominant approach to mixed production with moderately long series. More recently, however, this type of organization has become less common, often being replaced by product-oriented and flow-oriented organizational systems.
The diversified line group

In many cases the conditions affecting production are such that neither a highly developed line grouping nor an advanced degree of operation grouping are suitable. Instead, an intermediate type is chosen - what we may call the “diversified line group”. Production is concentrated in an arrangement that is primarily flow oriented, but in order to carry out many combinations of tasks, some critical operational stages are repeated two or more times. In this way a system is obtained that can efficiently combine the capacity of the flow group to accept and channel a large volume of materials with the capacity of the functional layout to execute all conceivable production assignments.

In this type of production system, group work is often an excellent organizational concept. The division of work between individuals must be adapted continuously to varying conditions, but this cannot be done entirely by management, and a substantial proportion must occur spontaneously on the initiative of the members of the group. In a group organization the capacity for such spontaneous self-adaptation can gradually be generated.

The service group

Conditions within service-producing organizations differ in several respects from the types of activity we have discussed earlier. Various forms of service are produced in large sectors, such as commerce, transportation, hotels and restaurants and motor vehicle repair shops. But service functions also occur in manufacturing industry, a good example being repair and maintenance activities. The service functions of a production unit must be highly adaptable to varying demands. Generally, the tasks to be done vary in nature. The workload is uneven and it is difficult to plan the work in detail. Group organization is a useful concept in this type of situation also. The work group itself can handle much of the variation that occurs in the inflow of tasks, in routine work planning and in other circumstances that tend to vary.
The construction group

In construction operations the product itself is the centre for the whole organization. Work organizations of this type are also found in industry, for example in manufacturing very large products (e.g. turbines, ships, process machinery).

Figure 17.8: Construction group

3.3 Flow groups in assembly work: Some trends and examples

In assembly work, flow groups have always been the most natural arrangement. Let us take the final assembly of a motor car as an example. When this arrangement was first conceived it was quite natural to introduce an assembly system that moved alongside a stock of materials, with the different components being assembled on the car as it moved past. This is an extreme example of flow orientation in assembly work. The flow of materials is completely decisive in arranging the work.

But an arrangement of this type can also have its disadvantages. The work is strictly controlled and the cycle time is normally very short. However, there are countless examples, especially in Japanese companies, of group organizations where the group members move with their work along the production line to overcome this disadvantage.

At subsequent stages of development, efforts were made to introduce buffer stocks in the production line in order to create greater freedom in different parts of the production system. This placed new demands on the system, and various technical solutions were advocated to separate the different links in the chain.

With reference to our previous discussion of different production system models, we may say that the introduction of buffer arrangements in motor car assembly changes the production system from a "machine-paced line" to a "worker-paced line". The following is an example from a newly constructed motor car engine factory.
Assembly of motor car engines

The assembly process can be summarized as follows. Seven assembly groups are organized beside an automatic transportation track loop. Except for certain steps which are handled before the loop stage, complete engines are assembled in each group. Up to six engines can be assembled at the same time within each production group. During the assembly stage itself there is no mechanized control of the flow as there is with a moving assembly line. Engines are moved manually while being assembled.

When an engine has been completely assembled by a group, it is transported automatically to a resting station which is common to all groups. At the same time it is automatically registered that an engine has left the group and the transport track moves a new assembly trolley forward to that group.

The advantages and disadvantages of this type of assembly process, as compared with the traditional assembly line, are as follows:

1. This arrangement is more flexible and less susceptible to interruptions and fluctuations in the production flow.
2. It offers ample possibilities for job expansion and a more stimulating kind of group work. Each of the small loops contains a production group, a “gang” whose members cooperate closely in everyday tasks and adapt the work to changing conditions. One of the seven groups is a training group. In this group there is a fairly strict and extensive division of tasks based on detailed instructions. In the other groups the division of work is made according to the abilities of individual members. There is therefore an opportunity to adapt the design of jobs within the group to the workers’ knowledge and experience.
3. It is not necessary to carry out an extensive and costly reconstruction of the line every time the production volume has to be increased or decreased. Capacity can be expanded to a certain extent by varying the size of the groups, up to six members. Further increases in capacity can be achieved by adding more groups.
4. Job design is better adapted to the individual and should therefore lead to better recruiting possibilities, reduced personnel turnover and less absenteeism.
(5) The new arrangement requires greater floor space and higher goods-in-process inventories than a moving assembly line.

(6) Capital investment is somewhat higher for the new arrangement.

(7) Work efficiency is lower than on a conventional assembly line because of the lower degree of specialization and the fragmentation of work segments.

This example illustrates not only how buffer arrangements can be introduced between different jobs to cater to the different capacities of individual workers but also how different parts of an assembly line - or an entire line - can be rearranged in parallel. Engine assembly is carried out at a number of stations, with an entire engine being assembled at each station.

The nature of parallel production operations is illustrated in the figure below.

**Figure 17.10: Line grouping and parallel grouping**

![Line grouping and parallel grouping diagram]

The most important advantages offered by the parallel arrangement of an assembly operation (or parts of an assembly operation) are as follows:

(1) Production reliability - it is naturally less likely that several subsystems will all be affected at the same time by disturbances than that a single large system will be affected.

(2) Flexibility - it is easier to handle different product models, as well as changes in production volume, in a parallel system.

(3) Work content and work organization - the possibility of creating tasks with a richer content, and of finding natural dividing lines between groups, is considerably greater. Opportunities for production groups to accept responsibility for quality and the division of work, for example, are also greater.

But parallelization of assembly work is always accompanied by a need for larger factory...
premises, by more work-in-progress and a lower systems level since the same work has to be divided among several workstations.

**Flow-oriented machine groups in batch production**

In a traditional layout in batch production, machines and personnel are grouped in departments, with each department carrying out its own separate function. For example, one department may handle turning, another drilling, a third milling, and so on. The advantage of this arrangement is that it results in great flexibility and a high degree of utilization of machine capacity. A major disadvantage is that the volume of goods-in-process, and therefore the amount of working capital tied up in these goods, is always substantial. Moreover, the work in a plant of this kind is highly fragmented. It is difficult for individuals or groups to see the connection between their own work roles and the overall activity of the company. It is therefore difficult for them to participate actively in work planning and in attaining the established goals of the company.

During recent years, interest has grown in finding ways of grouping machinery and equipment around flow-oriented groups in batch production, that is, forming groups around the manufacture of entire products or complex product components. We will discuss these trends briefly here. The figure below illustrates the basic principle of a flow-oriented group.

**Figure 17.11: Schematic diagram of a flow-oriented group**
With the help of a standard classification method, we have selected an assortment of different components, such as axles and flanges. In each of these groups there are subgroups that resemble each other as regards the types of work required. Machines, personnel and other resources needed for the components - from metal supplies to finished parts - are collected in one unit. Through the choice of suitable components, methods and equipment we can create a simple flow pattern.

With this manufacturing arrangement, throughput times, and therefore the working capital tied up in the system, can both be reduced. Production can be carried out with minimum supplies of materials on hand - this applies particularly to the workstations themselves. The lower the supply of materials on hand, the shorter and more accurate the throughput times become.

In a functional organization, all operatives’ tasks at their machine and the job planned for the machine are fixed in advance. A flow-oriented group is a machine group for the finished manufacture of a mix of components. It contains more machines or workstations than operatives, and each operative should preferably master several types of job. This means that all the members of the group must be able to work relatively independently. The group members are responsible for dividing the work amongst themselves and seeing that the material flows through the group as it should. Thus the work of a flow group relies heavily on teamwork and cooperation.

Unlike a functional grouping of machines, a flow group makes heavy demands on individuals. But a flow group also makes possible the creation of more attractive work roles for group members, because:

- they have a better overall view of their contribution to the larger production process;
- they have more variety in their work because they can move between various tasks;
- they have the chance to be trained for new jobs;
- they have more contact with their colleagues at work as well as with management.

An example In the figure below, a flow group has been created for the manufacture of pump axles in a metalworking company. In this group approximately 150 types of axle are produced; however, these are based on about ten general methods, of which the most widely used account for 65 articles. The simplest components are manufactured from pre-cut metal pieces during a single trip through the group. The most common components must go through the group three times. Operatives can easily return parts to the incoming station with the help of roller conveyor tracks. Two people work in this group; their work is delineated by the shape of the conveyor.
Figure 17.12: Flow group for the manufacture of pump axles
Flow-oriented manufacturing in short series requires certain definite conditions and cannot be used in all situations. For example, there must be a systematic structuring of the product mix to make it possible to channel certain types of product in a homogeneous flow. Moreover, production must be of such a nature that an “unbroken-flow principle” can be applied. If it is necessary to break the flow of materials within the flow group at a certain operational step and to send components outside the group for working, then planning will naturally become more complicated.

A key issue in the formation of flow-oriented groups is the degree of utilization of equipment that can be attained, especially in the case of more expensive production machinery. Here it is necessary to weigh machine costs against the cost of tying up capital in work-in-process. Recently, the clear trend is towards recognition of the fact that tying up capital in goods-in-process has reached such proportions that the order of priorities must be modified in favour of flow groups.

A further factor of decisive importance is the stability of the product mix. Flow grouping of machinery has to be based on the assumption that it is possible to foresee that a certain product or product component will be manufactured in a certain form and according to certain methods. In cases where there is some uncertainty about these factors, flow grouping is not possible.

In conclusion, we may again emphasize that in batch production there are often excellent reasons for choosing flow grouping of machinery and operatives rather than functional grouping. The main reasons are that, in practice, functional grouping is difficult to cope with from an administrative point of view, that substantial amounts of goods-in-process tie up considerable working capital and that jobs in a functional shop tend to be boring and monotonous for workers.

Questions for discussion

1. What are the main advantages of work groups?
2. Discuss the strengths and weaknesses of each production model in practice.
3. What would be the consequences for work efficiency of replacing one model by another?
4. Compare the advantages and disadvantages of flow-oriented groups in assembly work with those of other production models.
UNIT 4: ORGANIZATION DESIGN

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the essence of organization design and know the difference between product-oriented and business-oriented organizations.
2. Suggest an organization design appropriate to the production process.
3. Appreciate the advantages and disadvantages of these two types of design compared with other systems.

UNIT 4: CONTENTS

4.1 Design of product-oriented organizations
4.2 Design of business-oriented organizations
4.3 Case study: "Push-button"
UNIT 4: ORGANIZATION DESIGN

In this unit we will discuss product-oriented organizations and business-oriented organizations, which are the two most common designs.

4.1 Design of product-oriented organizations

The company within the company

The concept of product-oriented organization as a method of structuring production in batch manufacturing is becoming increasingly common. The conventional method of organizing production of this type has been in functional shops or departments, that is, where machines with similar functions are grouped together.

In product-oriented organizations precisely the opposite arrangement is made. A product-oriented organization may be defined as a production unit which is organized and equipped in such a way that it can independently manufacture a certain finished product or family of products. To put it another way, the aim is to group together, physically as well as administratively, the entire production chain for a specific product or group of products.

Product orientation follows the same principle as a flow group, not only as regards production but also at organizational level. A product-oriented organization is a larger unit than a flow group; it manufactures more complex products or product components and can consist of several flow groups. A product-oriented organization should be able to function rather as a company within a company. This means that it must occupy an independent position vis-à-vis its environment. All the necessary resources should be available so that the entire manufacturing chain can be handled from beginning to end for a certain product or component. It should also have its own administrative resources and operational services, such as maintenance, materials handling, and so on.

Manufacturing resources are located within the plant so that the entire production chain can be kept together in one place, there is very little dependence on other units and the coordination of products can be assured within the organization. In this way a simple planning process and short throughput times can be attained. The unit can also be truly independent of other working areas in the immediate vicinity.

If this method is to function effectively, however, all the machinery necessary for all the production operations must be available. In general, the capacity utilization of most machines will be lower than in a functional shop. Machine utilization will thus be a key factor in the feasibility of this organizational concept, and should be weighed against its advantages, especially as regards lower working capital tied up in stocks and simpler administration.

Flow patterns in a product-oriented organization: An example

By definition, the product-oriented organization refers to a certain flow of production. Within the unit itself, however, this flow can be more or less divided, and machine grouping can
vary from very pronounced line grouping to a more operationally grouped functional arrangement. Let us look at two examples of how the product shop may be organized.

In the first example, a heat exchanger unit, a systematic attempt has been made to build the production structure on the basis of flow groups. It proved possible to do this for most of the manufacturing process even though it is heavily influenced by customer orders and batches are small. The figure below shows how an attempt was made to come as near as possible to a “straight-line” layout. This simplifies materials handling and gives all operatives a good overall view of the manufacturing process.

**Figure 17.13: Layout for a heat exchanger unit**

![Diagram of a heat exchanger unit layout](image)

However, it will be seen that the flow is divided between two areas in the manufacturing chain. There is a materials buffer for assembly, and there is also a buffer between the pressing of plates and finishing of products. This is to achieve reasonable batch sizes and to reduce change-over times in production.

In our second example, relating to the manufacture of electric motors, figure 17.14 shows a product-oriented organization consisting of a number of flow groups in which different components are manufactured. The arrangement is based on the following principles:

- manufacture of components in units from raw materials, each in its own component flow or flow group;
- coordination of component flow directly with the main flow without material buffers or interim stocks;
- completion of main flow with delivery of finished motors.
4.2 Design of business-oriented organizations

We have now examined how, on the basis of work study, we can design jobs for individuals and teams in production, and we have seen how an entire production system consisting of several production groups can be organized. The production system is in its turn part of a business system.

Here we will discuss three subsystems within the business system which are important for the work organization of the production system:

- system for product design;
- system for subcontractors and suppliers;
- system for marketing, sales and customer contact.

These three constituents of the business system are closely connected to the production system, firstly because they affect work organization in the production system, and secondly because different work organizations alter the conditions affecting these subsystems. Let us examine these subsystems and their relationships to work organization (see figure 17.15).
Product design and its relationship with work organization

Work organization in the production system is determined to a great extent by the design of the product to be manufactured. If production is taken into account when the product design is established, this will influence the way the work can be organized. And conversely, product use can affect the methods of working and judgements in the production system. It is therefore important to ensure that product design and work organization interact effectively in production and work closely together.

We will consider two aspects of product design which have attracted particular attention in recent years:

1. Design for manufacturing
2. Modularization of complex products

Design for manufacturing It has always been part of the preparation and planning of industrial production to try to take account of production considerations in product design. For example, attempts have always been made to select those qualities which satisfy the product requirement, and which present no problems for machining and processing. Selection of materials can affect work organization in such areas as which machine in a processing group should be used, for example.
Recently, attention has been increasingly devoted to designing complex products in such a way as to make production and assembly easier. In the car industry attempts have been made to design the car so that assembly work can be organized in a more efficient manner. By adopting this approach, some Japanese car manufacturers have been able to improve the organizational efficiency of their assembly plant by changing the sequence of the operations involved and by modifying the assembly work, to include more pre-assembly of components. In many of these cases, a more production-friendly car design has turned out to be an important factor in designing work organization in the car factory.

**Modularization of complex products** In principle, modularization means that a large number of different products can be offered to the customer by combining a limited number of standardized modules in different ways. Modularization is therefore a means of meeting widely varying customer demands in a way that enables the manufacturer to improve production efficiency at low cost. An example may be drawn from the manufacture of pre-fabricated houses; modularization has been pushed a long way in company efforts to offer a wide range of choices to the customer within a framework of relatively standardized production. Wall units, roof structures, kitchen modules, bathroom modules, garage modules - these are all examples of structural units which help customers to design their own dream house. But for the manufacturer, modularization means that groups can be created to specialize in the low-cost production of a certain type of module by using efficient methods. Each team can also be given responsibility for checking the quality of its own output and, where necessary, carrying out tests of the various systems. A further consequence of specialization is that highly advanced tools and mechanical aids can also be used.

If product design is not modularized in this way, the construction of a house is largely a matter of handcraft. It is still the case, of course, that houses are often built on site by a team of building workers who demarcate their tasks in accordance with strict handcraft traditions. (And it can take months before the house is built.) With today’s production methods, a house can largely be produced indoors in factories where the work environment is satisfactory. Houses are then transported in building blocks to the site and erected so quickly that they can be roofed over in a day or two, or even within hours.

A second example comes from the electrical engineering industry. One product is an electric control box where circuit breakers, relays, measuring devices and components for adjusting, measuring and controlling electrical installation are all kept together. These control boxes used to be manufactured according to the specifications laid down by an individual customer. The manufacturer produced what the customer wanted and the result was a wide variety of different products which were manufactured in the relatively old-fashioned craft tradition. With modularization, however, it became possible to offer customers almost the same freedom of choice as in the past, but at considerably lower cost since production could now be organized using efficient production groups, each producing its own type of module. Another advantage of this arrangement was that delivery dates were reduced from several months to a few days.

Both these factors, design for manufacturing and modularization, are examples of close interaction between production and product design creating conditions that will improve the efficiency of work organization.
Subcontractors and their relationship with the work organization

"Subcontractors" here refers to all external companies responsible for the supply of raw materials, inputs and externally produced components for a company's activities. This subsystem is of great importance to the efficiency of the total business system. In recent years, industrial enterprises have begun to increase their use of subcontractors in order to concentrate on their own core operations. Consequently, interaction with subcontractors is growing in importance.

In this context we will limit ourselves to discussing two aspects of the relationship of subcontractors to production:

1. Subcontractors and just-in-time strategies
2. The development of the competence, skills and technology of subcontractors

Subcontractors and just-in-time strategies One of the most dramatic changes in manufacturing in recent years is a remarkable reduction in the volume of work-in-process. This reduction is of great significance for the overall financial result of production. Efforts to keep the smallest possible supply of materials begin during the first operation in a production chain and then spread throughout the entire production system.

The basic idea is that the materials to be used in a production system should arrive just in time and the quantities supplied should be limited. It was in order to meet this latter requirement that Toyota developed what is known as the Kanban system. The idea is that only just enough parts for any operation should be received from the previous stage to satisfy the immediate needs of current production. The size of the batch delivered to any operation is that of the load carrier (container or pallet) which comes from the previous station. Once this load carrier has been emptied, it is sent back to the previous stage and this is the signal to manufacture more parts for the next operation.

By adopting just-in-time strategies and keeping down the amount of work-in-process throughout the production chain, many companies have succeeded in achieving a dramatic reduction in capital employed. It might seem that a substantial reduction in the volume of buffer stocks and a large, immediate dependence on a constantly reliable flow of goods from outside suppliers would lead to a high level of vulnerability and many production disturbances. But experience shows that since everyone who is involved in the system - both externally and internally - is aware of the consequences of delivery failures, operating reliability remains high.

Development of the competence, skills and technology of subcontractors If some of the activities of an industrial enterprise are to be highly dependent on subcontractors, the development by these external parties of their own competence, skills, technology and methods is of great importance to the core manufacturing enterprise. This applies to a particularly high degree in the case of developed industrial products, where subcontractors have to supply complex components with a high technical content.

During earlier phases of the industrial development process, both product and components were designed by the company that was to market the product. In the case of cars, the design of the car as a whole was the responsibility of the car manufacturer, who approached component
makers in the industry and called for quotations for manufacturing these components.

However, this arrangement meant that the competence and skills, technology and methods of subcontractors became unsatisfactory. So the trend in recent years has been towards linking important subcontractors closer to the business system of the core enterprise and involving them in developing components and subsystems. As a result of this process, work organization in the production system of the core company also becomes more closely linked to the production system of the subcontractor. By effective coordination of these systems and by jointly utilizing the skills, knowledge and experience available on both sides, products and production systems can both be further developed.

**Marketing/sales systems and their links with work organization**

We would like to look at two particular aspects of this part of the commercial system:

1. Customization of products
2. Integration of the customer into the production system

**Customization of products** Earlier methods of mass producing standardized products have been replaced by the production of versions specifically designed for the customer. Even in the car industry much of the manufacturing is of cars produced in accordance with specifications drawn up by individual customers. Of course, this specification consists of a number of standardized model and equipment options, but the actual combination is specific to the customer. This customization is also made possible by the adoption of the just-in-time and Kanban-like methods mentioned above. Consequently, delivery dates for a customized car can be reduced to a few weeks.

Customization naturally brings new and difficult demands both for production and for sales. Production organization has to be able to make reliable forecasts of the mix of different models and equipment options, and it should be able to revise its plans at frequent intervals. Within the framework of the plans it must also be capable of producing a mixture of models on the same production line.

Corresponding demands are made on the sales organization, when a model or equipment mix which has been expected in production deviates noticeably from the actual sales mix. Then the sales team has to respond actively and attempt to influence sales so that they do not deviate too far from the model mix that the production organization is capable of producing.

Customization of products has therefore placed noticeably more rigorous demands on the interaction between production organization and sales organization. This is the case in many contexts, not only companies producing capital goods and consumer goods but also those producing services.

**Integration of the customer into the production system** As a result of customization, it may be said that the sale to the customer is the first stage in a Kanban system. When the special product required by the customer is delivered, the sale often includes an offer of service, and sometimes also a guarantee by which the supplier undertakes to put right any faults which may arise during a particular period after delivery. As a result of such service and guarantee commitments,
conditions are also created for more long-term and systematic contact with the customer. It immediately becomes possible to follow up on customer satisfaction. The information obtained can be fed back to designers for future product generations and to the production system in order to improve its results.

At present manufacturing enterprises and service companies are engaged in systematic programmes to create long-term, stable customer relationships. The customer should become an integrated part of the supplier’s own business system, and by responding to the customer’s wishes within a long-term, close relationship, the supplier hopes to ensure that the customer stays within the “family” and does not look for other suppliers.

Both these factors which affect the marketing and sale of the company’s products are consequently highly dependent on the work organization of the production system. They represent another expression of the growing need to further integrate the various components and subsystems of the business system.

Work organization in the production system, which in this context is the main focus of our interest, is, as we have seen, affected in many ways by considerations relating to other parts of the business system.

Case study: “Push-button”

Description of the business

In an engineering company which manufactures electrical installations and electrical low tension apparatus, one department manufactures circuit breakers in the form of push-button sets. The range of products includes 100 different models and there are 20 employees in the department. The production layout is broadly as shown in the diagram below.

<table>
<thead>
<tr>
<th>Management system planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept.</td>
</tr>
<tr>
<td>No. of persons</td>
</tr>
</tbody>
</table>

Plastic and metal components are bought from outside suppliers and kept in stock. Some metal parts are manufactured in a machine group where they are punched, bent, embossed and riveted together. Most of the work consists of assembling the push-button units. In the case of more complex units there is some pre-assembly at a separate workstation. Otherwise, the push-button units are assembled in individual assembly stations. The work is monotonous and the task cycle in the assembly department is approximately one minute. The batch size varies between 50 and 500 units. The throughput time for a product is 12 days on average, which means that substantial quantities of materials are kept in stock during the production process.

Problem: Long throughput times lead to long and uncertain delivery times, high stocks and low productivity. This means that competitors, mostly small firms, tended to steal business from
the company. The monotonous and unstimulating work led to a lack of worker commitment and low job motivation. There was a high rate of repetitive strain injuries. Absenteeism was also high and staff turnover was 40 per cent per year. The company decided to start a development project to change the work organization and working conditions.

How would you, if you were the project manager, arrange this project and what measures would you concentrate on trying to introduce?

Please compare your solution with the one provided in the annex to this unit.

Questions for discussion

1. What is meant by “a company within the company”?
2. What is the flow pattern in product-oriented organization?
3. What are the most common barriers to introducing product-oriented organizations?
4. What is business-oriented organization?
5. How can product design affect the business system?
6. What are the most important criteria for the effective integration of producers, customers and suppliers?
SOLUTION TO THE CASE STUDY

There is no simple standard solution for work organization at this level. If this task is given to four different groups, there will almost certainly be four different proposals as to what should be done and how to approach the problem, and none of them need be wrong. It is the process of trying to apply the contents of this module to a case study that is of value. This case was taken from the ABB Group in Sweden. The proposed solution is what was actually done in this case. But it should be emphasized that other proposals may be perfectly viable.

In ABB responsibility for ordering materials and planning the production process within the workshop was delegated to the workers. The old monotonous jobs were abolished and a group organization was introduced, by which employees in the workshop were gradually to learn all the tasks involved. Training was started for everyone so that versatility improved rapidly. A discussion was held about the business system in which this production was incorporated. As a result, everyone who worked in “Push-button” took part in a business development where the main point was to be involved in the creative process. Contacts were developed with companies that supplied raw materials and input items, so that defects in arriving materials were eliminated. The groups worked on a flow basis and tried to shorten the throughput time for the products. The batch sizes ordered were reduced to cut down stocks held in the system. The groups began to function more and more as a company within a company, where everyone was a businessman. They took over the planning of the business which had previously been handled by separate salaried employees and became involved in improving the quality of the products and the reliability of deliveries.

The result of all these changes could be summarized after 18 months as follows:

<table>
<thead>
<tr>
<th></th>
<th>Before the change</th>
<th>After the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput time (days)</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>Failure rate</td>
<td>15%</td>
<td>1%</td>
</tr>
<tr>
<td>Correct delivery date</td>
<td>25%</td>
<td>98%</td>
</tr>
<tr>
<td>Stock-in-trade and work-in-progress</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Absenteeism</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>Personnel turnover</td>
<td>39%</td>
<td>0%</td>
</tr>
<tr>
<td>Productivity</td>
<td>100</td>
<td>114</td>
</tr>
</tbody>
</table>
UNIT 5: WORKING TIME MODELS FOR HIGH PRODUCTIVITY

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Appreciate the effect of working time on productivity.
2. Classify different working time models and understand their relevance to specific working conditions.
3. Apply the main approaches to safe operating and working time.
4. Analyse time utilization during the shift.

UNIT 5: CONTENTS

5.1 Extended operating hours
5.2 Seasonal adjustments and variations in the flow of customers
5.3 Maintenance and operating hours
5.4 Weekend and holiday work
5.5 Customer-determined staffing
5.6 Shift work
5.7 Case study: “Working hours bouquet”
UNIT 5: WORKING TIME MODELS FOR HIGH PRODUCTIVITY

It is important for all companies to make the most flexible and efficient use of their production resources in the form of machinery and equipment. Making better use of the capital tied up in plant and keeping up with technical developments and rapid changes in markets are all important reasons for developing effective working time models. The point of departure for establishing such models is to distinguish between the operating time of the plant (the time a particular activity is in process), and the working hours of individual employees.

The working time of individual employees may be governed by laws or collective agreements, and it may also be influenced by special agreements on working hours. Individual employees may also have preferences regarding their working hours. Their wishes sometimes match the requirements for utilization of the plant, and in such cases working time solutions can be designed to meet the needs of production and workers at the same time. Here we will discuss some approaches to designing efficient working time models.

5.1 Extended operating hours

It is often possible by relatively simple means to extend the running time of machines and installations. For example, if an automatic charging unit is arranged around the machine, production can continue unmanned for a certain period. In this way, production can take place partly during breaks and can also continue for some time after the end of the working day. Working time at the beginning or end of the day can also be shifted for some people so that a machine can be started earlier and stopped later in the day. The working week can also be extended if special teams take over at the end of the regular working week and run the plant intensively during the weekends. In some activities which are highly dependent on the state of the economy, it might be reasonable during a boom to increase the number of working hours each day and week. Below we give examples of what can be achieved by extending operating hours.

A company that manufactures brushes has a production unit where the brush blanks are injection molded in three fully automatic machines. The following measures have been taken to extend operating hours:

- When a brush blank is faulty in some way it is automatically removed while being transferred from the machine to the collection containers for the finished plastic blanks.
- Each machine has a sensor which stops production if the machine breaks down. In this way it is possible to avoid damaging expensive equipment.
- The machines are supplied with material from large containers.

The operators on the machines have an eight-hour working day. Their task is to replace the empty container with a new one full of plastic blanks and to change tools when necessary, etc. Otherwise, the machines operate 24 hours a day. If necessary, they can also be run during weekends and holidays. Before these rationalization methods were introduced, eight people worked two shifts to produce the brush blanks. This is an example of how it has become possible to completely decouple operating hours from individual working hours and thus achieve significant productivity gains.
Another engineering company with highly automated machine equipment also used to have conventional two-shift production. Here they introduced cartridges for feeding and removing work pieces which allowed the machines to operate unmanned for four hours. These measures made it possible to change working hours so that a gap of three hours was introduced between the first and second shift. The first shift ran from 5 a.m. to 1 p.m. and the second from 4 p.m. to midnight. As a consequence, production continued not only during the three-hour gap between shifts, but also for four hours after the end of the second shift. The overall operating hours thus amounted to $8+8+3+4 = 23$ hours per day. The company has almost succeeded in achieving continuous operation throughout the day with two-shift manning.

5.2 Seasonal adjustments and variations in the flow of customers

Many businesses experience significant seasonal fluctuations. Agriculture and forestry, fishing and tourism are cases where it has always been necessary to vary the working hour model according to the season. In manufacturing industries there are often reasons for applying different working hour schedules for different seasons as a means of limiting the build-up of stocks and tying up of capital.

Services cannot be stored, so they have to be produced when the customer requires them. For this reason, we find more variety of working hours in this sector than in manufacturing industry. But in the service sector the demand for flexibility and customer adaptation is also increasing as a result of intense international competition, and there is a growing need to adapt working hour solutions to the way the flow of customers changes with time.

5.3 Maintenance and operating hours

In many industries it is preferable to time maintenance activities so that they do not disrupt production. This is particularly important in the process industries where useful models have been developed which enable maintenance to be carried out at times when the installation is not in operation. Japanese industry has come farthest in concentrating maintenance work during long production stops.

5.4 Weekend and holiday work

A company which manufactures rock drilling machines has made a considerable investment in flexible production equipment. At the same time, it has developed new working hour models, partly in order to improve productivity, and partly to offer the workforce more opportunities to select their working hours.

An important aspect of the new schedule is that an agreement has been reached by which some employees work on Fridays, Saturdays and Sundays. They work from 3 p.m. to 8 p.m. on Fridays and from 6 a.m. to 6 p.m. on Saturdays and Sundays. Their total working hours, discounting breaks, are estimated at 27.6 hours, and they get the same pay for weekend work as for a normal working week of 40 hours. For some people it is very attractive to work at weekends in accordance with this model: the arrangement results in significantly higher capacity utilization.
and is thus a more profitable solution for the company.

5.5 Customer-determined staffing

In an exclusive department store in a large city, management has studied the flow of customers throughout the day, the week, the month and the year. The flow of customers varies significantly from one period to another. On ordinary weekdays there is a peak around lunch time and another towards the end of the day. There are also peaks at the weekends. There is a peak during the last week of each month, and each year there is a very large peak in December. Conversely, there are times when there are very few customers.

Based on the expected flow of customers, a working time schedule has been drawn up which requires a relatively small core of permanently employed, full-time personnel who work normal weekly hours and whose working hours are arranged so that some of them are on duty at all times. All other staffing is by part-time personnel engaged on individual working hour agreements which oblige them to cover the peak hours. These part-time employees have a wide range of different schedules. They may work

- two days a week during the low season and three days a week in high season
- over lunch time
- a few hours on Friday afternoons
- when there is a vacancy on account of sickness or temporary leave of absence
- at weekends

It is important in this type of solution that part-time employees receive sufficient training to know the stock and assist customers competently.

5.6 Shift work

In the iron and steel industry, where capital-intensive production processes require a high level of utilization, there is a long tradition of identifying and applying effective working hour schedules. In a national trade organization for this industry, a bank of schemes has been developed which contains conventional schedules and more recently developed and more flexible schedules. The schedule bank below gives some examples of shift systems.

<table>
<thead>
<tr>
<th>Contractual weekly working hours</th>
<th>Weekly working hours</th>
<th>Weekly operating hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous three shift work, no weekend break</td>
<td>35</td>
<td>168</td>
</tr>
<tr>
<td>Continuous three shift work, weekend break</td>
<td>36</td>
<td>144-168</td>
</tr>
<tr>
<td>Intermittent three shift work</td>
<td>38</td>
<td>114</td>
</tr>
<tr>
<td>Continuous two shift work with weekend break</td>
<td>37 1/3</td>
<td>112</td>
</tr>
<tr>
<td>Continuous two shift work, no weekend break</td>
<td>36 1/3</td>
<td>107</td>
</tr>
<tr>
<td>Conventional intermittent two shift work</td>
<td>38</td>
<td>76-80</td>
</tr>
<tr>
<td>Continuous daytime working with weekend break</td>
<td>38</td>
<td>53.2-76</td>
</tr>
<tr>
<td>Continuous daytime working with no weekend break</td>
<td>37</td>
<td>51.8-74</td>
</tr>
</tbody>
</table>
Let us look more closely at two of the schedules within this bank.

**Intermittent three shift working** The Steel and Metal Workers' Union supplies uniform and easily readable forms for constructing working hour schedules.

- Weekly working hours: 38 hours/normal week throughout the year.
- Operating hours: 114 hours/normal week throughout the year.

* Ten shifts per year are worked on days between holidays and weekends, and a free shift incorporated in the schedule. Free shifts can be saved up to make a longer operational break for massive maintenance programmes.
* Shorter working hours in the summer (as a rule by having no work on nights before Monday).
* Operating hours schedule of 112 hours per week for three weeks and 120 hours per week in the fourth week.
* Operating hours schedule of 114 hours per week of which one ten-hour shift or two nine-hour shifts.

**Continuous three shift working with weekend breaks** Weekly working hours: 36 hours per normal week throughout the year.

a) Operating hours: 144 hours per normal week throughout the year.

At the iron works, where production is often controlled by the furnaces, it is frequently uneconomical and in some cases impossible to use a shift schedule which involves many short operating interruptions. Several companies have therefore developed a schedule with long continuous operational breaks.

The working rhythm is normally the following:

Four morning shifts + 48 hours off  
Four afternoon shifts + 24 hours off  
Four night shifts + 72 hours off

In addition, there are twelve free shifts in a sixteen week cycle.

In units which often have to switch between different types of shift schedules it could be an advantage to have a schedule with a short shift cycle. In such a schedule the work rhythm would be:

Six morning shifts + 72 hours off  
Three afternoon shifts + 48 hours off  
Three night shifts + 104 hours off  
Three afternoon shifts + 48 hours off  
Three night shifts + 48 hours off

b) Operating hours: 169 hours per normal week throughout the year.

The schedule can be constructed in many different ways; free shifts and reduced working
hour shifts are scheduled as convenient.

There are two different models with replacement teams:

1. Four shift teams with a replacement team
2. Five shift teams with an extra shift

The replacement team schedule is based on a shift cycle of 16 weeks but can also be designed in a variety of ways, for example:

- The replacements work in one shift team and can replace six jobs.
- The replacements work in two teams and can replace three jobs in each team.
- The replacements work in four teams and can replace one job in each team.

5.7 Case study: “Working hour bouquet”

An engineering company in the automobile industry where high capacity utilization is important has developed an entire “bouquet” of different working hour schedules. The supervisors can choose among them when they have to staff a given production schedule, and the employees can also express their wishes about working hours.

The following eight types of working hours occur:

Work schedule No. 1 is a normal daytime schedule. It begins at 7 a.m. and continues to 4 p.m., with a lunch break in the middle of the day.

Work schedule No. 2 is two-shift work, which is by far the most common type at the company. The first shift starts at 5.45 in the morning and finishes at 2 p.m. The second shift starts at 2 p.m. and continues until 11 p.m. (8 p.m. on Fridays). Both shifts include a break. The workers alternate on a weekly basis between morning shift and afternoon shift.

These are the only full-time schedules at this company.

Work schedule No. 3 is a reduced two-shift schedule where the morning shift runs from 5.45 a.m. to 11.30 a.m. and the evening shift between 5.30 p.m. and 11 p.m. Here too, they alternate on a weekly basis between morning and evening shifts.

Work schedule No. 4 is a reduced daytime schedule between 11.30 a.m. and 5.30 p.m., that is, 30 hours a week. The primary intention is that working hours should cover the gap between the two short shifts in work schedule No. 3.

Work schedules Nos. 3 and 4 are also known by the common term three-part shift.

Work schedule No. 5 is also a reduced two-shift schedule, but here the morning shift runs from 8.00 a.m. to 2 p.m. and the evening shift from 2 p.m. until 8 p.m. At the end of the seventies, the company built a new assembly department employing about 100 people, and the work there was based on these working hours. There was considerable demand for part-time work, mainly from women who wanted to start working. At the same time, there was pressure from society and the government to provide more job opportunities for women. The company planned its new department in such a way that two times six hours per day would give the required assembly capacity.
Work schedule No. 6 is a regular night shift schedule, which consists of 34 hours spread over five nights a week. These working hours are only used in very capital-intensive workplaces where normal two-shift working is not sufficient. By combining regular two-shift working with this type of night shift, the machines can be operated 24 hours a day if necessary.

If, for example, 100 workplaces need to operate around the clock this can be achieved either by 300 people working three shifts or 200 people working two shifts and 100 night-time workers. At this company it has been found that the latter model is the more attractive; it is also better from a medical and social point of view than the conventional three-shift work. In addition, it is more flexible.

Work schedules Nos. 7 and 8 include work on Saturdays and Sundays with weekdays free.

- No. 7 is a daytime schedule with 11.3 hours of work on both Saturdays and Sundays.
- No. 8 is a two-shift schedule, also with 11.3 hours of work per shift.

Diagram: The working hours bouquet

Task: In a narrow segment of the production system, it is necessary to achieve operating hours of 168 hours a week, in other words, continual operation around the clock seven days a week, for the next few months. How can you manage this by combining working hours from this bouquet?

Please compare your solution with the one given in the annex to this unit.

Questions for discussion

1. What is the distinction between operating hours and working hours?
2. What are the main ways to extend operating hours and working hours?
3. What is the impact on productivity of extending operating and working hours?
SOLUTION TO THE TASK

It is possible to activate 168 operative hours per week by combining work schedules 2, 6 and 8.
UNIT 6: CRITERIA FOR AN EFFECTIVE WORK ORGANIZATION

UNIT 6: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Describe and explain the most important criteria of good work organization.
2. Appreciate the importance of a compromise or balance between attractiveness (job satisfaction) and effectiveness.
3. Use the criteria in your company work organization analysis and design.

UNIT 6: CONTENTS

6.1 Effectiveness
6.2 Autonomy of small systems
6.3 Stability of the production system
6.4 Attractive jobs and the work environment
UNIT 6: CRITERIA FOR AN EFFECTIVE WORK ORGANIZATION

We have briefly touched on the trend towards new forms of work organization, and discussed some principles and general guidelines. It is clear that there is no simple or standard way of creating a work organization, each separate solution has to take into account the widely varying conditions at different workplaces.

The use of work studies makes it possible to isolate different tasks and to systematically test alternative solutions. Systematic work studies lead to the development of improved methods for performing individual tasks, and also help to find effective ways of combining individual tasks and jobs.

However, an effective business system requires a comprehensive analysis of the entire system. Product development affects production methods, and conversely, production can generate experiences that might affect product development. Marketing and sales must be based on what is produced, but contacts with customers can generate feedback that may have an effect on production and product development.

Developing the work organization also entails analysing all levels of the operation; individual jobs, tasks, work groups, production and business systems. A highly productive work organization can only be achieved if it is continually being improved and developed through day-to-day activities. Individuals and work groups must be committed to this continual process of development, and it is important that company management should encourage and empower employees to use their skills and talents effectively. Let us consider the most important criteria for an effective work organization.

6.1 Effectiveness

The first and most fundamental criterion for a good work organization is that available resources should be put to the best use and that the largest possible output should be obtained from the smallest possible input. Naturally, there are situations in which considerations other than those of a purely economic nature are of paramount importance. If, for example, there are evident safety or health risks at a workplace, and if additional investment is required to eliminate them, the appropriate steps must be taken even if it is not possible to point to any demonstrable economic benefit resulting directly from such measures. This is an example of how economic considerations (at least in the short term) have to give way to other factors.

In this financial analysis it is also important to take into account not only yardsticks that measure production per hour worked. As we have already mentioned, there are many other factors which may be of great importance, indeed, even greater than labour productivity. One example of this is the gains that can be achieved by adopting just-in-time strategies and reducing the volume of work-in-process between workstations in a production chain. Such an arrangement leads first to significantly lower capital costs and secondly to shorter delivery times. This factor is hard to measure in financial terms, but is still an important element in the competitiveness of the company.
As economic considerations are basic to the choice of a suitable form of work organization, the organizational principles and solutions that result in increased effectiveness and in better jobs for employees are naturally to be preferred.

6.2 Autonomy of small systems

Even if economic considerations must be carefully analysed in each individual case, there are several rules of thumb, or general lines of thinking, for the design of a good production system. These are guidelines that have become increasingly important during recent years in the development of new forms of work organization but in which precise calculations of short-term profitability are difficult, if not impossible. Nevertheless, there has been so much emphasis on these guidelines that we take special note of them here; but we must also stress that they stand somewhat apart from the basic economic factors.

The first of these guidelines for designing effective production systems is the search for greater independence for small systems in company organization. By this we mean production systems that consist of moderately large units and which can function with a relatively high degree of independence within the larger company. Breaking down the company into these smaller units reduces the need for coordination, and consequently management problems become simpler to deal with.

The decentralization that results from this type of production arrangement is also valuable in stimulating local initiative and increasing the ability to adapt to changing conditions in different parts of the company. It has also been shown that employees are often more contented and more involved in their work if they are members of smaller and more independent production units.

If we wish to create production systems based on this principle, four points are particularly significant:

1. The possibility of dividing up larger systems into smaller systems.
2. The possibility of arranging complete manufacturing units into smaller units so that the need for contacts with adjacent units is reduced.
3. The possibility of arranging for self-sufficiency as regards production resources, operational services, and so on.
4. The possibility of arranging for less direct management intervention from above, so that the independence of smaller units is not eroded by control from the upper levels of the hierarchy.

6.3 Stability of the production system

One further criterion for a good production system which has received increasing interest is the desire to arrange for stable production activities with a minimum of disturbance. The following requirements arise in this connection:

1. A simple flow pattern, which makes it easier to plan the work and give the employees an
overall view.

(2) Reliable technology with an optimum level of mechanization, so that technical disturbances are kept within reasonable limits.

(3) A disturbance-resistant work arrangement, so that all critical production stages are organized in parallel and those that are particularly sensitive to disturbance are protected by buffer arrangements.

6.4 Attractive jobs and the work environment

It is important to be able to offer people jobs that they find attractive and in which they can feel personally involved. Personal aspirations vary between individuals and situations, depending not only on personal ambitions and desires but also on abilities, knowledge and capacity to develop. A production organization must therefore offer a variety of jobs, so that individuals can progress from simple jobs to more complex work roles.

The following factors should be considered in an endeavour to create attractive jobs:

(1) The creation of jobs with different degrees of difficulty through flow orientation, different degrees of subdivision of work and different degrees of integration of auxiliary tasks. Variations of this kind make it possible to offer to different individuals at different times jobs that correspond to their abilities and wishes.

(2) The creation of individual jobs and group arrangements that bring about a degree of independence in work, through finished manufacturing of entire products, self-sufficiency of production service functions and buffering at the interface with adjacent systems. This independence is of value in terms of the production results obtained and the way the work is experienced by members of the group.

(3) The design of a work organization that is suitable for teamwork, as a result of flow grouping and similar arrangements that are compatible not only with more attractive jobs and work situations but also with greater efficiency.

(4) Provision of overall views from within the organization. In order for people to find their job attractive, they must be able to view the larger context of which their work is a part. It is also important they they should be involved, if possible, in the design of their work and be able to feel some sense of “belonging” to their group of fellow workers and the overall production process.

An important criterion for a good job is also the quality of the work environment. In Unit 4 we indicated the basic factors that have to be considered with respect to safety at the workplace. In addition, however, a work environment should also be pleasant to work in - in other words, it should be so designed that it becomes easier to adopt ergonomically correct working positions.

It is desirable for the people who work in a particular organization to be involved in developing this organization, not only to give them influence over the process, but also so that they can contribute to the process with their knowledge and experience.
Questions for discussion

1. What are the most important criteria for an effective work organization?
2. Is an autonomous small system more or less productive than a conventional small system? Give examples.
3. How do attractive jobs influence the productivity of production systems? Should there be some balance between attractiveness and effectiveness?
BIBLIOGRAPHY


ILO: Managing and developing new forms of work organization (Geneva, 1989).


Lindestad, H.; Norstedt, J.P.: Autonomous groups and payment by results (Stockholm, Swedish Employers’ Confederation).

Swedish Employers’ Confederation: Job reform in Sweden (Stockholm).

MODULE 18

PRODUCTION MANAGEMENT
MODULE 18: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand and describe the role of production management in productivity improvement.

2. Identify the main factors which determine the productivity of plant and equipment.

3. Describe the main stages of establishing and running a production facility.

4. Make use of a range of support approaches and techniques for improving the productivity of plant and equipment.

MODULE 18: CONTENTS

UNIT 1: Approaches to productivity improvement in production

UNIT 2: Productivity of production

UNIT 3: Designing effective manufacturing processes

UNIT 4: Workstation design: Ergonomics and safety

UNIT 5: Production planning and control

UNIT 6: Flexible manufacturing systems and information technology

Bibliography
UNIT 1:  APPROACHES TO PRODUCTIVITY IMPROVEMENT IN PRODUCTION

UNIT 1:  LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Identify the main potential areas for productivity improvement at the shop floor level.
2. Understand the role of production as part of the total value chain.
3. Define and explain the main objectives of production.

UNIT 1:  CONTENTS

1.1 Where to look for productivity potential
1.2 Production as part of the value chain
1.3 Objectives and philosophies of production
UNIT 1:  APPROACHES TO PRODUCTIVITY IMPROVEMENT IN PRODUCTION

1.1 Where to look for productivity potential

For all organizations, especially those engaged in manufacturing, the productivity of production systems is an important component of overall productivity. Productivity depends on the design of the product, the design of the process and the operation of the process, notably the quality of equipment and facilities.

The design of production processes involves working backwards from the product design and estimated demand to determine:

- process design;
- location of facilities;
- facility layout;
- required capacity;
- process plans;
- production schedules;
- monitoring and control procedures.

Control of production processes involves both operational control and financial control. Control information is used to ensure that operational activity conforms to planned levels and also to aid in decision making for development projects. Although the initial design of the product and process has the greatest impact on productivity, it is essential to keep operations under constant review and to make constant improvements.

Throughout this module we will be concerned with organizing production facilities and equipment in such a way as to achieve efficient production and high productivity. Many of these approaches are quite radical - such as selecting the facility location - or "expensive" solutions - such as implementing flexible manufacturing. However, before undertaking radical and expensive measures, it would be useful to examine some of the workplace approaches that can be used to improve the productivity of an existing facility.

Eliminate waste

When the activities of workers and machines are analysed in detail, it is often found that many of them result in or from:

- waste of time;
- waste of materials;
- waste of space;
- waste of movement;
- waste of effort.

Many of the procedures in this module will address such waste (effective facility layout should reduce wasted space and movement, for example) but periodic checks must be made to keep the focus on productivity improvement. Standard work study techniques of process...
charting and critical examination can be used to record, analyse and improve activities to reduce such waste of resources.

**Waste of time**

- machines are not working;
- people are not working;
- materials are not being worked upon.

In production operations, any time that equipment is not working is wasted time. Some wasted time is unavoidable since, for example, preventive maintenance must be carried out to ensure long-term efficiency. Normally, however, preventive maintenance reduces time wasted because of machine breakdown. Other causes of idle time are much less necessary or should be looked at to see if the time they waste can be reduced. One example is set-up times and the following approach should be followed to reduce set-up times.

- Minimize the number of set ups:
- Use standard components where possible;
- Balance changeover costs with inventory costs.
- Minimize the time for each set up:
- Carry out as much set-up work as possible while the machine is still operating;
- Examine the job to see if any set-up work currently done on the machine can be done off the machine, preferably in advance — preparation of dies, fixtures, etc.;
- Reduce the need for fitting and adjustment of tools by redesigning and simplifying tools and attachments;
- Consider designating a setting assistant to reduce the time needed for set up.

Another major waste of time is work-in-progress: materials sit on the floor waiting to be processed. Work-in-progress (WIP) is minimized by effective production scheduling and good materials handling, shortening distances to be travelled and using faster handling methods.

Wasted labour time can occur in concert with wasted machine time in the event of a breakdown or a wait for materials or parts. One approach to improving the productivity of labour is to maximize the flexibility of the labour force by using multiskilled operators capable of transferring between tasks and equipment.

**Waste of materials**

The quantity of scrap and wasted materials should be continually monitored. Manufacturing processes should be analysed to identify ways in which waste is produced and attempts made to improve yields (e.g. if garment parts are cut from a roll of cloth, some waste is inevitable. Careful relayout of patterns may reduce this waste.)

It should be a routine matter to check that:
- all equipment is working to its proper specification;
- all operators are properly trained;
- handling and storage methods do not cause damage to parts and products.
Waste of space

Space is an expensive commodity. To ensure it is not wasted, organizations must:
- regularly check layouts of equipment - minor process changes may invalidate an existing layout;
- check that the minimum level of stock is held;
- ensure that stock consumes the minimum amount of space.

Waste of movement

Most processes involve some movement. A good process design may, and should, minimize movement. However, the design should be regularly reviewed as new process or handling technologies may reduce or speed up movement.

Waste of effort

Human effort is expensive in terms of the time it uses up and in terms of the time needed for operators to recover from the exertion of physical work. Work which requires more than minimal physical effort should be examined to see if mechanical assistance will reduce the effort, and associated recovery time. Thus, heavy weights should not be lifted or moved by manual effort, but by appropriate handling technologies.

1.2 Production as part of the value chain

Production is part of an overall process that delivers desired outputs to customers. The process may also involve activities such as marketing, selling, warehousing and distribution. Production is part of the value chain that adds value to materials and components by a more or less sophisticated process. The term production is also applied to the generation and delivery of services.

A production system is a configuration of resources designed for the provision of goods or services and can be simply represented as in figure 18.1.

For a manufacturing organization, the various parts of the system may translate as shown in figure 18.2.

Figure 18.1: A production system
1.3 Objectives and philosophies of production

The objectives of a production system are normally to balance a number of factors in pursuit of organizational goals. The basic factors are customer satisfaction and resource utilization.

The aim of production is to ensure customer satisfaction by providing each customer with:

- the right goods;
- of the right quality;
- at the right time;
- in the right place; and
- at the right price.

At the same time the goods have to be produced at a cost that allows the organization to maximize the satisfaction of its owners or controllers.

There are different ways of reaching these objectives. Organizations can be classed as basically:

- "production oriented" where it is the job of the marketing and sales team to sell what the production team produces;
- or
- "market oriented" where it is the job of the production team to react to a marketing and sales programme.
Neither is an ideal situation. In the first case, if production is not in line with demand in the market place, it will be almost impossible to sell and in the second, if the sales programme does not take into account the constraints on the production system, it may not be possible to carry out the scheduled sales programme.

It is important that production be seen as one part of the overall process. Customer orientation is essential and production should be seen as an important stage in the customer satisfaction process. The aim of production is not to make "as many units as possible" but to produce in volumes sufficient to cope with demand from customers.

In the simplest production system, an organization makes a single product and goods are only produced to specific customer orders. However, in most areas:

- a single product would not satisfy existing demand;
- a single product would be a risky strategy - if demand for that one product declined, the organization would fail completely;
- customer demand is not constant or consistent over time;
- customers do not want to wait for goods.

Another point is that in many areas the lead time (the time taken from beginning the production cycle to delivering the final product) is sufficiently long that demand must be anticipated rather than waited for.

Coping with variable demand

Organizations that produce to customer order would, in a situation of variable demand, find themselves continually having too many or too few orders to balance with their production capacity. Unless capacity is very flexible, which is rare, the production system must adjust to variable demand.

Additionally, production to order may well be very inefficient since facilities and equipment would continually be changing to adjust to the different requirements of different customers. This is particularly true where an organization has a wide and varied product range.

In order to cope with variable demand, an organization can adopt one of two basic approaches:

- Influence the demand. This is achieved by marketing strategies aimed at developing new products to fill demand "gaps" and promoting sales in periods of low demand - through off-season price cuts, special promotions, etc.

- Absorb the fluctuations in demand. This second approach can then be addressed by one of three major philosophies:

  (i) Attempting to increase production flexibility

Increasing the inherent flexibility of production facilities allows the organization to switch from one product to another at short notice as demand changes. Flexible production results
from facilities in which the same equipment can be used on a variety of products, and from processes and working methods that have shorter lead times.

(ii) Varying the capacity to match demand patterns

Capacity can be increased by such approaches as additional staffing, overtime working, additional shifts and increased subcontracting.

(iii) Using inventory to smooth out the demand pattern

When demand is lower than production capacity, goods are produced and kept as stock. When demand is higher than capacity, goods are taken from stock and sold to customers. This allows capacity to be utilized effectively. However, the holding of stock incurs costs — both in terms of the money that is “tied up” in the stock and in terms of the space used to store the stock. Naturally, if demand does not rise once more to a level above production capacity, that stock will never be needed and the money invested in it is wasted. Organizations must therefore balance stock-holding costs with the optimal use of capacity.

Which of these philosophies and approaches is selected will depend on the nature of the process, the situation at the time and the balance of costs. The following points should always be considered.

- Some processes cannot easily be adjusted by additional working and, naturally, if a production facility is already working 24 hours per day, there is no room for increasing production.
- Labour policies or the industrial relations climate may render certain working patterns unacceptable.
- Increasing inventory levels may be impractical as in the case of a perishable or fashionable product.
- Inventory incurs costs which must be balanced against the costs of adjusting capacity.

These philosophies and approaches to demand variation are not mutually exclusive and an organization may use any number of them simultaneously.

Questions for discussion

1. What is the main purpose of the production process?
2. What are the most important potential areas for productivity improvement at the shop floor level?
3. What is the place of production in the total value chain?
UNIT 2: PRODUCTIVITY OF PRODUCTION

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Describe the main components or factors of production productivity and understand how to measure it.
2. List the main determinants of production productivity and analyse their input.
3. Understand and describe the main ways of improving production productivity.

UNIT 2: CONTENTS

2.1 Meaning of production productivity
2.2 Determinants of productivity
2.3 Some ways of improving productivity
2.4 Local measures of productivity
UNIT 2: PRODUCTIVITY OF PRODUCTION

2.1 Meaning of production productivity

Operations management or production management is one part of the total management system of an organization. Thus one aim of operations management is to improve the productivity of production facilities within an overall plan aimed at maximizing enterprise productivity.

Productivity and quality themselves are not absolute measures. They are good or bad compared to the productivity of a similar plant elsewhere (especially one belonging to competitors) or to the same plant in the past.

Raising the productivity of a production facility means obtaining greater output from the same resource inputs, or obtaining the same output from fewer resources.

A partial and simple measure of the productivity of production would be the number of units of output per unit of resource (e.g. cars per work-hour). To get a real indication of productivity, such partial measures (which tend to include one resource input only) need to be combined into a global or total measure which involves all significant resources. To do this it is often necessary to convert resources into some common measurement scale - monetary value being generally used. This itself gives rise to problems since money is not easily compared over time; we need to convert monetary sums to some common time base before such comparisons or additions can be made.

2.2 Determinants of productivity

The productivity of production is determined by:

- the nature of the product;
- the production process;
- the management of the production function.

Product design

Productivity starts with product design. Good design produces items which:

- meet the needs and aspirations of end users/customers; and
- are designed in such a way that the manufacturing process is as simple and cost effective as possible.

The productivity of the manufacturing process can be heavily influenced by design. A good product designer will:

- communicate with the production department during the design process;
- minimize the number of components and the amount of material used in the manufacture of all products;
- use a standard range of components;
- pay attention to the kinds of operation required to produce the finished product and the degree of mechanization or automation that may be possible;
- have regard to existing production facilities.

Some of these functions are the province of the management services or industrial engineering practitioner since they directly affect the productivity of the plant and equipment to be used; product design cannot be tackled in isolation from process design.

**Process design**

Process design is the investigation and selection of the actual production systems and methods and should be simultaneous with product design. Many questions have to be answered before enough information is available for product design (see checklist in the box below).

At the design stage those responsible for process and production planning should work with the design team so that the final design leads naturally to:

- a planned sequence of manufacturing operations;
- optimal work organization;
- a clear understanding of the types and quantities of materials to be used;
- the specification of plant, equipment and tools necessary for the process.
Module 18
Unit 2

Product and process design checklist

Functionality
1. What are the basic functions of the product? (apply value analysis)
2. What are the subsidiary or secondary functions? For example, the product may be a digital watch. The primary function is that of a timepiece but subsidiary functions may include stopwatch, calendar and alarm functions.
3. Can any of the functions be eliminated - do they all add sufficient value to the product?
4. Can any functions be provided in alternative ways? - especially by combining them with other necessary functions.

Materials
1. What materials are used in the product?
2. What is the specification of each material?
3. Can alternative materials or specifications be used - especially cheaper ones - without adversely affecting product quality?
4. Are the materials and specifications standardized with materials and specifications of other products?
5. What is the anticipated scrap or wastage rate; can it be reduced?
6. What indirect materials are used? e.g. for packaging.

Size and specification
1. What are the dimensions of the product? Why?
2. What tolerances are specified? Why?
3. Can standard parts be used?
4. What level of finish is required?

Manufacture
1. Can any operations be eliminated?
2. Can any operations be combined?
3. Can any operations be simplified?
4. Can standard processes be used?
5. Can standard tools, jigs and fixtures be used?

For more detailed information consult Module 10 on industrial engineering techniques.

Effective and appropriate design of the product and the production process gives potential for high productivity.

Production management

The potential for high productivity obtained from careful product and process design is only realized if the operation of the process is adequately planned, managed and controlled. Put in its most simple form, production planning must ensure that:
Module 18
Unit 2

- all required resources are made available at the right time;
- all materials and components are within the operating specification;
- all equipment is operating within its specified performance levels;
- all workers are fully trained and motivated.

It is the role of production management to develop and implement plans to ensure that these conditions are met, and to provide the monitoring and control required to ensure they are adhered to.

2.3 Some ways of improving productivity

Productivity can be improved in a number of ways. Consider an operation which is part of the manufacturing process for a given product.

i. A batch of components is delivered for processing.
ii. When the operators finish the job they are currently working on they set up the machine for this new batch of work.
iii. The operators process the batch of work.
iv. The batch of work awaits collection and transfer to the next operation.

*Productivity will increase if:*

- the batch of components is delivered from the previous operation just in time for this operation to begin;
- the set-up time for the operation can be reduced;
- the process can be performed faster (without affecting quality);
- the batch is collected as soon as it is completed.

Thus, the process should be recorded (perhaps using process charts) and analysed using the method study critical examination procedure to identify possible improvements at any point.

Key points to attack in a productivity improvement programme are:

**Bottlenecks** - where one piece of equipment or operation causes operations later in the process to wait for work. This is often made obvious by queues forming at the bottleneck operation. One solution is to add extra capacity (in the form of additional equipment) but this may be expensive and, since capacity comes in sizeable chunks, may create wasted capacity. Other solutions, such as those below, must then be sought.

**Lead times** - the lead time of an operation is the time from the beginning until the end of the operation. Most operations have “make ready” and “put away” activities associated with them, such as setting up machines, cleaning, etc. Any reduction in these ancillary activities, either by eliminating them or reducing the time they take, can have significant effects on capacity and productivity.

**Idle time** - all production equipment is idle for some of the time - for example, for routine maintenance. However, idle time is also created by poor production management, by poor maintenance (resulting in breakdowns), by poor materials supply, and so on.
A summary of approaches to improving the productivity of plant and equipment is shown in figure 18.3.

**Figure 18.3: Approaches to productivity improvement in production**

2.4 Local measures of productivity

The first step in solving a problem is to identify it. This is the purpose of productivity measurement. Although measures of the productivity of a department or organization as a whole are important in determining the well-being of that department or organization, it is also important to have more localized measures. In terms of production plant and equipment, we may want a measure of each item of plant in a production process. This helps indicate the problems raised above — inefficiencies due to bottlenecks, long lead times and idle time.

The nature of the measures used will depend on the nature of the production process. In flow production systems, where all the equipment is, in effect, part of the same operation, only one measure for the whole process may be needed. In jobbing production, we may need a separate measure for each machine.

One simple, but useful, measure is that of machine efficiency.

\[
\text{Machine efficiency} = \frac{\text{Actual machine usage}}{\text{Machine capacity}}
\]
Machine efficiency is rarely 100 per cent if capacity is taken as full, continuous load since the machine will also be involved in set ups, maintenance, cleaning and so on in addition to unscheduled breakdowns.

An efficiency analysis can be carried out (regularly or as a one-off exercise when a problem is perceived) by comparing the planned levels of each category to the actual levels. The comparison is made in the following way:

<table>
<thead>
<tr>
<th>Machine efficiency analysis</th>
<th>Machine C</th>
<th>Department B15</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard percentage</td>
<td>Actual percentage</td>
<td></td>
</tr>
<tr>
<td>Planned maintenance</td>
<td>2</td>
<td>2.3</td>
<td>+0.3</td>
</tr>
<tr>
<td>Set ups</td>
<td>3</td>
<td>2.6</td>
<td>-0.4</td>
</tr>
<tr>
<td>Waiting time</td>
<td>3</td>
<td>3.6</td>
<td>+0.6</td>
</tr>
<tr>
<td>Breakdown</td>
<td>0</td>
<td>3.0</td>
<td>+3.0</td>
</tr>
<tr>
<td>Working time</td>
<td>92</td>
<td>88.5</td>
<td>-3.5</td>
</tr>
</tbody>
</table>

The table shows the degree to which the planned capacity is being used and the reasons for reduced working time. This can naturally form the basis of further investigation to improve the situation.

Apart from continuous control and improvement of performance, the careful design of production processes is the best guarantee for achieving high levels of productivity and quality.

Questions for discussion

1. What is the distinction between productivity of production and total productivity? How can you measure production productivity?
2. What are the main determinants of production productivity?
3. Discuss the product and process design checklist and think of more questions which are important for your specific conditions.
4. What are the major ways of improving production productivity?
UNIT 3: DESIGNING EFFECTIVE MANUFACTURING PROCESSES

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the main issues involved in production design.

2. Decide on alternatives — to produce or to buy — by comparing expected costs and other factors.

3. Consider different types of production system, their advantages and disadvantages and their potential in productivity improvement.

4. Analyse and suggest improvements in location and layout of facilities and equipment.

UNIT 3: CONTENTS

3.1 Introduction to process design

3.2 Make or buy decisions

3.3 Selecting types of production system and manufacturing method

3.4 Location and layout of facilities

3.5 The process plan
UNIT 3: DESIGNING EFFECTIVE MANUFACTURING PROCESSES

3.1 Introduction to process design

Process design is linked to product design. The nature of the materials, the size and shape of the product will affect decisions on equipment to be used and the economic viability of different process components.

Process design, as with production generally, applies to all organizations - not just manufacturing. Plant and machinery (which form an important part of many production facilities) take many forms — body scanners, computers, ovens, etc. It is not a "once and for all" activity. Processes must be re-evaluated and perhaps redesigned when:

- existing process equipment requires renewal or replacement;
- new technologies become available;
- new forms of work organization are available;
- new products are added to the product range;
- volumes of production change significantly.

Equipment selection influences other resources. One particular process or process stage may be labour intensive but use little energy whereas another may make extensive use of sophisticated equipment but little labour. Therefore relative resource costs, and predicted changes in costs, should influence process design conditions.

Discuss the example in the box below.

Example

A firm makes simple, brightly coloured boxes for storing children's toys. The materials employed are wood and screws. The job can be done manually using simple hand tools but this would be highly labour intensive. Introducing power saws and power screwdrivers increases the capacity per operator but also increases the costs of setting up the process.

Process design decisions are made by considering:

- the cost of providing facilities to carry out the process;
- the material costs incurred within the process;
- the labour costs incurred within the process;
- the material handling costs;
- other operating costs (maintenance, energy, etc.).

Such costs have to be carefully analysed - not least because some of them are large, one-off, capital costs whereas others are annual, repetitive costs. Relative evaluation requires the calculation of payback rates using net present value or discounted cash flow methods.
In order to effectively design a manufacturing process, the following stages should be followed:

i. Work back from finished product to establish component parts and eventually raw materials, using standard components wherever possible. This will have been considered at the product design stage, and information should therefore be readily available.

ii. Take a make or buy decision for each component (see 3.2 below).

iii. Select the type of production system (see section 3.3) and manufacturing methods.

iv. Plan the layout and if necessary the location of facilities and equipment (see section 3.4).

v. Plan the arrangement of each individual workstation.

vi. Prepare a process plan (see section 3.5).

vii. Periodically review the process design.

These stages are explained in more detail in the sections below.

**3.2 Make or buy decisions**

A make or buy decision involves balancing the advantages and disadvantages of each course of action. Buying in components from outside may mean a shorter delivery time and may offer savings on stock-holding costs and administration. Making components gives greater control over the specification and quality of the components and reduces dependence on other organizations. The first stage must be to identify and evaluate feasible manufacturing methods for each component - if these do not exist (within our organization), we must buy in.

The make or buy decision is particularly important with new components and may be heavily influenced by the availability of spare capacity on appropriate equipment.

The final decision will be cost-related. If we buy in, the costs associated with a component are variable - in direct relationship to the quantity (ignoring any quantity discounts on purchase). If we make, there will be fixed costs associated with setting up the appropriate facility and variable costs associated with actual production. It may be possible to express these costs in a simple break-even graph.

A careful evaluation of which parts and components should be manufactured in house and which should be bought in can contribute significantly to improving productivity.

**3.3 Selecting types of production system and manufacturing method**

We have seen so far that decisions about production facilities involve a number of interrelated factors. Process design leads to a specification of the various operations that are required to convert materials and components into finished products. However, the actual method by which these operations are linked depends on the nature of the production system. Selecting the basic type of production is an important stage in creating or improving a production facility which fulfils the twin objectives of meeting customer needs and minimizing operating costs.

There is a wide range of production systems but they can be broadly classified into:
Continuous (C)- systems which operate over long periods of time without significant breaks e.g. flow production lines and chemical processes;

Repetitive (R)- in which the system operates in discrete batches or lots, each of which is similar to previous batches e.g. bread making;

Interruption (I)- in which single items are processed, perhaps to specific client/customer requirements e.g. signwriting and shipbuilding.

These broad categories include “traditional” production systems such as jobbing, batch and flow.

**Jobbing production**

Jobbing production involves the completion of an entire product by a group of operators working within a defined group of production facilities. Jobbing production involves:

- products which are often specifically designed or tailored to the customer’s requirements. Thus, one particular order represents one job that may never be repeated in exactly the same form;
- a highly skilled labour force;
- minimal use of formal systems of production control since the system relies on shop supervision and the skill of the operators;
- use of general purpose equipment and tools since it needs to adapt to each job.

It is a highly flexible form of production in that it can cope with any job in the broad categories in which the organization works. When the job is highly complex and very large, the system is often termed project production and uses project management techniques to plan and control progress (as with shipbuilding or large construction projects).

**Batch production**

Batch production is similar to jobbing production but uses standard components in the production of a wide range of products. In order to move towards economies of scale (but never matching those found in flow production), for example by minimizing set-up times for equipment to work on a different type of component, components are processed in lots or batches and thus some of the flexibility of jobbing production is lost. However, the fixed costs are usually lower. As the batches move from one operation to another, there is inevitable queuing of components and so work-in-progress costs can be high.

**An example of batch production**

A firm manufactures wheelbarrows. Each barrow has two metal handles which are made from metal tubing. The tubing is cut to size from lengths of tubing bought in - the saw produces 40 handles from one length.

This is the batch size. A box of 40 tube lengths is moved from the saw to the bending machine which is the next operation in the production process. No operation takes place until the complete batch of 40 handles has passed through the previous one.
Flow production

Flow production is used for one single item or a small group of products and involves high volume, often round-the-clock, production in which the material/component being processed moves continually from one workstation to the next as each operation is completed. The operations to be carried out on each piece of work must be identical. Such systems use specialized equipment and are therefore capital intensive and relatively inflexible although they can often make use of relatively unskilled labour. They can only be used where there is a high and stable demand for the product.

An example of flow production

A firm makes transformers. Steel coil is fed automatically into a press. Pieces cut from the coil fall down a chute and onto a conveyor where they are moved to the next operation. The next process begins as soon as the first part arrives on the conveyor.

Figure 18.4 illustrates the main qualities of the flow, batch and jobbing production systems, in relation to their classification.

**Figure 18.4: Flow, batch and jobbing production systems**

<table>
<thead>
<tr>
<th>Production system</th>
<th>Classification</th>
<th>Special purpose</th>
<th>Labour skill</th>
<th>Flexibility</th>
<th>Efficiency</th>
<th>Capital intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Batch</td>
<td>Repetitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jobbing</td>
<td>Intermittent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

Hybrid systems

Some of the disadvantages of the various systems have been addressed by the design of hybrid systems. The use of group technology, for example, is a hybrid of batch and flow production in which components are grouped into “families” and items of equipment are grouped into “cells”. Within a cell, a form of flow production is practised on a particular batch of components from a given family.

Similarly, autonomous group working is a hybrid of flow and jobbing systems achieved by breaking a long flow line into a number of self-contained work areas which operate job production.

The functions to be managed, and the resultant productivity issues, will depend on the type of production system. Batch systems, for example, are likely to include the management of input or material stocks; a fast-food chain does not include the distribution of finished goods. In turn, the choice of production system depends on the nature of the output in terms of both product
range and volume. It may also depend on other factors such as the availability of skilled labour and money for capital investment.

The design for a certain type of production system also depends on the available production technology (compare sections on flexible manufacturing systems and computer-integrated manufacturing).

3.4 Location and layout of facilities

3.4.1 Location of facilities

For most organizations, location is a "one-time" decision but for others, such as retail chains opening new branches, it is repeated many times. A location decision might be a determining factor in productivity.

Location may affect:
- fixed costs (e.g. land prices);
- variable costs (e.g. transport costs).

It is itself influenced by:
- process inputs (e.g. the availability of raw materials, labour, notably specialist labour, or a primary energy source);
- process outputs (e.g. the cost of distributing the end product).

Factors that bear on the choice of location apart from the nature of the process and associated inputs and outputs include:

- Internal factors - financial position, culture, tradition;
- External factors - political, economic, social.

These factors change over time and thus the decision to locate in a chosen place may not be absolute or permanent. In some organizations, there is a choice to be made between one large, central location (offering economies of scale in production) and several smaller, dispersed facilities (offering lower transport costs). Again, a relative cost analysis is important as a basis for comparison.

The relative total costs of siting in different locations may depend on the forecast production volumes. One location, for example, may have lower fixed costs but higher variable costs when compared to another. It is possible to express this situation mathematically or graphically as in figure 18.5.
Figure 18.5: Relation between costs and production volume

But we have to be aware that it is not possible to make a decision solely on the basis of cost comparisons.

3.4.2 Layout of facilities

Layout planning is the micro-level location decision. Once we have made the macro-level decision about the site of a production facility (and selected our production process and system), we need to design the relationship between the various items of plant, machinery and equipment within the site.

Layout is important to all organizations. A person working alone in an office must decide where to place the desk, filing cabinets, cupboards, etc. for maximum efficiency. Because the number of variables is low, the problem can usually be solved by trial and error. In a larger organization, the problem is multiplied many times and more systematic techniques are required.

In addition to the situation where we are designing the layout for a totally new production facility, we need to examine layout whenever we change the process in terms of nature or capacity, or whenever we change the product mix.

Objectives of layout planning

The objectives of layout planning are to:
- increase efficiency;
- minimize handling costs;
- minimize congestion;
- increase safety;
- facilitate coordination;
- improve quality of working life (often a by-product rather than a prime aim) remembering that the layout affects both flow of materials and human relationships.

Layout planning is most important for flow and batch production methods. In jobbing production, the variable nature of the processes involved means it is rarely possible to arrive at an optimum layout.
Types of layout

The basic types of layout are:

Process - (also called functional layout) work centres grouped according to the function they carry out with the product moving (normally in batches) from one to another, e.g. all drilling machines together; all milling machines together;
- normally suitable for small quantities of a large range of products (as in jobbing production);
- more flexible than other forms of layout and allows for specialist supervision but may increase throughput times, work-in-progress and handling costs.

Product - for small numbers of large volume, standardized products;
- work centres provide sequence of operations needed to produce an entire product and the product is moved continuously along the work centres;
- gives opportunities for mechanization and automation of both manufacturing and handling and if there is only one product, it may result in mass or flow production;
- inherently inflexible and requires a stable and secure demand for the (range of) product(s).

Fixed position (special form of product layout)
- material or major product remains fixed and services (labour, other materials, etc.) are brought to it; e.g. shipbuilding, agriculture;
- used where the costs of moving the product are exceptionally high;
- may be used in industry for prototyping of new products.

These different basic layout types may each become economically viable for a different product range/volume mix. As production volumes rise, and especially if the range is not large, there is generally an increasing advantage to product layout.

Figures 18.6 and 18.7 show the flow of materials through a process layout and a product layout; the advantages and disadvantages of process and product layouts are summarized in figure 18.8.

The same classification of layouts applies to service organizations. Hospitals, for example, can be considered as process layouts since they have separate areas for different functional activities such as X-ray, surgery, pathology, pharmacy, etc.

There are a number of techniques which can be used to provide information to assist in layout planning once the basic form of layout has been determined. The aim of such techniques is normally to arrive at a shortlist of layouts and then to evaluate them in terms of:

- establishment costs (building/alteration costs);
- installation costs (including service provision);
- operating costs (costs of space, transport, labour, services, etc.);

and to include other considerations such as safety and environmental factors.
Obviously, layout is also constrained by existing buildings and services, which may make it too costly to redesign or reroute.

**Figure 18.6: Flow through a process layout**

![Diagram of process flow through a process layout](image)
Travel chart

A travel chart is a device for analysing the amount of movement between a number of stations in a production process. The actual movement may be obtained by analysing historical records, by observation or by studying the detailed production specification. Each journey between any two locations is recorded on the chart against the appropriate journey start and end points. In some cases it is sufficient just to record the number of journeys (for example, for people moving in a large office); in others the number must be modified by the load being moved - e.g. number of pallets or weight of material moved. A simple travel chart is shown in figure 18.9.
The travel chart immediately shows up any backtracking (any entry below the diagonal indicates backward movement) but also shows the nature of the production process - in a flow production system, all entries would be just above the diagonal since all items follow the same route.

**Relationship chart**

In order to make this information more useful for determining layout, the next step (especially where the travel chart is more complex than the simple one shown) is to construct a relationship chart in which additional information about the process is combined with data from the travel chart to make recommendations about “priority for proximity” - which stations in the process must be near to other stations.

For example, we can see that in our example it is most important that the “Goods received” section and the “Stores” are close to one another, since the greatest number of journeys is made between these two stations.

Similarly, it is irrelevant whether the “Goods received” section is near to the “Milling shop” since there are no direct journeys between these two places. The relationship chart derived from the travel chart is shown in figure 18.10.
The number of journeys made is not the only determining factor, as shown by the inclusion of a category of "Undesirable" for proximity — this could exist where there is noise, smell, heat, vibration, etc.

These two charts between them provide useful information on which to base a provisional layout. This is often done simply by using a scale drawing of the area and templates to represent particular items of equipment, but it can involve three-dimensional models or even computer layout planning. The provisional layout must then be analysed and discussed before a final layout is established and specified.

Over time, changes may invalidate a layout — it should therefore be re-examined periodically.

Exercise 1

Participants should work in groups to identify the factors that would be important in choosing the location of a new:

- hamburger restaurant;
- car manufacturing plant;
- airport;
- hospital.

Exercise 2

Work through the location example below.

Prepare a list of equipment/facilities to be located in a new kitchen. Identify which should be located near to or far away from each other. (Consider the process of preparing a dinner and clearing away afterwards).

Identify whether this is a product or process layout. Would the layout be different for a household kitchen and for a large hotel/restaurant?

Materials handling

Any layout will involve the movement of materials and components either to or between workstations. In many organizations, materials handling is an important part of the production process and is often a high-cost factor in production. Flow production relies very much on the continual movement of materials; batch and jobbing production involve intermittent movement of the batches themselves and of the supply of materials and parts. In some cases, such as transport service organizations, materials handling is the main reason for the organization’s existence; in others it may be a major activity or a major production process in its own right (e.g. airport baggage handling, mail order services).
Effective materials handling:

- reduces production delays;
- minimizes work-in-progress;
- increases effective capacity;
- reduces stock levels;
- contributes towards safe working practices;

and thus has a major effect on productivity.

In almost all situations, a number of alternative handling strategies are available - some of which (rather like production processes themselves) will require large capital investment, while others will require significant labour input. Hopefully, the layout will have been designed in such a way as to eliminate handling wherever possible and to minimize it generally. The handling that remains should be only what is essential to meet the type of production system involved and the handling itself must then be designed in such a way as to be effective and efficient. In practice, the handling system will normally be designed at the same time as the production process and layout, but, as with production, changes in circumstances and in technology mean that it is important to keep handling methods under review.

The choice of handling technologies depends on:

- the variety of goods to be moved;
- the volume of goods to be moved;
- the nature of the goods to be moved (form, size, weight, volume);
- the stability of the production process;
- the way in which the goods are delivered;
- the way in which the goods are stored;
- the degree to which movement routes can be predicted;
- building constraints (levels, area, pillars, etc.);
- whether any part of the production process can be carried out during movement (e.g. painting, drying).

It is important to make a choice between specialist handling methods which are designed for a particular form of material, and general purpose, more flexible methods which can cope with a variety of materials.

One common approach is to determine a “standard load” and to build handling systems which can cope with this load. Palletization is the most common example of this approach. A variety of materials can be palletized and the same handling methods can then be used on any pallet.

A pallet load is, however, a batch. While the batch is being accumulated, some materials or parts are waiting and work-in-progress is increased. A conveyor system which moves the parts as they are produced reduces this work-in-progress and should therefore be considered where the value of the materials/parts justifies the investment.

The aim should be to establish an integrated production process, layout and handling
system to minimize movement distance and time.

Approach to layout problems

Summarizing the above, we can lay down a basic approach to dealing with layout problems.

1. Determine the production method.
2. Determine the production capacities of each type of machine.
3. Calculate the number of machines of each type required (consider allowing room for expansion).
4. Determine the basic handling methods.
5. Determine the space requirements of each type of machine - allowing room for materials movement to/from the machine - to allow safe working conditions.
6. Determine the space requirements of the handling systems (e.g. space for conveyors or routes for trucks).
7. Work out the space required for work-in-progress/buffer stocks.
8. Work out the proximity relationships of the various machines/sections according to the process and material flows.
9. Draw up a scale plan of the area, clearly showing doorways, pillars and columns, windows, etc.
10. Construct templates of all units that are to be included in the layout - for a process layout, this may be a group of machines.
11. Place the templates on the plan according to the relationship priorities (start by placing the final production stage near the finished goods store or an exit).

Principles of effective materials handling systems

1. Eliminate handling wherever possible by good process design and by identifying and eliminating unnecessary movement.
2. Move goods while they are being processed if possible.
3. Plan the layout of facilities to minimize handling occasions (number of pick-ups and put-downs) and transport distances.
4. Do not mix items which must be separated later.
5. Use unit loads to allow handling systems to cope with a range of materials.
6. Use handling systems that protect goods in transport.
7. Do not use handling systems for storing goods but do integrate handling and storage systems to avoid/minimize unloading and reloading into stores.
9. Use straight line movements where possible.
10. Use gravity where appropriate - avoid lifting materials vertically up buildings more than once, preferably at the start of any process.
11. Except in flow production systems, let the handling/movement of goods be controlled by the receiving production facility, not the dispatching one.
Exercise 3

Five sites have been considered for the location of a new production facility for Aurocama International. Initial investigations have cut these down to two possible sites in Drensburgh and Philmon. The costs of these two locations have been summarized as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Establishment costs</th>
<th>Annual fixed costs</th>
<th>Variable costs/1,000 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drensburgh</td>
<td>$1,500,000</td>
<td>$800,000</td>
<td>$7,000</td>
</tr>
<tr>
<td>Philmon</td>
<td>$1,950,000</td>
<td>$825,000</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

The establishment costs will be spread over three years, and anticipated production volume is in the range 75,000 to 125,000 units per year.

A. Draw a graph to illustrate the annual cost figures for different production volumes assuming that the establishment costs can be regarded as one-third of total establishment costs to be recovered each year.

B. If the final demand for the goods (and hence the production volume) turns out to be 90,000 units, which of the two locations offers the lowest costs?

Discuss the problem in small groups.
Make sure that everybody understands the problem and the nature of the graph they have to construct.
Draw the graph on a flipchart.
Check your graph and make sure that the graphs are identical in all groups.
Answer question B.
Discuss the problems associated with obtaining the data that are used in the problem.

See the solution to this exercise in the Appendix to Unit 3.

3.5 The process plan

After completing all the previous steps in designing or redesigning a manufacturing process, we are able to define the process plan.

The process plan is the result of process design and should show:

- departments/sections/shops in which manufacturing processes take place;
- sequence of activities/operations;
- type/quantity of materials used;
- plant and equipment used for each operation;
- jigs, fixtures and tools used for each operation;
- optimum equipment settings;
- type and quantity of labour required;
- estimated completion time for each operation.

When designing a production process or facility for a new product, it may be necessary to model the major factors involved and to manipulate the model to discover the implications of such factors as volume changes, alternative sequencing, different handling methods, etc. It may be possible to use a computer to simulate the production process; in such cases it is possible to evaluate alternative scenarios very rapidly and provide much better information for decision making.

The last step of our design methodology for manufacturing processes consists of periodically reviewing the process design. The design may be reviewed by industrial engineers or through small group activities and suggestion schemes (compare Module 7 on organizing a company productivity and quality movement).

Questions for discussion

1. What is the essence and purpose of process design? How does it relate to productivity?
2. Why is it important to compare different alternatives of the production process and outsourcing?
3. What are the main factors and criteria to be used when selecting the best type of production systems in specific circumstances?
4. How can better location and layout of production facilities influence productivity?
5. What are the main elements of the production process plan? Explain their roles.
Exercise solution

Drensburgh  Establishment costs  $1,500,000
  Establishment costs/year  $500,000
  assuming 3-year payback  $800,000

  Total annual fixed costs  $1,300,000

  Variable costs/1,000 units  $7,000

Therefore:

<table>
<thead>
<tr>
<th>Production volume</th>
<th>Variable costs ($000)</th>
<th>Total costs ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75,000</td>
<td>25</td>
<td>1,825</td>
</tr>
<tr>
<td>85,000</td>
<td>595</td>
<td>1,895</td>
</tr>
<tr>
<td>95,000</td>
<td>665</td>
<td>1,965</td>
</tr>
<tr>
<td>105,000</td>
<td>735</td>
<td>2,035</td>
</tr>
<tr>
<td>115,000</td>
<td>805</td>
<td>2,105</td>
</tr>
<tr>
<td>125,000</td>
<td>875</td>
<td>2,175</td>
</tr>
</tbody>
</table>

Philmon  Establishment costs  $1,950,000
  Establishment costs/year  $650,000
  assuming 3-year payback  $825,000

  Total annual fixed costs  $1,475,000

  Variable costs/1,000 units  $5,000

Therefore:

<table>
<thead>
<tr>
<th>Production volume</th>
<th>Variable costs ($000)</th>
<th>Total costs ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75,000</td>
<td>375</td>
<td>1,850</td>
</tr>
<tr>
<td>85,000</td>
<td>425</td>
<td>1,900</td>
</tr>
<tr>
<td>95,000</td>
<td>475</td>
<td>1,950</td>
</tr>
<tr>
<td>105,000</td>
<td>525</td>
<td>2,000</td>
</tr>
<tr>
<td>115,000</td>
<td>575</td>
<td>2,050</td>
</tr>
<tr>
<td>125,000</td>
<td>625</td>
<td>2,100</td>
</tr>
</tbody>
</table>

A. The graph should look like the one in figure 18.11.

B. If the final production volume is 90,000 units, from the graph it can be seen that the Philmon site will offer the lower costs.
Figure 18.11: Annual cost figures for different production volumes

<table>
<thead>
<tr>
<th>Production Volume (000 Units)</th>
<th>Total Costs ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>2.2</td>
</tr>
<tr>
<td>105</td>
<td>2.1</td>
</tr>
<tr>
<td>115</td>
<td>2.0</td>
</tr>
<tr>
<td>85</td>
<td>1.9</td>
</tr>
<tr>
<td>75</td>
<td>1.875</td>
</tr>
</tbody>
</table>

- DRENSBURGH
- PHILMON
UNIT 4: WORKSTATION DESIGN: ERGONOMICS AND SAFETY

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the main ergonomic principles and criteria for workplace design.
2. Check the status of visual conditions at the workplace, identify problems and suggest solutions.
3. Advise on how to avoid or reduce strenuous work through workplace design.
4. Understand the ergonomic principles for signals displays and panels design.

UNIT 4: CONTENTS

4.1 Working positions: Standing and sitting
4.2 Visual conditions
4.3 Strenuous work
4.4 Design of controls and tools
4.5 Signal displays and panels
UNIT 4: WORKSTATION DESIGN: ERGONOMICS AND SAFETY

Modern technology is increasingly exceeding people’s ability to adapt, both physically and mentally, to change. Heavy manual work still occurs, but many modern jobs require the repetition of simple operations or just the monitoring of a production process.

Reduced productivity and many common illnesses result from inappropriate human-work relationships.

4.1 Working positions: Standing and sitting

Standing position

A job that involves standing all day puts a lot of strain on the legs. This may result in swelling, insufficient supply of blood to the muscles, and fatigue. Jobs requiring a lot of movement and considerable stretching of muscles are often performed in a standing posture.

In any standing work, bending of the back should be avoided. Leaning forward or to one side causes the muscles in the legs, back and shoulders to be tightened to hold the body in that position. Continuous bending causes the back muscles to be strained. Straightening up again causes pains in the back as it has stiffened into a fixed position.

It is impossible to stand at ease if the working height is not set correctly, or if the controls, materials and tools to be used are not within easy reach. There should be plenty of foot room, as this allows the working position to be altered and loads to be evenly distributed.

Standing on one leg can lead to load pressure on the hip joint which is equal to two and a half times the weight of the body. This can occur if a standing worker has to operate a badly positioned foot pedal.

The working height is also important. If it is incorrect, the body quickly tires. The working height should be such that the job can be done with the back straight and the shoulders relaxed.

The work should be done with a natural hand position as close to the body as possible. Different types of work require different working heights. If the work demands precision, where vision is important, then the working height should be higher. Precision work often also requires support for the arms. Where heavy work is involved, the working height should be low enough to allow the workers to use their body weight to the best advantage.

It is important when working in a standing position that:

- the tools needed for the job are within easy reach;
- the height of the work table is adjusted to the height of the workers, so that the working surface is at elbow level;
- the workers should stand immediately in front of and close up to the work table/bench with their weight evenly distributed on both feet. There should be enough room for their legs and
feet;
- controls such as levers or switches should be lower than shoulder height;
- the surface that the workers are standing on should be suitable for the working conditions.

It should be noted that the special nature of any particular job may mean changing the working height.

**Sitting position**

Work which does not require a lot of muscular effort and which can be performed within a limited area should be done in a sitting position. It should be possible to reach the entire work area without unnecessary stretching or twisting.

A good sitting position means that the person is sitting straight in front of and close to the work. The work table and chair should be designed so that the working surface is just at elbow level.

The design of the chair should satisfy certain basic requirements; it should be possible to adjust the height of the chair. Sufficient leg room is necessary to allow free change of leg positions. The chair height should be most comfortable when the feet are placed flat on the floor. When this is not possible, a foot rest can sometimes improve seating comfort.

**4.2 Visual conditions**

It is essential for workers to see clearly. Most objects should be 50 cm away from the eyes, providing that they are not too small. If the objects are very small they should be placed on a raised surface or it may even be necessary to use some form of magnifying glass. Otherwise workers have to lean forward with the head bent, putting an unnecessary strain on the neck.

Operating sophisticated equipment such as microscopes or computer display units while sitting puts enormous demands on the worker. This form of static load on the eye muscles causes headache and eye strain. Further complications in this type of work are repetitive finger movements and restricted posture. The results are pain in the hands and arms; muscle stiffness; and aching back and shoulders. In addition to visual and postural conditions, display unit operators should be given frequent breaks to avoid excessive fatigue.

Discomfort caused by sitting at machines or VDUs can be resolved in the following ways:

- careful adjustment of the display or lens conditions to suit individual vision;
- adjustment of the eye-to-display distance and the display positions to suit the individual worker;
- adjustment of general lighting in the workplace to the quality of illumination required, or the provision of special lighting in the work areas;
- variations in the work, so that it is possible to have adequate rest from tasks which put a strain on the eyes;
- ensuring that individuals have the right to take a break in a separate room in order to rest
their eyes;
- ensuring that the work chair is adjusted to a suitable height and that the sitting position is comfortable.

Another cause of uncomfortable working positions is protruding machine parts, which force workers to twist the body in order to “look around the corner”.

4.3 Strenuous work

Heavy work: Continuous heavy manual work increases the rate of breathing and the heart beat. If workers are not in good physical shape, they will tire easily. The use of mechanical power to replace heavy work helps reduce these risks, and increases the work opportunities for people with less muscle power.

Static loads: The most natural way to work is to move rhythmically. This “dynamic” load enables the muscles to alternate between contraction and relaxation. If an object is lifted up and held, this puts the muscles under a uniform “static” load. Muscles under static load become tired because they are continually contracted. After a short time the muscles feel painful. A static load on the muscles over a long period of time will also increase pressure on the heart.

Lifting: Lifting and carrying heavy loads manually should be avoided. Lifting should be performed by mechanical devices as much as possible. Otherwise, several people should help. It is important that everybody works together and uses the correct lifting methods.

4.4 Design of controls and tools

Controls: It is important that control switches, levers and knobs of different kinds are within easy reach of the operator in a normal standing or sitting posture. Frequently, many of the controls on a lathe or similar machines are below waist height and at more than arm’s reach from the operator.

Further requirements of control include:

- selection of adequate types of control (e.g., hand controls for precision of high-speed operation and foot controls for larger force operation; there should be no more than one pedal per operator);
- a distinction between emergency controls and those which are used in normal operations (by separation, colour coding, clear labelling or guarding);
- prevention of accidental activation of controls (by proper spacing, adequate resistance, recesses or shields);
- adequate resistance in operation, with a clear indication of activation of the controls;
- operating procedures which are easy to understand according to common sense (knobs on electrical equipment to turn clockwise for “on” and “increase”, but valves turn counterclockwise for “open”, etc.).

Operating procedures based on common sense are very important. In a hurried situation or
an emergency, people tend to operate important controls as they would normally react. Common sense reactions may differ among countries. Sometimes, “on” and “off” switch positions can even be reversed. It is important to ensure that operating directions are compatible with common sense and do not entail any danger by mistaken operations. If a piece of equipment is purchased that does not conform to the local custom for movement, it should be very clearly labelled to indicate “on” and “off” actions.

Hand tool selection: The design of hand tools can affect the productivity and health of an operator if they do not fit the individual or task. Poor quality tools must be avoided. In most instances tools are bought from an outside vendor. The following considerations are important in selecting and using hand tools:

- avoid static load on the shoulder or arm due to continuous holding of the tool in a raised position or gripping of a heavy tool (proper arm position and adequate weight);
- avoid awkward wrist angles (while using tin snips, pliers, etc.);
- reduce uncomfortable pressure on the palm or joints (caused by pliers which are too small);
- avoid pinch points (as with double-handed tools such as tin snips, scissors);
- make handles easy to grasp, with good electrical insulation and without sharp edges or corners;
- consider special-purpose tools for repeated actions, e.g. a soldering iron with a bent tip, a tool holder for using a chisel, etc.

4.5 Signal displays and panels

It is easy to react to one clear signal. It takes a fraction of a second to press a button when a signal lamp lights and mistakes rarely occur. However, things become more difficult if it is necessary to make a choice before acting (for example, if the worker has to notice a red lamp flashing among several lamps of different colours before pressing a button). Consequently all the information and signal systems used to initiate subsequent operations should be as simple as possible.

In order to be able to read instruments rapidly it is important that:

- the instrument panels are sufficiently large and clear;
- the instruments are clearly marked and placed according to work process or category;
- all gauges turn in the same direction;
- all gauges are easy to read instantly when pointing at the normal functioning position (e.g. by marking of target zones).

All signals and information displayed to the operator must be easily distinguishable. This can be done by the proper placement of display positions and by changing the size, shape or colours of the displays. Good ways to do this include:

- placing the instruments or indicators in logical sequence or in correspondence with the machines they represent;
- locating frequently used signals between work table height and eye level;
- changing the size, shape or colour for different categories of instruments or indicators;
Module 18
Unit 4

- using simple words or abbreviations to mark each instrument or indicator clearly;
- removing or covering unused displays;
- distinguishing emergency signals by their position, size and colour;
- using signal lights of different colours where appropriate.

Questions for discussion

1. What are the most important ergonomic principles in workplace design for standing and sitting positions?
2. What are the most important visual conditions for safe work and efficient performance?
3. What are possible tools to reduce strenuous work and fatigue?
4. What are the common principles in designing signals and panels?
UNIT 5: PRODUCTION PLANNING AND CONTROL

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Describe the main structure and activities in production planning.

2. Understand and participate in production capacity planning, and explain its links to productivity improvement.

3. Know and use production scheduling techniques.

4. Understand and use production control to improve the utilization of production capacities.

UNIT 5: CONTENTS

5.1 The production planning process

5.2 Capacity planning

5.3 Aggregate capacity planning example

5.4 Production scheduling

5.5 Production control
UNIT 5: PRODUCTION PLANNING AND CONTROL

5.1 The production planning process

Production planning consists of all those activities which are necessary after the product and process design stages to ensure that efficient and effective production takes place. Assuming we are starting to manufacture a new television set, and that we have designed the set and the basic production process, we need to:

- identify all the materials, parts and components that make up the set;
- decide which to make and which to buy in;
- ensure a consistent and reliable supply of all bought-in materials and components;
- ensure that we have the manufacturing capacity to meet anticipated demand;
- obtain a delivery schedule from the marketing/sales department;
- ensure that we know the time taken for each stage of the manufacturing process;
- construct a schedule of work in each of the manufacturing facilities;
- check that a purchasing/stock regime will ensure delivery of the materials and components at the appropriate time;
- produce a control system that ensures that all planned activities take place according to the schedule.

A diagram representing a very basic outline of the production planning process is shown in figure 18.12.

Figure 18.12: Production planning
5.2 Capacity planning

Capacity is usually regarded as the designed, theoretical maximum rate of output of a facility. Actual capability to produce depends on this capacity figure but also on efficiency, absenteeism, reliability, etc.

Capacity planning can be regarded as the fundamental responsibility of production management. The starting point for planning a production facility must be the quantity to be produced in a given time scale - a forecast of product demand. Forecasting involves the statistical analysis of past data to give an estimate of future activity. Thus, we must have data available or else rely on predictions, which often give less reliable results.

Once we have a reliable forecast of future demand, we must check that we can produce goods to meet that demand. This is capacity or aggregate planning. At its most simple level, this means translating product demand into machine time and work-hours to satisfy that level of demand, and comparing the results with the available machine time and work-hours of present production facilities. The productivity of production facilities is vitally important. High productivity means we can meet the same level of demand with fewer resources.

Capacity planning at its most general can be summarized as:

- assessing present capacity;
- forecasting future demand over the planning timescale;
- identifying ways of bridging the “gap”;  
- evaluating the different ways;
- choosing a solution to provide required capacity.

When the demand and capacity analyses have been carried out, we can construct integrated sales and production plans, as shown in figure 18.13.

**Figure 18.13: Integration of sales and capacity plans**

```
DEMAND FORECASTING

MARKETING PROGRAMME (advertising, promotion)  CAPACITY ANALYSIS

CAPACITY PLANNING

SALES PLAN  PRODUCTION PLAN
```
We also need to know how the demand fluctuates over the time period - whether it suffers from peaks and troughs, whether there is a set cycle and so on. We need long-range demand forecasts for capacity planning and shorter-range forecasts for scheduling production.

Aggregate production planning (i.e. numbers of cars or gallons of beer) refers to planning the whole output of the organization, and arises from the business plan. Aggregate production gives rise to capacity planning which in turn gives rise to the master production schedule (the MPS) breaking down the aggregate to the level of individual products. The MPS leads into materials requirements planning (MRP), concerned with materials and inventories. The final stages involve shop floor sequencing and scheduling.

Where there is a mismatch between capacity and demand, planning can:

- modify demand (by pricing, promotion, stock); or
- modify supply (overtime, short-time, using stock, contracting).

Inventory control can be a major part of capacity planning - (buffer) stocks can be used as protection against plant or equipment failure; as decoupling mechanisms in a production system to ensure that the failure of one part of a system does not cause the entire system to stand idle; and simply for production smoothing, to give constant production levels while actual demand fluctuates.

Decisions on capacity adjustment eventually lead to a situation where we decide on the level of production we can realistically meet - this is the outline production plan and is normally a series of simple aggregate targets, set at quarterly or monthly intervals.

This planning of capacity is best done by use of a “unit load”, which can often be a physical unit such as number of cars. Where a mix of products is involved in the same production facility, some “typical mix” may be identified so that the target becomes a total of 1,000 units made up of individual products in the same proportions as will be made in the planning period. As the planning gets increasingly detailed, standard hours may be used as the planning unit.

The master production schedule, the next stage of the planning process, must focus on individual products or parts that are sold directly to customers. This can then be translated into a materials requirement plan and detailed production schedules.

The master production schedule (MPS) specifies the quantity of each item to be produced within the planning timescale (often one year). Changes to the MPS are possible during its period of operation but changes should only be made to the later stages of the schedule except in real emergency. From the MPS, using the component list for each product (often called a bill of materials) and knowing the lead time for each component, we can work back to the intermediate times when components and materials need to be available. Manufacturing or purchasing and inventory decisions must then be made. This whole process is known as materials requirements planning (MRP) and the combination of the MPS and MRP gives rise to detailed purchasing and production schedules.
Production planning and productivity

In order to achieve high productivity, planning must ensure that all resources are effectively used. Most operations will consume some labour and make use of some plant and equipment. Where the plant is sophisticated and expensive, it is vital that it be used to the fullest level. Production planning and scheduling must ensure this. Where the plant and equipment are simple, it may be more important to concentrate on high levels of labour utilization.

In all production systems the time taken to produce goods from raw materials is less than the time that the materials spend in the plant. Materials spend time in stores and as work-in-progress. Often the time from receiving a customer order to fulfilling the order is many times longer than the production time. Therefore it is necessary to address both working time and non-working time in any productivity improvement process.

Production planning must therefore be concerned with minimizing time between operations as well as minimizing time spent on the operations. As with many other areas of production, there is a balance to be struck. In order to achieve high utilization of equipment, it is necessary to ensure that the equipment does not wait for materials and parts to arrive. This is achieved by having a sound inventory policy and effective materials handling and control. However inventory incurs cost - and thus contributes to the denominator of the productivity ratio by consuming resources. The relative costs of stock holding and underutilized equipment must be known and taken into account when planning and scheduling work.

5.3 Aggregate capacity planning example

Consider a company which manufactures products according to the structure in figure 18.14.

Figure 18.14: Display of product structures

<table>
<thead>
<tr>
<th>Product Group</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sub-assembly</td>
<td>S1 S2 S3 S1 S3</td>
<td>S4 S5 S6 S4 S6</td>
</tr>
<tr>
<td>Component</td>
<td>C1 C2 C3 C4 C5</td>
<td>C1 C2 C3 C5</td>
</tr>
</tbody>
</table>
Aggregated capacity planning will probably be carried out at product group level, e.g. a given facility (F1) takes:

- 3 minutes to produce 1 item of component C1
- 2 minutes to produce 1 item of component C2
- 3 minutes to produce 1 item of component C3
- 3.5 minutes to produce 1 item of component C4
- 2.5 minutes to produce 1 item of component C5

A planning unit is used, of 1,000 units of product group A in a (typical) ratio of:

<table>
<thead>
<tr>
<th>Product</th>
<th>1 - 50%</th>
<th>2 - 30%</th>
<th>3 - 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product 1 (50% of 1,000)</td>
<td>500 units</td>
<td>300 units</td>
<td>200 units</td>
</tr>
<tr>
<td>Component usage per planning unit is:</td>
<td>= 500 x C1</td>
<td>= 300 x C4</td>
<td>= 200 x C3</td>
</tr>
<tr>
<td>= 500 x C2</td>
<td>= 300 x C5</td>
<td>= 200 x C5</td>
<td></td>
</tr>
<tr>
<td>= 500 x C3</td>
<td>= 300 x C3</td>
<td>= 200 x C3</td>
<td></td>
</tr>
<tr>
<td>= 500 x C4</td>
<td>= 300 x C5</td>
<td>= 200 x C5</td>
<td></td>
</tr>
</tbody>
</table>

Totals = 700 x C1 = 700 x C2 = 1200 x C3 = 800 x C4 = 1300 x C5

The capacity of facility F1 required for this planning unit is:

<table>
<thead>
<tr>
<th>Component</th>
<th>Usage</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>700 units x 3 minutes</td>
<td>2100 minutes</td>
</tr>
<tr>
<td>C2</td>
<td>700 units x 2 minutes</td>
<td>1400 minutes</td>
</tr>
<tr>
<td>C3</td>
<td>1200 units x 3 minutes</td>
<td>3600 minutes</td>
</tr>
<tr>
<td>C4</td>
<td>800 units x 3.5 minutes</td>
<td>2800 minutes</td>
</tr>
<tr>
<td>C5</td>
<td>1300 units x 2.5 minutes</td>
<td>3250 minutes</td>
</tr>
</tbody>
</table>

Total = 13150 minutes = 220 hours
A similar exercise gives a product demand estimated as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Group A</td>
<td>1240</td>
<td>1380</td>
<td>1500</td>
<td>1380</td>
</tr>
<tr>
<td>Product Group B</td>
<td>1010</td>
<td>1180</td>
<td>1200</td>
<td>1180</td>
</tr>
</tbody>
</table>

The capacity required to meet the demand for Product Group A in Period 1 is 1240 units at 220 hours/1000 units, therefore:

\[
\text{Capacity} = \frac{1240 \times 220}{1000} = 272.8 \text{ hours (approx. 273 hours)}
\]

Similarly, the capacity required to meet the demand for Product Group B Period 1 is 1010 hours but at 150 hours/1000 units, therefore:

\[
\text{Capacity} = \frac{1010 \times 150}{1000} = 151.5 \text{ hours (approx. 152 hours)}
\]

Approximate capacity required is therefore:

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Group A</td>
<td>273</td>
<td>304</td>
<td>330</td>
<td>304</td>
</tr>
<tr>
<td>Product Group B</td>
<td>152</td>
<td>177</td>
<td>180</td>
<td>177</td>
</tr>
<tr>
<td>Total requirement</td>
<td>425</td>
<td>481</td>
<td>510</td>
<td>481</td>
</tr>
</tbody>
</table>

If Facility 1 normally operates for 40 hours per week and we assume 13 weeks per period (except for period 3 when there is a 2-week maintenance shutdown) and a utilization of 96% (allowing for breakdowns and changeovers), then:

in Period 1, capacity available = 13 weeks x 40 hours x 96 per cent = 499 hours

and overall:

<table>
<thead>
<tr>
<th>Facility 1</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity required</td>
<td>425</td>
<td>481</td>
<td>510</td>
<td>481</td>
</tr>
<tr>
<td>Capacity available</td>
<td>499</td>
<td>499</td>
<td>422</td>
<td>499</td>
</tr>
<tr>
<td>Variance</td>
<td>74</td>
<td>18</td>
<td>-88</td>
<td>18</td>
</tr>
<tr>
<td>Cumulative variance</td>
<td>74</td>
<td>92</td>
<td>4</td>
<td>22</td>
</tr>
</tbody>
</table>
A negative cumulative variance would indicate an inability to meet demand. The cumulative variance of only plus 4 in the third period, here, indicates a borderline situation which could be affected by minor changes in the utilization level of the facility.

A negative variance in any one period indicates a need to build up stocks in earlier periods to help meet demand. In this case, spare capacity in periods 1 and 2 must be used to build up enough stock to cope with undercapacity in period 3.

In reality, stocks carried forward into the new production year would affect the situation and would have to be taken into account.

5.4 Production scheduling

Scheduling relates to the issue of work to machines and facilities at predefined times; it gives target dates for each operation in a process.

With jobbing production where each job is produced to an agreed customer specification, this is done simply on the basis of delivery dates agreed with the customer - the customer order is, in effect, the schedule. With other forms of production, different customer orders may be batched for efficiency and orders may be made for stock. So although scheduling can sometimes be done by arranging production to meet customer requirements directly if they are relatively even over time, we may use inventory management (or other devices) to smooth out variations in customer-driven flow.

We require information about operation and activity capacities and durations, including:

- materials procurement;
- production;
- distribution.

Capacities and durations are obviously affected by the economies of operations, which are themselves affected by batch sizes.

Gantt charts

The simplest scheduling technique is the Gantt or bar chart on which the various stages of procurement and production are represented by a bar against a common time scale. In the most straightforward cases, this is achieved by starting with the delivery date and working backwards towards the starting point for the process, this is known as reverse scheduling.

The matter is complicated by batch sizes. Large batch sizes may be the most efficient in terms of minimizing set-up times but they can reduce flexibility and lengthen overall completion times.

Assume we have a batch of 100 components to go through five production operations, where the material is provided from stock so there is no material procurement time.
Also assume that the operation completion times are:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Duration (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

A Gantt chart for this simple example is shown in figure 18.15.

However if the result is unacceptable since the completion date is later than the customer's specification, we could decide to go for two batches (A and B) of 50 components each. Assuming that the additional set-up time, although costly, may not be significant (i.e. is measured in hours rather than weeks), we can arrive at an amended chart as shown in figure 18.16. This gives a reduction in overall completion time from 18 to 12 weeks (although the facilities may not now be as conveniently available for other work).

**Figure 18.15: Gantt chart for the manufacturing of one batch**

**Figure 18.16: Gantt chart showing lead time shortened by producing in two batches**
There are a number of alternative forms, such as starting the second batch on Operation 1 as soon as the first batch is finished. All versions will create some idle time on the production facilities. The “best solution” may be one that fits in best with batches of other components that can be used to “plug the gaps”.

Scheduling is thus a complex process and organizations may make use of particular planning and scheduling methodologies. One increasingly common approach is just-in-time manufacturing or JIT.

JIT started basically as an inventory and delivery programme in which small amounts of materials and components are delivered exactly where and when they are required for the manufacturing process to continue uninterrupted. JIT results in smaller stock levels but requires highly disciplined ordering procedures and supplier cooperation. Thus, JIT is often seen as part of a wider programme of quality and procedural improvement; if this is not the case there is a tendency for a large organization simply to shift the burden of carrying inventory from themselves to the supplier. JIT should relate to a number of areas of the organization and not be limited to stock-holding policy. Production scheduling is a complex topic, and further reading is suggested in the bibliography at the end of this module.

Dispatching

When the production plan and schedule are drawn up, the next stage is to put them into effect by issuing manufacturing instructions. In flow production, this is a simple task but in jobbing production it can be complex.

The documentation may include:

- works orders to the production department;
- material release notes to the stores;
- orders for the tool stores;
- job cards which travel with the batch of work;
- schedules or load charts for machines or facilities which show the relationships between various jobs released.

Exercise: Gantt chart

A production system involves operations on a batch of 1,000 components as follows:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Duration (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
</tr>
</tbody>
</table>

Draw a Gantt chart to represent the progress of the batch through the process.
Draw a separate chart to represent the situation if the work is split into two batches of 500 components.

a) Use the charts to show the overall completion times.
b) What factors may affect the decision to split the original batch of 1,000?

Check your solutions with those given in the Appendix to this unit.

5.5 Production control

Controlling the productivity of equipment and facilities involves both production activity control, in terms of ensuring that deviations from the production plan and schedule are monitored and corrected, and control of the production facilities themselves.

Few systems operate exactly according to plan. Unexpected (and in many cases unavoidable) events cause actual results to deviate from planned results. The purpose of production control is to identify such deviations rapidly and to take action to correct them. However, it must be stressed that good production control is made much easier by good production planning.

Identification of deviation requires the monitoring of operations and the provision of performance data. The simplest form of control is to use the delivery dates themselves and to compare actual output up to those dates with planned output. In practice, information obtained at this stage is often too late to be of real benefit - monitoring must take place at intermediate points in the production process. Most production systems use some form of reporting at a number of key points to provide monitoring information. Such reporting systems may be clerical (in which production operators or their supervisors make returns on their completed work) or “automated” (e.g. goods being moved between work centres may be recorded by a barcode reader). The production controller then compares this reported activity with the production schedule and can identify discrepancies and assess their possible impact on delivery dates.

In order to ensure that production delays are minimized, it is necessary to have an effective routing procedure. When a batch of components leaves one workstation, it is important to ensure that it is correctly and speedily passed on to the next workstation in the process. This is not particularly difficult but there must be a formal procedure to ensure that it happens. One common solution is to fill in a route card for the batch and to keep it with the batch as it moves from station to station. Upon completion of an activity, those responsible for moving goods can scan the route card and identify the next destination. With flow production, the process itself takes care of routing.

If batches of goods for different products arrive at a workstation at the same time, it is obviously necessary to decide which batch should be dealt with first. This is known as dispatching. Dispatching should normally be done on the basis of scheduled completion time but sometimes this has to be overridden because of delays earlier in the system, or because a machine later in the sequence is lying idle for some reason. Occasionally it is necessary to split batches so that the whole batch is not delayed. However this will result in increased set-up times and more difficult control later in the process and it should only be done if there is no alternative.
In addition to controlling what happens on any production facility at any one time, it is necessary to take a global view of the facilities themselves.

It is essential that facilities be properly maintained and a preventive maintenance schedule should be established for all items of plant and equipment. If this means that the equipment is not available for operation, the time required for such work has to be taken into account when the capacity is determined. Similarly, where the process involves a significant labour content, the labour force must be adequately organized and motivated.

In addition to throughput control, there must be quality control to ensure that finished goods, and by implication, intermediate parts and components, are of the specified quality. Proper specification and planning is the prerequisite of high quality, but monitoring of output, by production operators themselves or by quality control officers, is often necessary to make sure that specified quality levels are in fact met.

We have already stated that control involves comparing actual with planned results. A common method of showing such comparisons is through the use of performance ratios. For example if in a given period:

(A) The production plan includes a budgeted production of 12,000 standard hours
(B) Actual production is 11,500 standard hours
(C) Actual time worked is 11,800 hours

Then

\[
\frac{C}{A} = \frac{11,800}{12,000} \times 100 = 98.3
\]

This is known as the capacity ratio, which measures how effectively the capacity of the production facility was used.

\[
\frac{B}{C} = \frac{11,500}{11,800} \times 100 = 97.5
\]

This is a measure of productivity or how efficiently the production facility was used. Such ratios can be measured at regular intervals; they show underlying trends in effectiveness.

It is important to remember that any control system is based on the collection of performance data such as these ratios but is only complete when such performance data are analysed and used as the basis of corrective action where necessary. If ratios are less than “ideal” the reasons should be investigated and corrected.

**Exercise: Cost variance analysis**

Twenty thousand units of a component have been produced in a given period. Standard material usage is 0.5 kg per component at a standard price of $1.5 per kg. Actual material drawn
from the stores was 9,800 kg and the total purchase price of that material was $15,680.

(a) Calculate:
   (i) Total material cost variance (what was paid minus what was expected)
   (ii) Material volume variance (difference in material used compared to material budgeted for - expressed at standard price)
   (iii) Material price variance (difference in budgeted and actual price for actual material used)

(b) Which, if any, of these variances are favourable?
(c) What action could be taken to address any unfavourable variance?

Some methodological advice for this exercise

1. Ensure that you understand the problem and the nature of the results required. A brief answer is required for section (c).
2. When you have made your calculations, check that materials volume variance and materials price variance add up to the total material costs variance.
3. Comment on the usefulness of variance analysis as a control technique.
4. Discuss in a group what action might be taken if the materials volume variance were unfavourable.

Check the Appendix to this unit for the solution to this exercise.

Questions for discussion

1. What major activities are required in the production planning process?
2. What is the relationship between the production plan and the sales plan? How is it used in capacity planning?
3. What are the major differences between production planning and production scheduling? What are the main techniques for production scheduling?
4. What is the essence of production control? How can you link this to production productivity?
5. What kind of monitoring processes may be applicable to a steel mill, a soft drinks bottling plant, and the invoice section in the head office of a mail order business?
Exercise solution

Gantt chart

a) The overall completion time for chart 1 is 23 hours and for chart 2 is 14 hours.
b) Factors which would affect the decision are:
   - set-up times (if the total additional set-up time for each operation exceeds nine hours, the overall completion time would be longer);
   - the opportunity to use the facilities in the “gaps” created by splitting the batch.

Exercise solution

Cost variance analysis

(a) (i) Actual cost of materials = $15,680
    Budgeted cost of materials = 20,000 units x 0.5 kg/unit x $1.5/kg = $15,000
    Total materials cost variance = 15,680 - 15,000 = $680

(ii) Material actually used = 9,800 kg
    Budgeted material usage = 20,000 units x 0.5 kg/unit = 10,000 kg
    Standard price = $1.5/kg
    Materials volume variance = (9,800 - 10,000) x 1.5 = $300

(iii) Actual price = ($15,680/9,800) = $1.6/kg
    Budgeted price = $1.5/kg
    Actual material used = 9,800 kg
    Material price variance = (1.6 - 1.5) x 9,800 = $980

(b) Only the materials volume variance is favourable; less material was used than planned. (The negative figure indicates a favourable variance.)

(c) The total variance is unfavourable because of the unfavourable materials price variance. Therefore the only possible direct actions are to:
   - negotiate a lower price with the supplier;
   - find another supplier who can offer a lower price.

However, the total variance can also be brought under control by more efficient usage (increasing the materials volume variance further). Therefore ways should be investigated of improving this yield.
UNIT 6: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Explain the essence of the flexible manufacturing system (FMS) and its advantages and disadvantages in relation to other production systems.
2. Understand the structure of computer-integrated manufacturing (CIM), its relation to FMS and their complementary roles.
3. Understand and explain the ways in which FMS and CIM contribute to improving production productivity.

UNIT 6: CONTENTS

6.1 Flexible manufacturing systems
6.2 Computer-integrated manufacturing
UNIT 6: FLEXIBLE MANUFACTURING SYSTEMS AND INFORMATION TECHNOLOGY

6.1 Flexible manufacturing systems

In Unit 3 we discussed the different types of production systems. Flow production is highly specialized, large volume production which is normally very capital intensive as it often makes use of mechanization and automation. This results in high throughput levels with associated economies of scale but is often inflexible and can only be used if the product has a long life expectancy and stable demand. Flexible manufacturing systems (FMS) are an attempt to bring the advantages of flow type production to batch production systems. The potential of FMS arises from developments in production technology and a major need for FMS arises from customer demand for a more varied range of products.

FMS are designed to allow a manufacturing organization to respond quickly to changes in demand while offering some of the benefits of economies of scale. They use sophisticated equipment which, however, can be reprogrammed frequently and easily. FMS thus use complex control systems based on computerized or numerically controlled production facilities and equipment. FMS must be considered at the product design stage. Standard products, components and production processes are an important part of FMS. In order to facilitate FMS, the organization must:

- break down each job into common production operations;
- automate as many of those operations as possible;
- select equipment which combines operations to minimize work-in-progress;
- establish a batch production system for operations;
- establish batch sizes to minimize set-up times;
- overlap operations, where possible, so that a part which completes one operation can move straight on to the next (as in flow production) - parts within the batch are then not left standing awaiting completion of the entire batch;
- select handling and transportation systems that minimize travel time between operations and that allow the movement of individual parts or sub-batch quantities;
- ensure that equipment is reliable - this involves selecting high performance, highly reliable equipment and carrying out routine preventive maintenance;
- institute an overall control system (probably computerized) which networks the various workstations together, to allow for rapid and up-to-date data gathering on progress.

If the system is really an FMS it should be relatively easy (but not necessarily desirable) to make changes to the routing of batches, workloads, volumes, etc.

Since FMS are usually based on sophisticated computer control systems, it is often feasible to simulate a potential system before it is actually implemented. This makes it possible to experiment with different arrangements and layouts without the expense of setting up the physical equipment. It is unlikely that a “perfect” simulation can be run, but the results of simulation exercises are part of the decision-making information that can be made available to industrial and production engineers. Some of the modern simulation packages allow graphical representation of the results on screen and this makes it much easier for non-specialists to visualize the final
FMS can make a major contribution to the productivity of equipment and facilities since they should provide:

- improved utilization of equipment (and hence of capital);
- reduced throughput times (and hence more output in a given time period);
- reduced work-in-progress (and hence less capital tied up in stock);
- reduced labour costs (through increased automation);
- consistent quality of output;
- more effective planning, scheduling and control.

Of course, the capital costs of establishing FMS can be high and a calculation must be made to ensure that the potential savings justify the investment.

6.2 Computer-integrated manufacturing

The increasing use of computers and microprocessors in general has not bypassed the world of production. Computer-aided-design (CAD), computer-assisted-manufacturing (CAM) and computer-aided-engineering (CAE) are becoming increasingly commonplace. Figure 18.17 shows how the various forms of computer assistance relate to each other. Computer-integrated manufacturing (CIM) is the term given to the overall system which includes data management of the various interconnecting processes.

**Figure 18.17: Relationships between various forms of computer assistance**

![Diagram showing relationships between various forms of computer assistance](Diagram)
CIM, like FMS, arises both from the development of technology and from manufacturers' need to continually improve quality and productivity. However, in addition to making existing operational processes more effective and efficient, advanced technologies also make it possible to implement production methods, systems and processes that would not otherwise be viable.

The key feature of CIM, as distinct from CAD, CAM and the other subprocesses, is the integrative nature of CIM systems. CIM is essentially targeted at the information needs of manufacturing - information required both for operational control and for development work. CIM thus extends the use of computers from straight operational application (as in CAD and CAM) to planning, scheduling, and decision-making activities. The software involved may be generic software tailored to a particular system to fit the organization, or it may be part of a complete integrated system based on a particular planning and control methodology. Information is used to link the various parts of any system and CIM passes information automatically from one part of a process to another. As with all data-processing activity, CIM involves the collection, storage, retrieval, analysis, transmission and dissemination of data.

CAD should result in design data being stored in a database which is accessible by the CAM system. The CAM system may then transmit parameters directly to a computer-controlled piece of equipment or manufacturing facility.

A full CIM system thus uses information technology to integrate design, production and delivery of a product and should facilitate:

- rapid (re-) design of products in response to demand changes, resource cost changes or new technologies;
- faster transfer of design proposals into production processes;
- quicker and more effective evaluation of the feasibility and cost of proposed designs;
- more effective production planning, scheduling and control;
- faster product-to-market times;
- reduction in labour costs through automation;
- reduction in "quality costs" through reduced inspection, scrap and rework.

Although linking of the different parts of a production system is an integral part of CIM, the various parts of the system should not be so tightly coupled that failure in any one part brings down the entire system — the system should include some redundancy, back-up and decoupling mechanisms.

Of course the introduction of CIM is not without both its problems and its costs. CAM, alone, can involve the use of robots, NC machine tools, automated guided vehicles, automated storage systems and so on — none of these devices is cheap! The introduction of CIM may make it necessary to re-evaluate decisions made earlier in the life of an organization. Location decisions, for example, may be affected by the shift in relative costs associated with a CIM system. CIM is not just a hardware/software solution. It also affects the way people work and the way they interrelate. This can be both an advantage and a disadvantage. Most people resist change and the changes to working practices that accompany CIM can make workers feel threatened by the devaluing of their existing skills and the need to learn new ones. The introduction of any new technology must be handled carefully and sensitively. Implemented and used effectively, however, CIM can help break down the (communication) barriers between
specialist areas (design, production, accounts, etc.) since they start to share common pools of data.

The long-term advantages may thus extend further than those originally anticipated - but only if CIM is carefully planned, implemented and monitored.

Questions for discussion

1. What are the main features of flexible manufacturing systems? Do they relate to flow and batch production systems? Discuss the advantages and disadvantages of FMS.
2. How does FMS contribute to production productivity improvement?
3. What are the main components of computer-integrated manufacturing?
4. How does CIM contribute to productivity improvement?
BIBLIOGRAPHY

A wide range of books and journal articles deal with the subject matter contained in this module. The following are samples only.


MODULE 19
MATERIALS MANAGEMENT
MODULE 19: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand materials productivity and develop an approach for improving it.
2. Design an inventory management system.
3. Organize the purchase function to maintain continuity of supplies at competitive prices.
4. Reduce the cost of storing and moving materials.
5. Identify and reduce wastage of materials.

MODULE 19: CONTENTS

UNIT 1: Approach to materials productivity
UNIT 2: Improving inventory management
UNIT 3: Procuring materials
UNIT 4: Storage and movement of materials
UNIT 5: Reducing waste

Bibliography
UNIT 1: APPROACH TO MATERIALS PRODUCTIVITY

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Relate materials productivity to the profitability of the organization.
2. Understand the life cycle of materials and the associated costs.
3. Define materials productivity.
4. Understand the systems approach and its application to materials productivity.
5. Identify key result areas and materials productivity indices.

UNIT 1: CONTENTS

1.1 The importance of managing materials
1.2 Materials productivity
1.3 An approach to improving materials productivity
1.4 Company policy manual
1.5 Materials productivity indices
1.6 Practical exercises
UNIT 1: APPROACH TO MATERIALS PRODUCTIVITY

1.1 The importance of managing materials

Rapid advances in technology, automated manufacturing systems and shorter product life cycles have underscored the need for a critical examination of materials management. Materials productivity can significantly affect the total productivity and profitability of an organization because:

- In many companies materials are the largest single element in product cost and thus provide a major opportunity for improvement. Fifty-six cents of each sales dollar are spent on production materials by manufacturing industries in the USA and average materials expenditure accounts for 42 to 65 per cent of product cost in various Indian industries.
- Return on investment can be significantly improved by reducing materials and associated costs such as capital, storage and purchasing. Analysis of one company (Able) revealed that a 5 per cent reduction in materials cost would increase the profit margin from 8 per cent to 10.3 per cent and the return on investment from 10 per cent to 13 per cent; the reduction cost would be equivalent to increasing sales by 28.8 per cent. Figure 19.1 provides a graphic representation of the relationship between basic elements which influence return on investment.
- Reducing the materials cost lowers the break-even point.
- Improving materials productivity involves changing management systems and improving labour productivity.
- Inventory reduction can release capital for more productive investments, especially in capital-scarce economies.

1.2 Materials productivity

Productivity is the relationship of outputs to resources consumed. In addition to the cost of direct and indirect materials (see figure 19.2), further costs are incurred at various stages of production and the materials life cycle. Materials flow through the organization while people and machines work on them to produce the final product. The faster the flow of materials from supplier to customer, the higher the productivity and performance of the organization. A faster flow will also reduce costs throughout the materials life cycle to produce an overall minimum cost for the organization.

Therefore, materials productivity can be defined as a ratio of the cost of all direct and indirect materials including raw materials, components, sub-assemblies, maintenance, repair and operating (MRO) supplies, packing materials consumed and associated purchasing, storage, and other costs incurred throughout the materials life cycle to produce one unit of production.

The box below indicates the major reasons for low materials productivity.
Figure 19.1: Return on investment and its elements: an example from the “Able Company”

Labour
$1,100,000

plus
Materials
$2,300,000
($2,185,000)

plus
Overheads
$1,200,000

Sales
$5,000,000

minus
Cost of sales
$4,600,000
($4,485,000)

plus
Operating income
$4,000,000
($515,000)

Divided by
Sales
$5,000,000

Profit margin 9%

10.3%

Multiply
Return on investment
10.0%

13.0%

Inventories
$500,000

$475,000

plus
Accounts Receivable
$300,000

plus
Fixed assets
$2,900,000

Sales
$5,000,000

Divided by
Total assets
$4,000,000
($3,975,000)

Assets turnover rate
1.25

(1.26)
Low materials productivity occurs when

- materials are waiting to be processed;
- specifications are not properly formulated;
- materials take too long to be processed;
- costs and budgets are rising;
- materials are frequently rejected and purchased on an emergency basis;
- inspection takes too long;
- deliveries are frequently late leading to changes in production plans and/or hold-ups;
- materials are moved over long distances and handled frequently;
- processing yields too much scrap and wastage;
- materials are not ordered in the appropriate quantities.

1.3 An approach to improving materials productivity

To achieve corporate goals, improving materials productivity should be based on:

- reducing prices paid for materials;
- reducing capital and other costs;
- improving the availability of appropriate materials;
- reducing materials consumption and wastage.

These aims require the development of a multi-pronged strategy directed at the purchase, storage, movement and processing of materials. A critical examination of all the systems and processes involving materials would help to identify areas for improvement.
Module 19
Unit 1

Figure 19.2: Materials life cycle and costs

* Customer needs
  * Product design
  * Production plan & schedule

Quality specifications

* Material price
  * Processing time
  * Non-standard materials

Quantity planning

* Excessive inventory
  * Inventory cost
  * Obsolescence cost
  * Transportation cost

Procure

* Material price
  * Transportation cost
  * Purchasing cost
  * Rejections
  * Delays
  * Packaging cost

Store and issue

* Capital and other costs
  * Inspection
  * Deterioration
  * Obsolescence
  * Materials handling
  * Space cost
  * Stock-out cost
  * Insurance cost

Process

* Rejections
  * Scrap
  * Wastage
  * Stock-out cost
The systems approach

The activities of the materials sub-system of an organization interact with each other. For example, reducing the purchase price by buying in bulk can lead to increased inventories which lock up more capital and may lead to higher overall costs. Therefore all activities in the materials sub-system should be grouped in one unit (see figure 19.3), so that all the relevant factors can be taken into consideration.

Because of the interaction between different sub-systems, improving materials productivity may lead to reduced performance in other organizational areas; for example, reducing inventories to release capital can lead to delays in production and late delivery to customers. The choice of a particular technology may lead to more waste, thereby increasing overall cost. A systems approach would facilitate a strategy integrating materials management with management of the total organization to achieve long-term gains.

An organization is an open system, influenced by its technological, economic, political and physical environment. This means that materials productivity will be influenced by economic policies relating to the import of materials and technology, by the transport infrastructure and the physical availability of materials.

Therefore, to achieve higher materials productivity, due attention must be paid to the:

- macro-level environment and to suppliers and customers as part of the organizational system. This facilitates the integration of vertical sub-systems, i.e. supplier, organization and customer;
- integration of all sub-systems of the organization through mechanisms for coordination and teamwork;
- integration of all activities of the materials sub-system by organizing them in a single unit.
Key result areas

Key result areas must be identified for the environment, organizational objectives and policies. The macro-level environment in which a company operates must be scanned in order to understand the threats and opportunities and to isolate the critical factors. Similarly, a thorough examination of management objectives, structures, practices, and procedures will bring out strengths and weaknesses of the organization. To improve materials productivity the key result areas may be identified as:

* integration of product design, production and marketing;
* improving the reliability of suppliers;
* strategic planning, including materials requirements and market research;
* materials consumption and waste control;
* reducing costs for storing and moving materials;
* reducing inventories.
Improvement programme

The basic elements of a programme for improving productivity have been described in Modules 5 and 6. These elements are equally applicable to similar programmes for materials productivity. The identification of key result areas and the factors influencing them will help in developing a tailor-made programme for a particular organization. Productivity techniques could be used to establish cause-effect relationships and to identify factors influencing specific areas. Targets should be fixed in each of the key result areas so that an improvement programme can be developed to achieve these goals. For example, a large public sector organization in India decided that materials cost should not be more than 52 per cent of its product cost. This facilitated development of projects to reduce materials cost.

1.4 Company policy manual

It is recommended that organizations develop a manual which lays down the basic framework of a corporate policy to direct efforts towards organizational goals. The contents of a materials policy manual would be:

* objectives, key result areas, and materials productivity indices;
* organizational structure clearly spelling out responsibilities, delegation, interface relationships, coordination mechanisms;
* purchasing policy and practices;
* supplier development, evaluation and relationships;
* ethical practices;
* surplus and scrap disposal;
* inventory management;
* stores receipt, inspection, accounting, handling, and other procedures.

1.5 Materials productivity indices

Productivity measures should be developed to monitor the different factors influencing materials productivity. These indices will make it possible to compare organizational performance over a period of time or with other similar organizations, to identify areas which require improvement. The output must be defined in a meaningful manner to encourage teamwork and coordination between different departments for achieving corporate goals. An approach based on translating key result areas into appropriate output measures and developing ratios with significant inputs or with past performance has been found to be highly practical. Some examples of the most important key indices are given below.

1) Materials consumption

\[
\text{Product cost or sales value}
\]

2) Annual materials consumption

\[
\text{Average inventory held}
\]
3) Production loss due to non-availability of materials
   Total production

4) Number of stock-outs (current)
   Number of stock-outs (standard)

5) Total handling cost
   Total value of materials received and issued

6) Deliveries on schedule
   Total number of deliveries

7) Value of loss due to deterioration, obsolescence, pilferage
   Average inventory held

8) Scrap generated
   Total materials consumed

9) Savings made as a result of value analysis or other studies
   Total materials cost

10) Transportation cost
    Total materials cost

11) Total waste generated
    Total materials consumed

### Changing paradigms

Approaches to managing materials productivity have undergone a significant change in the context of changing managerial, technological and organizational requirements. The changing paradigms are given below:

<table>
<thead>
<tr>
<th>Old rules</th>
<th>New rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Problem-solving approach</td>
<td>Strategic planning</td>
</tr>
<tr>
<td>2) Push system</td>
<td>Pull system</td>
</tr>
<tr>
<td>3) Lowest prices</td>
<td>Reliable suppliers</td>
</tr>
<tr>
<td>4) Low item price</td>
<td>Low organizational cost</td>
</tr>
</tbody>
</table>
Module 19
Unit 1

1.6 Practical exercises

Exercise 1

Study the diagram below and relate the objectives and activities to materials productivity, using the contents of the module. Hold a group discussion. Can you add subjects which are important to materials management in your organization and which are omitted here?

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>CONCEPT &amp; APPROACH CH-1</th>
</tr>
</thead>
</table>
| To achieve company goals-profitability, stability and growth ensure availability of materials at optimum costs and reduced prices for meeting production targets | * Importance  
* Material Productivity  
* Approach  
* Policy manual  
* Indices |

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>INVENTORY MANAGEMENT CH-2</th>
</tr>
</thead>
</table>
| Specifying quality  
Deciding quantity  
Procuring  
Stocking and Processing materials | * Interface with PPC  
* Materials directory  
* Inventory cost & analysis  
* Inventory systems  
* Choice of inventory system |

<table>
<thead>
<tr>
<th>PRODUCTIVITY</th>
<th>PROCURING MATERIALS CH-3</th>
</tr>
</thead>
</table>
| Materials prices  
Inventory costs  
Purchasing costs  
Stockout costs  
Storage costs  
Movement costs  
Process waste  
Flow of materials | * Changing role of procurement  
* Price management  
* Materials specifications  
* Changing relationship with supplier  
* Supplier development & selection  
* Follow up  
* Strategic materials planning |

| | STORAGE & MOVEMENT CH-4 |
| | * Cost Aspects  
* Surplus & Obsolescence  
* Location of Stores  
* Storage Methods  
* Housekeeping Practices  
* Materials Handling  
* Freight Management |

| | PROCESSING MATERIALS CH-5 |
| | * Introduction  
* Sources of Waste  
* Approach & Strategy  
* Techniques |

Quotation/tender evaluation
Supplier evaluation
Higher inventories
JIT-linked operations
Inventories - a necessity
Inventories - a sign of inefficiency
Threaten supplier
Build relationship
Supply specifications
Supply performance requirement
Inventories - asset
Inventories - idle capital
Keep people busy
Keep materials busy
Module 19
Unit 1

Exercise 2

Work out return on investment, profit margin and asset turnover ratios for the following two companies (consult figure 19.1).

**Figures in million dollars**

<table>
<thead>
<tr>
<th>No.</th>
<th>Items of financial statement</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Fixed assets</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>ii)</td>
<td>Inventory</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>iii)</td>
<td>Cash and accounts receivable</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>iv)</td>
<td>Labour cost</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>v)</td>
<td>Materials cost</td>
<td>10</td>
<td>9.5</td>
</tr>
<tr>
<td>vi)</td>
<td>Overheads</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>vii)</td>
<td>Sales</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

Exercise 3

1. Describe briefly the materials life cycle and identify costs at its various stages.

2. You have been requested to develop productivity indices for measuring waste management and for materials procurement in your organization. Suggest five possible measures for each.

3. Profits can be increased by improving materials productivity or by increasing sales. Comment and describe the relationship between materials productivity and return on investment.

Please check your solutions with the answers given in the annex to this unit.
ANNEX TO UNIT 1

ANSWER TO EXERCISE 2

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Financial items</th>
<th>Company A</th>
<th>Company B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Costs (iv+v+vi)</td>
<td>12</td>
<td>11.5</td>
</tr>
<tr>
<td>b)</td>
<td>Operating income (vii)-(a)</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>c)</td>
<td>Current assets (ii) + (iii)</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>d)</td>
<td>Total assets (c+i)</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>e)</td>
<td>Profit margin [(b)/(vii)]</td>
<td>25%</td>
<td>28.12%</td>
</tr>
<tr>
<td>f)</td>
<td>Asset Turnover Ratio (vii/(d))</td>
<td>1.14</td>
<td>1.33</td>
</tr>
<tr>
<td>g)</td>
<td>ROI [(e)x(f)]</td>
<td>28.50%</td>
<td>37.39%</td>
</tr>
</tbody>
</table>

ANSWERS TO EXERCISE 3

Question 1: Consult figure 19.2 in this unit

Question 2: The possible indices are

(a) **Waste management**

i) Total production
   - Materials used

ii) Waste recycled
    - Total waste

iii) Total waste generated
    - Total production

iv) Waste collected
    - Total waste

v) Waste reduction (current period)
    - Waste reduction (base period or standard)
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>vi)</td>
<td>Cost of waste disposal</td>
</tr>
<tr>
<td></td>
<td>Total cost of production</td>
</tr>
<tr>
<td>vii)</td>
<td>Total waste generated</td>
</tr>
<tr>
<td></td>
<td>Materials consumed</td>
</tr>
<tr>
<td>viii)</td>
<td>Value of non-moving items</td>
</tr>
<tr>
<td></td>
<td>Total inventory value</td>
</tr>
<tr>
<td>ix)</td>
<td>Value of scrap sold</td>
</tr>
<tr>
<td></td>
<td>Total production value</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Procurement</td>
</tr>
<tr>
<td>i)</td>
<td>Total purchase cost</td>
</tr>
<tr>
<td></td>
<td>Total number of orders</td>
</tr>
<tr>
<td>ii)</td>
<td>Total value of materials purchased</td>
</tr>
<tr>
<td></td>
<td>Total purchase cost</td>
</tr>
<tr>
<td>iii)</td>
<td>Total number of suppliers</td>
</tr>
<tr>
<td></td>
<td>Total number of items</td>
</tr>
<tr>
<td>iv)</td>
<td>Average lead time (current period)</td>
</tr>
<tr>
<td></td>
<td>Average lead time (base period or standard)</td>
</tr>
<tr>
<td>v)</td>
<td>New suppliers located (current period)</td>
</tr>
<tr>
<td></td>
<td>Total number of suppliers</td>
</tr>
<tr>
<td>vi)</td>
<td>Number of such orders</td>
</tr>
<tr>
<td></td>
<td>Total number of orders</td>
</tr>
</tbody>
</table>

**Question 3:** Improving materials productivity can lead to higher profits because

i) reducing prices decreases the cost of sales, leading to improved profit margins.

ii) reducing inventories leads to a reduction in current assets, hence an improved assets turnover ratio.
Increasing sales would also influence profits but will generally require a much higher degree of increase. For example the impact of reducing materials cost by 5 per cent is equivalent to increasing sales by 28 per cent. The relationship between materials productivity and return on investment is shown graphically below.

\[
\text{ROI} = \frac{\text{Operating income}}{\text{Total assets}}
\]

While \( \frac{\text{operating income}}{\text{sales}} \) = profit margin

and

\( \frac{\text{sales}}{\text{TOTAL Assets}} \) = assets turnover ratio
UNIT 2: IMPROVING INVENTORY MANAGEMENT

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the factors influencing inventory level.
2. Use inventory analysis and inventory costs for developing inventory and purchase policies.
3. Choose inventory systems for different items.
4. Design an inventory system.

UNIT 2: CONTENTS

2.1 Interface with production planning and control (PPC)
2.2 Materials directory
2.3 Inventory analysis
2.4 Types of inventory costs
2.5 Optimizing inventory costs
2.6 Inventory systems
2.7 Exercises
UNIT 2: IMPROVING INVENTORY MANAGEMENT

Inventories represent an idle investment which increases costs but does not add value to the product. As much as 20 to 30 per cent of working capital may be tied up in inventories. The objective of inventory management is to increase the inventory turnover ratio (ratio of sales to average inventories) while ensuring that production targets are met. Inventory management is primarily concerned with placing and timing orders to optimize the costs incurred in purchasing and stocking materials. The size of inventory to be kept is influenced by the accuracy of production planning and control and the reliability of suppliers, as well as by the cost of buying and storing materials.

2.1 Interface with production planning and control (PPC)

Production planning and control interacts with inventory management. PPC determines the quantity and timing of products to be manufactured. The materials plan derived from this information indicates what materials will be required, in what quantity and at what time. For direct materials the production schedule can be translated into a materials plan by multiplying the components required for one unit of production; this procedure is called materials requirement planning (MRP). Past consumption patterns can also be used to work out a materials plan with the help of statistical techniques such as regression analysis for indirect materials. However, the variables influencing actual consumption of a particular indirect material must be identified to achieve an accurate forecast, since overconsumption of a material in the past may produce an inflated estimate. Past consumption values should, therefore, be reviewed before projecting future requirements. Future plans might also modify the materials forecast. If forecasts are not accurate, inventories may increase or shortages may occur. Inaccurate forecasts will also affect purchasing and other downstream activities in the materials life cycle. If more components are produced than can be used in assembly, this will add to inventory. Production scheduling must ensure that only the components required are produced and that they are available at the right time. This means that the sales, production and materials departments must work closely together to achieve the minimum overall cost.

With increasing automation of manufacturing and the development of sophisticated PPC software, inventory and purchasing are becoming part of computer-integrated manufacturing (CIM) systems. An overview of such developments is given in figure 19.4. The implementation of materials requirement planning (MRP) and just-in-time (JIT) systems is a step in this direction. These developments require a change in approach to inventory and purchase management. Emphasis is placed on minimizing inventories through:

* more frequent deliveries from suppliers;
* reduced lead time;
* careful evaluation of suppliers;
* long-term contracts;
* minimizing defects.
2.2 Materials directory

The directory provides comprehensive information about every item, facilitates standardization and improves communication between different organizational units. For example, a materials directory helps the design department create new products using available standard materials. It also helps to reduce internal lead time.

The directory should contain the code number, name of the item, specifications, inspection methods, lead time, components/places of use, list of suppliers, substitute materials and a cross-index by manufacturer’s part number.

Figure 19.4: Materials management as part of computer-integrated manufacturing (CIM)

- Computer-integrated manufacturing
  - Product design and engineering
    - CAD
    - CAE

  - Production planning and control
    - MRP
    - JIT
    - OPT

  - Production (CAM)
    - FMS
    - GT
    - CAPP
    - AGVS
    - AS/RS

Notes:

- AGVS Automated guided vehicle system
- AS/RS Automatic storage and retrieval system
- CAD Computer assisted design
- CAE Computer assisted engineering
- CAM Computer assisted manufacturing
- CAPP Computer assisted process planning
- FMS Flexible manufacturing systems
- GT Group technology
- JIT Just-in-time production
- MRP Materials requirement planning
- OPT Optimized production technique
2.3 Inventory analysis

An average industrial organization uses up to 50,000 different items. Tight control on stocks of each item would not be practical or worthwhile, since items are not of equal importance. It is desirable to group the items and subject each group to controls commensurate with their importance.

Items can be classified according to their use, consumption value, or availability in the market. This analysis is based on the principle of ‘VITAL FEW-TRIVIAL MANY’ - also referred as Pareto’s curve. A higher degree of attention is focused on the VITAL FEW materials which significantly affect results. The analysis helps to achieve the twin objectives of minimizing inventories and ensuring that materials are available to meet production targets. Various types of analysis may be made depending upon the characteristics of the items in question. Each analysis has a specific objective.

i) ABC analysis
Items are classified according to their consumption value since a small percentage of items account for a large percentage of expenditure. This type of analysis is most important from the point of view of controlling capital locked up in inventories. The average pattern of percentage of items and percentage of value may work out as follows:

<table>
<thead>
<tr>
<th></th>
<th>percentage of number of items</th>
<th>percentage of expenditure in dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>A items</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>B items</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>C items</td>
<td>70</td>
<td>10</td>
</tr>
</tbody>
</table>

ii) VED analysis
This analysis is done to consider the vitality of an item and the effect on production in case of non-availability. The analysis is especially useful in the case of spare parts to highlight the essential items.
V - stands for vital items without which production would come to a halt
E - is for essential items without which temporary loss of production or dislocation of production work occurs
D - denotes desirable items - all items other than V and S which are necessary but do not cause any immediate loss in production

iii) SDE analysis
This analysis is based upon the availability of an item: it is very useful in developing countries where certain items are scarce.
S - refers to scarce items, especially those which have to be imported or for which reliable suppliers are not available
D - refers to difficult items, which are available in the market but cannot be procured easily or quickly
E - refers to easy items which are readily available (mostly local items)
POLICIES FOR A, B, and C ITEMS

Policies for A items: (Less than 10 per cent of items accounting for more than 70 per cent of the value)

(1) Since these items account for over 70 per cent of the value, smaller orders should be placed more frequently to reduce the capital locked up in inventories.

(2) Consumption of many items might vary considerably from time to time during a year. Future consumption should be estimated so that only the necessary quantities arrive just before they are required for consumption. Of course, a small extra stock (safety) should be carried to meet any eventualities.

Future consumption can be estimated with the help of periodic production schedules and master schedules. In the absence of proper production schedules there is no reliable way of estimating what quantities will be required. It should be emphasized that proper inventory control calls for good production planning.

(3) Annual or six-month contracts with scheduled deliveries are appropriate for A items. A JIT system should be implemented for these items if possible.

(4) For items not covered by long-term contracts quantities, schedules and safety stocks should be reviewed frequently.

(5) As stocks of these items are to be kept as low as possible, the purchasing department should make maximum efforts to ensure quick delivery from suppliers.

(6) Consumption should be checked very closely.

(7) Top executives in the purchasing department should be responsible for buying A-items.

(8) Stock and issue records should be meticulously maintained in the inventory control department or in the stores.

(9) Stock reports on A items should be sent frequently to top management, probably once a month.

(10) Accurate materials estimates will be required.

Policies for B items: (Less than 20 per cent of the items accounting for about 20 per cent of the value)

(1) The policies for B items in general are between those for A and C items.

(2) Order quantities, reorder points and safety stocks should be fixed for B items on an annual basis.

(3) Annual or six-month contracts with scheduled deliveries can be used to advantage for B items.

(4) Stock and issue records must be carefully maintained.

(5) Between three and six orders per year should be adequate for B items.
Policies for C items: (over 70 per cent of the items accounting for less than 10 per cent of the value)

The aim here is to reduce the work of ordering and stock keeping and ensure availability at all times by stocking liberal quantities.

1. Stocks sufficient for six months to one year can be kept since little capital is tied up in C-items.
2. Annual or six-monthly orders should be placed to reduce paper work in the purchasing department and also to take advantage of discounts for bulk purchase.
3. A whole group of items (e.g. all paints) should be ordered at the same time. This saves ordering work and transportation costs. In addition, each order becomes large enough for the vendors to make concessions and give discounts.

Inventory management should focus on a higher level of planning and control of A, V and S items. This will reduce inventories of A items and ensure the availability of vital and scarce materials to avoid the cost of production hold-ups. The policy framework should cover all activities during the life cycle of an item.

2.4 Types of inventory costs

The following types of inventory costs are incurred:

- the cost of purchasing materials including salaries and operating expenses, computer time, telephone and other services, stationery, and other costs;
- inventory carrying cost including capital cost, salaries, premises, depreciation, pilferage and deterioration. The annual inventory carrying cost is generally 20 to 40 per cent of the value of inventory;
- costs of the materials themselves;
- the cost of stock-out which cannot always be quantified, as non-availability may lead to loss of goodwill.

2.5 Optimizing inventory costs

Optimizing inventory costs involves two approaches.

i) Developing an inventory system to decide on the volume and timing of orders. For the given annual requirement of an item, order size will determine inventory carrying costs; if the item is purchased and delivered in one lot, the purchasing cost is low but inventory carrying cost is high; on the other hand, if the item is purchased and delivered in small lots, the purchasing cost is high but inventory carrying cost is low. The concept of economic order quantity (EOQ) can be used to minimize these costs. The EOQ is given by the formula
Module 19
Unit 2

**EOQ** = \( \sqrt{\frac{2AS}{i}} \)

- **A** = Annual consumption of an item of value $s
- **S** = Cost of placing one order of value $s
- **i** = Inventory carrying cost per year per $ expressed as a decimal

**EOQ** = Quantity per order in $

The order quantity given by this formula would need modification to suit specific conditions such as the availability of discounts, concessional freight rates, perishable or bulky nature of the item, market conditions or import policy. The decision to buy in bulk to take advantage of discounts depends on the savings in materials and/or freight costs compared with additional inventory carrying costs.

ii) The cost of stock-out is minimized by maintaining safety (buffer or reserve) stocks to respond to variations in consumption and/or uncertainties of supply. Variations arise because of inaccurate materials forecasts, changes in demand pattern, excessive rejections and increases in lead time. Supplier reliability in terms of delivery and quality will be of critical importance.

Estimates of variations in consumption and lead times are needed to decide on the level of safety stocks for a particular item. Guidelines for determining safety stocks are suggested below:

- Ample safety stocks (three to six months consumption) should be kept for C items. This will give maximum safety for 70 per cent of the items with minimum capital investment.
- Higher levels of safety stocks should be kept for vital and scarce items. C items which are vital and scarce should have the highest safety stocks.

It should always be borne in mind that the price of materials is a function of supply and demand, quantities purchased, negotiating skills and relations with suppliers.

**2.6 Inventory systems**

The inventory system determines the volume and timing of orders. Traditional systems such as the fixed order quantity system and the fixed period order system are being replaced with MRP (material requirements planning) and JIT (just-in-time) systems to meet changing requirements. The inventory systems most commonly found in enterprises are given below:

a) Fixed order quantity system or reorder level (ROL) system

In this system, a fixed quantity equal to the economic order quantity (EOQ) is ordered when stock reaches reorder level. The system involves deciding on safety or minimum stock, reorder level and maximum stock for each item, as follows: reorder level is equal to safety stock plus consumption during lead time. Maximum stock is equal to safety stock plus EOQ. A graphical representation of this order system is given in figure 19.5. This is one of the most commonly used systems and best suited for independent items. As the system primarily uses historical consumption data, it is being replaced with MRP for dependent items. The fixed order system is most suitable for items with a constant rate of consumption and a steady market price. The danger is that extra orders placed at irregular intervals may not be
b) Fixed period order system or cyclical system
   A review of stock, consumption and other parameters is carried out for each item after a predetermined fixed period and orders are placed to make up the shortfall. An item is put on this system under the following conditions:
   - The review period is decided according to the EOQ or quantity for which the supplier offers better terms. The frequency of review will depend on the degree of control desired by management - A, V and S items are reviewed more frequently. Generally the review period for A, B and C items is 1 week, 4-12 weeks, 12-52 weeks respectively.
   - The level of safety stock is determined.
   - The replenishment level is equal to consumption during the (review period plus lead time) plus safety stock levels.

   The quantity ordered should cover consumption during the review period and lead time. The size of the order, therefore, is equal to consumption during the review period plus procurement lead time plus safety stock minus stock on hand or on order or both. A graphical representation is given in figure 19.6.

   This system makes it possible to combine orders for different items from the same supplier and is very convenient to operate. It is suitable for items with irregular or seasonal demand as well as for continuous manufacturing operations.

c) Materials requirement planning (MRP)

   This is an integrated computer-based production planning and inventory control system, designed for dependent items, i.e., materials and components which can be deducted from the bill of materials. The major objective of MRP is to make parts, components, raw materials and products available at the right time in the right quantities, while maintaining inventory at the minimum level. It is very effective because of its sensitivity to future requirements and is therefore proactive in nature.
The master production schedule is converted into gross requirements for components, parts and raw materials through explosion of the bill of materials. To arrive at gross requirements the products to be manufactured during the planning period are multiplied by the quantity of each component required to produce one product to arrive at gross requirements. Net requirements are then worked out by subtracting the stocks of different components. Net requirements are then related to lead time, producing a material requirements plan phased over time. A graphical representation is given in figure 19.7.

Thus, "when to order" (the timing question) is answered by the logic of the system which considers the lead time, and requirement of end products according to the master production schedule relating to customer demands. The most commonly used approach is to order quantities required during the planning period, i.e., the "lot for lot" approach. But this approach sometimes indicates small quantities which may not be economically viable to procure or produce in-house. In such cases, a formula such as EOQ is used to determine lot size.

Since the MRP system depends on translating end product demands into requirements, consumption variation may not be a major factor but variations could occur because of changes in lead time and reject rates. Safety stocks will be required to cater for these variations, although these can be kept down if possible changes are considered when net requirements are calculated. Safety stocks are determined by past experience and may vary from zero to several weeks’ supply.
d) Just-in-time (JIT)

Developed as a part of the now famous Toyota production system, JIT represents a complete manufacturing philosophy developed to improve customer service by producing only the quantities required at the time they are needed. JIT integrates production planning, inventory management and purchasing subsystems, causing each operation to produce exactly what is required, when it is required and in the quantities required. In JIT, only final assembly uses production plans based on sales demand, acting as a “pull” factor. Final assembly uses the products...
of the previous process, a procedure which is repeated from assembly "backwards" to the first operation and suppliers, thus reducing inventories. Many JIT materials are delivered close to the point of use.

Successful implementation requires:

- production systems designed to provide flexibility through a multiskilled workforce, small batch sizes and reduced set-up times;
- close relationship with suppliers for shorter lead times and minimum defects;
- an information system which "pulls" the materials (Kanban system) to transmit "pull" signals from assembly back to the first operation and supplier. A Kanban is a card indicating the quantities to be manufactured and withdrawn. A withdrawal Kanban shows the quantities that an operation can take from the earlier processes; a production-ordering Kanban shows the quantities that the preceding operation or supplier should produce. Kanban could be used within different departments or sections of an organization, or between supplier and organization. The flow of two Kanbans is shown in figure 19.8.

Figure 19.8: Flow of two Kanbans

The JIT system is usually implemented for A class high-value items in organizations requiring a regular flow of materials or producing a few standard products. Compared to computer-controlled MRP, JIT is a simple system depending on human 'pull'.

Supplier and buyer work together to decide on the volume and timing of deliveries, based on the production schedule. Consideration is given to the materials to be delivered, the transportation route, the packing and the system for communicating requirements to the supplier. The level of safety stocks is based on the nature of the item, frequency of deliveries and supplier reliability, and ranges from a few days' to few weeks' requirements. The potential of the system is illustrated by the experience of Hewlett Packard which was able to improve the rate of on-time deliveries from 21 per cent to 51 per cent and reduce inventory by $9 million.

An example of JIT implementation in a firm in the USA is given in figure 19.9.
Figure 19.9: Implementation of JIT compared to the traditional production organization

Receiving of
* Materials
* Parts
* Components

Receiving
inspecting
prepacking

Subassembly
material

Inventory

Subassembly
operation

Subassembly
inventories

Final
assembly

Finished
goods
inventory

Production inventory
Work-in-process inventory
Finished goods inventory

= 6 weeks
= 3 weeks
= 3-6 weeks

JIT Operation

Receiving of
* Materials
* Parts
* Components

Subassembly
inventories

Final assembly
inventory

Finished goods

Production inventory
Work-in-process inventory
Finished goods inventory

= 6-10 days
= 1 day
= 3 days

Choice of system

Rather than developing inventory systems in isolation, efforts are now being directed towards developing systems which integrate different subsystems to improve organizational productivity and reduce overall costs. Rapid advances in information technology have opened up new possibilities for sophisticated systems. The choice of a particular system will depend on the philosophy and needs of an organization and its subsystems. The various inventory systems are not necessarily mutually exclusive.

A comparison of systems in terms of their significant features is given in figure 19.10.
It should be possible to adapt systems to suit the specific needs of an organization. MRP could be used for long-range planning while JIT would be more suitable for routine daily control. Fixed period order systems could be implemented for A and B items with C items on a fixed order quantity system. In addition, informal procedures such as shortage lists can supplement traditional inventory systems. Attempts are being made to combine the advantages of MRP and JIT to develop a hybrid system. Some examples of such systems are JIT/MRP, Requirement Kanban and Dynamic Kanban.

<table>
<thead>
<tr>
<th>Type of system/inventory level</th>
<th>Order Point</th>
<th>Cyclical</th>
<th>MRP</th>
<th>Flow control</th>
<th>JIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintains low inventory level</td>
<td>fair</td>
<td>fairly good</td>
<td>good excellent</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Application to items, type of demand</td>
<td>all types * particularly good for independent demand</td>
<td>all types</td>
<td>primarily dependent demand</td>
<td>primarily dependent demand</td>
<td>dependent demand</td>
</tr>
<tr>
<td>Application to type of operations</td>
<td>all types of manufacturing operations * particularly good for service operations</td>
<td>all manufacturing operations * service operations</td>
<td>primarily intermittent manufacturing operations, with great product variety</td>
<td>continuous manufacturing, with little product variety</td>
<td>continuous manufacturing, with moderate product variety</td>
</tr>
<tr>
<td>Demand data used</td>
<td>historical</td>
<td>* actual in simple operations * historical in complex operations</td>
<td>actual</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>Time-phased order point?</td>
<td>no</td>
<td>* yes in simple operations * no in complex operations</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Computer required?</td>
<td>optional</td>
<td>optional</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Bill of materials explosion/aggregation capability</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Administrative effort required</td>
<td>minimal</td>
<td>moderate</td>
<td>moderate</td>
<td>moderate</td>
<td>moderate</td>
</tr>
</tbody>
</table>
Module 19
Unit 2

2.7 Exercises

1. Indicate ‘True’ or ‘False’ in the blank space
   i) Inventory management should be considered in isolation from a PPC system
   ii) MRP is more suitable for dependent items
   iii) A items should be procured more frequently than C items
   iv) A fixed period order system is more suitable for C items
   v) Safety stocks depend on the reliability of the supplier
   vi) Safety stocks ensure 100 per cent availability of materials
   vii) MRP could be used for long-range planning while JIT is more suitable for daily control
   viii) JIT facilitates reduced lead time and inventories while improving on-time deliveries
   ix) Under VED analysis larger safety stocks should be kept of desirable items than of essential items
   x) Larger stocks should be kept of items which are C V and S than of items which are A, D and E in ABC, VED, and SDE analyses

2. The average monthly consumption of an item is 200 units and the normal lead time is one month. If maximum consumption has been 250 units per month and maximum lead time is 1.5 months, what safety stocks should be kept under a fixed order quantity system?

3. ABC classification
   The following table indicates that for an annual consumption of $177,600 an annual average inventory of $22,200 has been carried.

<table>
<thead>
<tr>
<th>Items</th>
<th>Annual Consumption</th>
<th>No. of orders</th>
<th>Value of orders</th>
<th>Average Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>160,000</td>
<td>400</td>
<td>4</td>
<td>40,000</td>
</tr>
<tr>
<td>Q</td>
<td>16,000</td>
<td>127</td>
<td>4</td>
<td>4,000</td>
</tr>
<tr>
<td>R</td>
<td>1,600</td>
<td>40</td>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>177,600</td>
<td></td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

   “ABC analysis helps to reduce the blocked up capital”. Justify this statement by its application to the above situation.

4. (i) List all the elements in purchasing and inventory carrying costs.
   (ii) Can the design department contribute towards improving materials productivity? How?
   (iii) Describe the JIT system and show how it determines the quantity and timing of orders.

   The answers to the questions are given in the annex to this unit.
ANNEX TO UNIT 2

ANSWERS TO QUESTIONS

Exercise 1

i) False ii) True iii) True
iv) False v) True vi) False
vii) True viii) True ix) False
x) True

Exercise 2

A simple method to work out safety stocks is given below:

a) variation in lead time = 1.5 - 1 = 0.5 month
b) safety stock for variation in consumption = 250 - 200 = 50 units
c) safety stocks for lead time variation = 0.5 x 250 = 125 units
d) total safety stock = 125 + 50 = 175 units

Note:
1. The above method gives higher safety stocks because the two variations may not occur at the same time.
2. Sophisticated statistical tools such as Monte Carlo simulation can be used to determine the probability that variations in lead time will occur at the same time as variations in consumption. The level of safety stocks should be based on the probability of such occurrence and the importance of the item.
3. If one of the variations is likely to occur safety stocks can be decided on that basis alone.

Exercise 3

ABC classification

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual consumption value</th>
<th>% of total annual consumption</th>
<th>Class of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>160,000</td>
<td>90.1</td>
<td>A</td>
</tr>
<tr>
<td>Q</td>
<td>16,000</td>
<td>9</td>
<td>B</td>
</tr>
<tr>
<td>R</td>
<td>1,600</td>
<td>0.9</td>
<td>C</td>
</tr>
</tbody>
</table>

Applying ABC analysis, A class items should be purchased more frequently to minimize blocked capital and C class items should be purchased in bulk to minimize ordering costs. Hence the items can be ordered as follows:
If the total number of orders remains the same a reduction in average inventory of $8,733 is possible i.e., 40 per cent. Hence the ABC classification can help reduce capital locked up in inventory.

Exercise 4

(i) The elements of the two costs are:
   a) Purchasing costs include salaries and operating expenses, computer time, telephone and other services, stationery, entertainment and other costs incurred in making purchases.
   b) Inventory carrying costs include capital cost, salaries, premises, depreciation, pilferage, deterioration and other expenses incurred in keeping stocks.

(ii) The design department can contribute to improving materials productivity by
   a) Using standard components as far as possible.
   b) Consulting the purchase department in formulating specifications to optimize purchase cost.
   c) Designing components and products using minimum materials - using value engineering and finite element analysis.
   d) Timing design changes to minimize obsolescence.

(iii) JIT represents a complete manufacturing philosophy developed to improve customer service by producing only the required quantities at the time they are needed. It integrates production planning and control, inventory management and purchasing subsystems. In JIT, only the final assembly uses production plans and acts as a 'pull' factor. The supplier and buyer work together to decide on the quantity and timing of deliveries, based on the production schedule. Specific daily requirements are relayed directly to the supplier in the context of a general agreement on quantity, delivery schedule and prices.
UNIT 3: PROCUREMENT MATERIALS

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the importance of procurement and good supplier relations.
2. Draw up materials specifications to optimize overall costs.
3. Set criteria for selecting suppliers.
4. Undertake strategic materials planning.
5. Organize supplier development and follow-up activities.

UNIT 3: CONTENTS

3.1 The changing role of procurement
3.2 Price management
3.3 Materials specifications
3.4 Good supplier relations
3.5 Supplier development and selection
3.6 Strategic materials planning
3.7 Exercises
UNIT 3: PROCURING MATERIALS

3.1 The changing role of procurement

Purchasing, an essential and integral part of any enterprise, is becoming increasingly important for the economic health and stability of the business. The objective of purchasing is to arrange and maintain a supply of necessary materials at competitive prices. The purchase function undertakes a series of activities including inviting bids, selecting suppliers, placing orders and expediting supplies. At enterprise level this function often starts with processing indents spelling out specifications and other details of the item. Over a period of time, this passive role changes to a more creative and proactive role. In successful organizations, the purchasing department is considered as a producer of components obtained from outside, its importance depending on the number of outside components and suppliers. Purchasing can improve materials productivity by:

- procuring materials at reduced prices;
- ensuring a steady flow of materials required for the production programme at minimum overall cost;
- acting as a link with the outside world, exchanging information between suppliers and the enterprise.

Purchasing must coordinate and integrate its activities with the users to understand their long-term and short-term requirements. With its knowledge of new materials and supplier capabilities, it can contribute effectively to design and production, particularly in deciding specifications. It is also concerned with inventory control, stores and other downstream activities of the materials subsystem.

Specific action plans are needed to reduce prices, lead times, rejection rates and inventories and to identify new materials and suppliers. Suppliers significantly influence prices, quality, costs and timely delivery of materials. Key measures for improving procurement performance are related to:

- price management;
- materials specifications;
- good supplier relations;
- supplier development and selection;
- strategic materials planning.

Let us consider them in detail.

3.2 Price management

The first responsibility of the purchasing department is to obtain materials at the right price. This does not mean the lowest price but the price which results in the lowest overall cost to the organization and which at the same time ensures a reasonable return to suppliers. Price depends on specifications, competition, quantity and bargaining with the supplier. Standard materials
will cost less than non-standard materials. Substituting cheaper materials is a way of reducing prices.

Purchasing systems and procedures should create conditions under which suppliers compete on prices and service, assuming a reasonable number of suppliers. Locating new suppliers and maintaining long-term relationships can play a critical role in reducing prices. Open bids should be invited for A items because the expense involved in purchasing justifies the effort. Limited bids will be useful for B and C items. The location of suppliers also influences freight and other costs.

Invoices and materials cost estimates can provide a useful guide to fair prices. Price forecasts are also useful and statistical techniques such as regression analysis can be applied. Bargaining can also help obtain maximum value at minimum cost. Purchasing staff need to be trained in negotiating skills, and should be well-briefed on all details of the item. For imported goods exchange rate fluctuations determine the prices in local currency. It is therefore important to keep track of such fluctuations and negotiate prices in a currency which offers a favourable exchange rate.

3.3 Materials specifications

Materials specifications provide a basis for communication between supplier and enterprise and also within the enterprise, reducing internal lead time. The quality and quantity of materials to be used in production are specified at the design stage of the product. These specifications are formulated after balancing the requirements of manufacturing, marketing and purchasing, in addition to the actual design requirements. The principles of value engineering and finite element analysis can help in drawing up specifications to optimize the use of materials. Value engineering identifies the function of various components and items and shows how to satisfy these requirements in the most cost-effective manner. Finite element analysis (FEA) optimizes the use of materials at the design stage. The conventional approach to design is based on formulae available in the literature which make highly simplifying and conservative assumptions about component geometry, loading and boundary conditions. Whenever there is uncertainty about loading patterns, a substantial safety margin is allowed. Experience shows that the conventional approach to design provides excess materials where they are not required and insufficient materials where they are most needed. This approach, known as the ‘lumped parameter approach’ takes a gross view of the whole problem of design. The finite element analysis approach has helped designers identify low and high stress areas to produce optimum designs. It also improves the speed, accuracy and flexibility of design revision. It eliminates the time-consuming and costly prototype development phase required in conventional design, thereby drastically reducing product development cycle time. Some examples where FEA has led to reduced materials costs are given in the box below.

The purchase department can provide feedback to the design department on the availability and price of materials. These two departments can collaborate in deciding:

- whether standard materials can be used;
- whether non-standard components/materials could be made in-house;
- how to write specifications in an unambiguous manner;
<table>
<thead>
<tr>
<th>Problem definition</th>
<th>Methodology</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lathe design</td>
<td>Structure was analysed for static and dynamic load condition using CMTI, FEA package “CEMFPP” on Vax 11/785 computer system</td>
<td>The FEA analysis of design resulted in 30 per cent improvement in stiffness, 40 per cent reduction in weight. This resulted in 700 kg. of material saving</td>
</tr>
<tr>
<td>Bearing life improvement</td>
<td>FEA static and dynamic analysis was used to analyse the force behaviour. It was observed that bearings were not placed in correct position in old design and bearing selection was not proper</td>
<td>Suitable placement of bearings of correct size resulted in increase of life by 40 times from present 15000 hrs to 600,000 hrs. There was direct saving of bearing cost of $ 1600 per annum</td>
</tr>
<tr>
<td>The weight reduction and toggle press</td>
<td>Analysis of the structure and drive mechanism was carried out using FEA package and the design was optimised</td>
<td>In the optimum design the weight of the structure was reduced by 300 kg.- reduction of 20 per cent in the weight</td>
</tr>
</tbody>
</table>

- how to ensure the quality of components and materials bought from outside suppliers;
- when to make design changes to minimize obsolescence of inventory;
- how to organize meetings between suppliers, design and production personnel to discuss problems of mutual interest;
- how to draw up materials specifications for new products;
- which strategic materials and components will require long-term market research and substitution.

Before placing orders the purchasing department must check whether it is possible to modify the specifications in order to reduce prices, while still meeting the functional requirements of the design. The quantity ordered must also be thoroughly examined to avoid excess purchases and stocks.

Developing specifications requires teamwork. Professionals from the design, manufacturing, marketing and materials departments should all be involved so that specifications reflect the requirements of all these functions. A committee may be formally set up or else the materials
department may designate a coordinator on an informal basis. This should be done during the early stages of the design process.

3.4 Good supplier relations

Short product life cycles, automated manufacturing and information technology, new materials and just-in-time systems emphasizing zero defects have all changed the relationship between the supplier and the buying firm, so that the supplier becomes an extension of the enterprise, and the production systems of buyer and supplier are integrated. There is a mutually beneficial relationship whereby supplier and buyer help each other improve performance. Three cost benefits accrue as a result of this long term relationship:

- The supplier is encouraged to make capital investments in research and development and to reduce costs in manufacturing operations.
- Suppliers use value engineering and other methods to improve product component quality.
- Suppliers are in a better position to undertake modifications through gaining experience in manufacturing.

Xerox Corporation, under its programme of continuous supplier involvement included suppliers in the design of new products, often substituting performance specifications for blueprints in the expectation that suppliers would design the final parts themselves. This approach emphasizes the need for involving suppliers at an early stage and has shifted the focus from lowest price to lowest overall cost. This has led to the concepts of early supplier involvement (ESI) and value added partnership (VAP).

Early supplier involvement

In 1984, a study indicated that when suppliers are involved early in the design process they can give their expertise in the following areas:

- materials specifications
- tolerances
- standardization
- order size
- process changes in supplier’s manufacturing operations
- packaging
- inventory
- transportation
- assembly changes in buyer’s plant

Early supplier involvement helps build mutual trust, especially for items with a long lead time and projects with a long gestation period.

Value added partnership is based on the ‘give and take’ principle where suppliers share the development of new processes and new materials providing extra service, cooperation and cost reduction programmes while the buyers provide assistance with technology, management and finance, as well as making a commitment to order. Such long-term arrangements encourage
suppliers to help buyers solve their problems with materials. There are several arguments for such a partnership.

- Every time a new set of partners comes together a learning process is required, and break-downs in communication are more likely to occur during early transactions than during later ones.
- Changing market conditions and changing technology require adaptation on the part of buyers and sellers. Adjustments are much less painful when the partners support each other.
- The likelihood of quality problems and late deliveries is greatly reduced in a continuing relationship.
- An open relationship can help cushion bad times. Customers and suppliers who value each other are more likely to help each other during times of adversity.
- Suppliers copy from the behaviour of an aggressive, price-optimizing purchaser. Such buyers will find it more difficult to obtain on-time delivery than buyers who have continuing relations with their suppliers.
- Opportunistic buyers are more subject to shocks resulting from problems encountered by the supplier.
- Opportunistic buyers should expect less effective performance from suppliers who believe that they have little to lose in the way of follow-on business.

Value added partnership promotes a network of organizations in the design, manufacture and marketing of a range of products and is being considered as an alternative to vertical integration. Many Japanese companies have links with a large number of subcontractors based on the VAP concept. Toyota subcontracts not only the production of parts but the entire responsibility for producing them, including design for some models.

3.5 Supplier development and selection

The proper selection and development of new suppliers plays a critical role in purchasing. This is not an ad hoc responsibility of purchasing management but a continuous opportunity to search and locate new sources of supplies, which should be part of corporate policy. The major activities involved in this process are locating and developing new sources and selecting the right source.

Locating and developing new sources

The first step is to maintain a database or information directory of background information on potential suppliers and the materials they handle. New suppliers can be located through trade journals, newspaper advertisements, trade associations, supplier catalogues, telephone directories (particularly the yellow pages) and trade exhibitions. Sales representatives and the purchasing departments of other enterprises could also provide useful information. However, only reliable suppliers who fulfil the requirements of the organization should be included in the directory.

The background information to be evaluated before a supplier’s name is entered in the directory or database includes:
Module 19  
Unit 3

- financial information such as credit ratings and bank references;
- technology, R&D facilities, design capabilities and manufacturing facilities;
- quality management systems, quality control techniques and inspection facilities;
- managerial competence, management philosophy, top management qualifications and training;
- service record including adherence to delivery schedules, capacity to supply rush orders and render technical assistance, and price performance.

In addition, buyers operating a JIT system would require an assessment of the supplier’s capacity to meet the requirements of frequent deliveries with practically zero defects. Four stages of a supplier’s typical progress towards meeting JIT requirements are given in figure 19.11.

**Figure 19.11: Chart of supplier’s JIT progress**

<table>
<thead>
<tr>
<th>SUPPLIER CHARACTERISTICS</th>
<th>STAGE 1</th>
<th>STAGE 2</th>
<th>STAGE 3</th>
<th>STAGE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Exploration”</td>
<td>“Acceptance”</td>
<td>“Pilot project”</td>
<td>“Implementation”</td>
<td></td>
</tr>
</tbody>
</table>

**Overall measurements:**

<table>
<thead>
<tr>
<th>Knowledge of concepts</th>
<th>Hazy or no awareness</th>
<th>Understood</th>
<th>Applied</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management commitment</td>
<td>Uncommitted</td>
<td>Superficial</td>
<td>Evaluating</td>
<td>Drivers</td>
</tr>
<tr>
<td>JIT customers</td>
<td>None</td>
<td>Talks with one or two</td>
<td>Contracts with several</td>
<td>Majority of output</td>
</tr>
</tbody>
</table>

**Manufacturing process:**

<table>
<thead>
<tr>
<th>Quality programmes</th>
<th>Not formalized</th>
<th>Quality circles</th>
<th>PPM targets</th>
<th>Low PPM achieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity flexibility</td>
<td>Very inflexible</td>
<td>Discussing options</td>
<td>Flexible work force</td>
<td>Flexible automation</td>
</tr>
<tr>
<td>Pull mechanisms</td>
<td>Shortage lists</td>
<td>Sales orders</td>
<td>Some kanbans</td>
<td>All kanbans</td>
</tr>
<tr>
<td>Batch sizes</td>
<td>Monthly to quarterly</td>
<td>2 weeks</td>
<td>Weekly</td>
<td>Daily</td>
</tr>
<tr>
<td>JIT purchasing</td>
<td>None</td>
<td>Talking with suppliers</td>
<td>Some JIT</td>
<td>Majority JIT</td>
</tr>
</tbody>
</table>

**Supply process:**

<table>
<thead>
<tr>
<th>Delivery frequency</th>
<th>Monthly</th>
<th>2 weeks</th>
<th>Weekly to daily</th>
<th>As required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery quality variance</td>
<td>Uncontrolled</td>
<td>5%</td>
<td>1%</td>
<td>Low PPM</td>
</tr>
<tr>
<td>Delivery quality variance</td>
<td>± 10%</td>
<td>± 5%</td>
<td>± 1%</td>
<td>None</td>
</tr>
<tr>
<td>Delivery time variance</td>
<td>± Weeks</td>
<td>± Days</td>
<td>± Hours</td>
<td>None</td>
</tr>
</tbody>
</table>
In addition, a visit to the plant for on-the-spot assessment and discussion with employees will give useful information.

It may not be possible to locate reliable suppliers, particularly in developing countries, and considerable initial difficulties may be experienced such as high cost, lack of technical expertise or non-availability of raw materials. Buyers may have to provide technical, financial, and other assistance and coddle suppliers to derive long-term benefits. Buyers may visit industrial centres to locate potential suppliers; exhibitions and trade fairs also prove very useful. Some organizations invite present suppliers to consider extending their range.

Selecting the right source

The first step is to invite competitive bids and to eliminate those which do not meet requirements. The bidding procedure should correspond to the importance of the item and should be cost effective. An open-bid system through newspaper advertising may be used for A items while B and C items may be based on a limited bid system. There should be enough bids to provide real competition.

The next step is to evaluate the bids according to pre-established criteria. Obviously, price should not be the only criterion; quality and service should also be considered. A weighted factor approach is usually the most suitable. Factors are selected according to the item and the organizational requirements, and points are awarded to each factor preferably before the bids are opened or even invited. Common factors are price and past performance on delivery and quality. Sometimes qualitative factors such as managerial, technical, and financial capabilities may be considered when selecting a new supplier. Progressive companies form a team drawn from purchasing, design, quality, manufacturing, finance, and related functions to select suppliers, especially for A-items or for items being put on a JIT system. The team should carefully examine the capabilities of potential suppliers in R & D, production and quality management, and also look into the company's financial, purchasing and industrial relations.

As a very general guide, the following factors and weights are suggested. However, it should always be borne in mind that weights must reflect the relative importance of the factors for a particular item and a particular situation.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>50%</td>
</tr>
<tr>
<td>Service</td>
<td>20%</td>
</tr>
<tr>
<td>Price</td>
<td>30%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

The definition of points and method of calculation is given below:

i) Quality is the measure of supplier performance in providing materials to given specifications.
Quality performance points = \frac{\text{Number of accepted lots}}{\text{Total number of lots}} \times 50

ii) Service is the measure of promptness of the supplier in meeting delivery schedules.

Service performance points = \frac{\text{Number of lots as per schedule}}{\text{Total number of lots}} \times 20

iii) Price is the measure of price differential for the same material by different suppliers.

Price performance points = \frac{\text{Lowest price}}{\text{Supplier's price}} \times 30

The sum of all these performance points indicates the composite rating. A perfect score would be 100, made up of quality (50) service (20) and price (30). It is unlikely that a perfect score would ever be achieved.

The supplier and buyer should keep in touch with each other to identify problems at an early stage and the supplier’s telephone, telex and fax numbers, as well as the names of contacts should be easily available. A proper follow-up system should be designed to ensure that supplies are received on time. The details of the follow-up system will depend on the nature of the items and the urgency of requirements. Generally, important items should be followed up closely with the supplier. In addition, items on the shortage list will demand immediate action on the part of the buyer. Generally, suppliers for these items should be requested to warn the buyer about delays in supplies.

3.6 Strategic materials planning

Historically, corporate planning or the long-range plans of an enterprise were seldom translated into materials plans. The development of a new generation of materials such as semiconductors, ceramics, integrated plastic and metal parts, the scarcity of materials and increasing international and environmental uncertainties have resulted in a change in this approach. It has become essential to identify critical or problem materials early in the corporate planning process so as to make them available at competitive prices. It is necessary to organize materials research, identify long-term needs and determine critical items.

Organize materials research

A separate materials research section should be created in large organizations to identify new materials through systematic market research. In smaller organizations this task can be taken up as a special activity by a senior manager of the materials management or purchasing department. A multidisciplinary team should be made up of personnel from materials, R & D, production, finance and product design to assist in this work.
**Identify long-term needs**

One of the major outputs of the planning process should be a long-range materials and purchase plan indicating critical items. The plan will involve analysing general economic trends, technological forecasting, price variations and developments in materials science. The analysis should be integrated with the planning process so as to work out future needs and their likely impact on the profitability of the organization.

**Determine critical items**

The current problems relating to materials, long-term material needs, manufacturing strategy and company policy will provide a list of critical items, on which materials research and purchasing should concentrate. Specific action plans should be developed for each item, including substitute materials, value-analysis studies, ‘make or buy’ decisions, locating and developing new materials.

### 3.7 Exercises

**Exercise 1**

**Gaskets**

Mr. Xavier, managing director of United Electric, is concerned about the company’s choice of suppliers for gaskets, which are used in much of the vital equipment at the power generating plant. The gaskets are consumed at an average rate of 22,000 per month, a rate which is expected to go up by 35 per cent after expansion of the plant next year. The quality of the gaskets is crucial to plant safety and maintenance down time. Gaskets are difficult to purchase and non-availability disturbs the preventive maintenance schedule.

Mr. Xavier belongs to the same club as Mr. Joe, the general manager of Modern Gaskets Pvt. Ltd., one of the suppliers to United Electric. Recently Joe complained to Xavier that United Electric had stopped buying from Modern Gaskets, although theirs was the lowest bid for the last order. Xavier told Joe that normally he did not interfere with the details of procurement but he promised to ask his purchase manager, Mr. Boland, to investigate.

The following morning, Xavier called Boland and told him of Joe’s complaint. He said that he didn’t want to influence the company’s procurement policies but he did feel that Boland should investigate to make sure that Modern Gaskets was treated fairly.

Boland discovered that Modern Gaskets was indeed the lowest bidder during the last procurement. Quotations for an order of 20,000 were as follows:

- Modern Gaskets Pvt. Ltd. $ 4.50 per piece.
- Rockwells Ltd. $ 4.55 per piece.
- Mahua Pvt. Ltd. $ 4.60 per piece
Orders were placed with Rockwells and Mahua for 10,000 pieces each. Mahua has automated process control technology and a modern R & D centre, and has done considerable developmental work on gaskets, while Modern Gaskets and Rockwells have done very little. The quality and delivery records of the suppliers on the last ten orders are as follows.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Quality ordered</th>
<th>Quantity defective</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahua</td>
<td>12000</td>
<td>244</td>
<td>1 week early</td>
</tr>
<tr>
<td>Rockwells</td>
<td>8000</td>
<td>184</td>
<td>1 week late</td>
</tr>
<tr>
<td>Modern Gaskets</td>
<td>6000</td>
<td>240</td>
<td>On time</td>
</tr>
<tr>
<td>Modern Gaskets</td>
<td>12000</td>
<td>324</td>
<td>2 weeks late</td>
</tr>
<tr>
<td>Mahua</td>
<td>8000</td>
<td>76</td>
<td>On time</td>
</tr>
<tr>
<td>Rockwells</td>
<td>10000</td>
<td>58</td>
<td>1 week early</td>
</tr>
<tr>
<td>Modern Gaskets</td>
<td>4000</td>
<td>176</td>
<td>2000 on time</td>
</tr>
<tr>
<td>Rockwells</td>
<td>12000</td>
<td>196</td>
<td>2000 four weeks late</td>
</tr>
<tr>
<td>Mahua</td>
<td>8000</td>
<td>90</td>
<td>1 week late</td>
</tr>
<tr>
<td>Modern Gaskets</td>
<td>10000</td>
<td>324</td>
<td>1 week late</td>
</tr>
</tbody>
</table>

United Electric’s inspection department has set an acceptable quality level of 3 per cent on gaskets.

1. Discuss whether Boland was justified in eliminating Modern Gaskets as a supplier.
2. Prepare a report for Xavier explaining the decision to eliminate Modern Gaskets, using quantitative data as much as possible.
3. Discuss the supplier selection and development approach adopted by United Electric in view of the proposed expansion.

Exercise 2

1. List five techniques for reducing waste during processing of materials.
2. You have been requested to develop an evaluation plan to measure the performance of suppliers. Describe how a weighted factor system can be used in selecting suppliers.

Answers are given in the annex to this unit.
Exercise 1  Gaskets

a) Methodology

1. Since quality and service were critical it was decided to evaluate supplier performance on the basis of price, quality and service.

2. Decide the weighting for each factor, to reflect relative importance. To encourage suppliers to reduce defects and arrange deliveries on time, the following weighting was used.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>45</td>
</tr>
<tr>
<td>Service</td>
<td>30</td>
</tr>
<tr>
<td>Price</td>
<td>25</td>
</tr>
</tbody>
</table>

3. The allocation of points was decided as follows:
   a) Quality
      If defects are more than 3 per cent points = 0
      For no defects points = 45
      Therefore for 2.03 per cent defects points = (45 - 2.3/3 x 45) = 10.5
   b) Service
      If delivery is late by 4 weeks or more points = 0
      If delivery is on time or early points = 30
      Therefore if delivery is late by 2 weeks points = (30 - 2/4 x 30) = 15
   c) Price
      For minimum price points = 25
      For maximum price differential i.e., 2.2 per cent points = 0
      Therefore for price differential -1.1 per cent points = (25 - 1.1/2.2 x 25)
4. The points obtained by each supplier are given below:

<table>
<thead>
<tr>
<th>Factor</th>
<th>MOHUA</th>
<th>ROCKWELL</th>
<th>MODERN GASKETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Lot No.</td>
<td>Average % Defective</td>
<td>Points</td>
</tr>
<tr>
<td>1.</td>
<td>2.03</td>
<td>14.55</td>
<td>2.53</td>
</tr>
<tr>
<td>2.</td>
<td>0.95</td>
<td>30.75</td>
<td>0.58</td>
</tr>
<tr>
<td>3.</td>
<td>1.13</td>
<td>28.05</td>
<td>1.63</td>
</tr>
<tr>
<td>4.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Avg. Points</td>
<td>1.37</td>
<td>24.45</td>
<td>1.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service</th>
<th>Delay (wks)</th>
<th>Points</th>
<th>Delay (wks)</th>
<th>Points</th>
<th>Delay (wks)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Early</td>
<td>30</td>
<td>1</td>
<td>22.5</td>
<td>On time</td>
<td>30</td>
</tr>
<tr>
<td>2.</td>
<td>On time</td>
<td>30</td>
<td>Early</td>
<td>30.0</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>3.</td>
<td>1</td>
<td>22.5</td>
<td>2</td>
<td>15</td>
<td>On time</td>
<td>30</td>
</tr>
<tr>
<td>4.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Avg. Points</td>
<td>0.33</td>
<td>27.5</td>
<td>1</td>
<td>22.5</td>
<td>1.4</td>
<td>19.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Price</th>
<th>Price difference from Min (%)</th>
<th>Points</th>
<th>Price difference from Min (%)</th>
<th>Points</th>
<th>Price difference from Min (%)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.02</td>
<td>0</td>
<td>1.1</td>
<td>12.5</td>
<td>Minimum</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Avg. Points</td>
<td>1.37</td>
<td>24.45</td>
<td>1.50</td>
<td>22.45</td>
<td>3.58</td>
<td>0</td>
</tr>
<tr>
<td>Total Points</td>
<td>51.95</td>
<td>57.45</td>
<td>44.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) Answers to the questions

1. Boland was justified is not placing an order with Modern Gaskets, since its composite rating was lowest and its quality rating was zero.

2. The salient points to be covered in the report:
   a) Ratings obtained by the three suppliers.
   b) Mahua had done considerable work in developing its production technology and quality control systems, hence the order was justified.
   c) The composite rating of Rockwells in terms of quality, service and price justified splitting the order i.e., 10,000 gaskets from each firm.

3. a) The basic approach to supplier evaluation is considered satisfactory. However, preliminary evaluation based on technology, quality control systems, R&D facilities and other relevant factors should be carried out to eliminate unreliable suppliers.
   b) In view of the proposed expansion and increasing requirement for gaskets, efforts to develop suppliers should be strengthened to encourage competition and ensure a steady flow of gaskets. Long-term relationships with the present suppliers should be developed, and if
possible, JIT systems should be implemented. Technical and other assistance should be provided to Rockwells and to Mahua. If Modern Gaskets is interested a detailed discussion could be held to identify areas where improvements would be required.

Exercise 2

1. The major sources of waste during processing are
   i) poor product design
   ii) carelessness
   iii) inappropriate technology
   iv) little emphasis on quality control
   v) wrong choice of materials
   vi) poor maintenance
   The techniques to reduce waste are
   i) clean or no-waste technology
   ii) quality control/management
   iii) product design
   iv) recovery and recycling
   v) process planning

2. In a weighted factor system, a number of criteria are used to evaluate the performance of a supplier. Price, quality and service are the three most common factors considered for this purpose. It is presumed that the supplier’s technical, managerial and financial capability has already been evaluated at the preliminary stage.
   The factors are selected according to the nature of the item and organizational requirements. Each factor is awarded points to reflect its weighting. Performance on each factor is multiplied by the points and the total reflects the overall performance of the supplier.
   Performance on each factor is measured as follows:

   \[
   \text{Quality} = \frac{\text{No. of accepted lots}}{\text{Total lots}} \times \text{points} = x_1
   \]

   \[
   \text{Service} = \frac{\text{No. of lots delivered on time}}{\text{Total lots}} \times \text{points} = x_2
   \]

   \[
   \text{Price} = \frac{\text{Lowest quotation}}{\text{Price quoted}} \times \text{points} = x_3
   \]

   Total points = \( x_1 + x_2 + x_3 \)
UNIT 4: STORAGE AND MOVEMENT OF MATERIALS

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Relate storage and movement costs to materials productivity.
2. Develop guidelines for location of stores and storage of materials.
3. Identify key measures to improve productivity during storage and movement of materials.
4. Design a materials handling system.
5. Improve freight management.

UNIT 4: CONTENTS

4.1 Identification and disposal of obsolete and surplus stocks
4.2 Location of stores
4.3 Proper storage methods
4.4 Good housekeeping practices
4.5 Materials handling
4.6 Freight management
4.7 Exercises
UNIT 4: STORAGE AND MOVEMENT OF MATERIALS

The storage and movement of materials influence costs and do not add value to the product. The costs involved are:

- direct costs such as deterioration, obsolescence, handling, pilferage and space;
- indirect costs such as idle time caused by delays in moving materials.

The keys to improving productivity in this area are:

- identification and disposal of obsolete and surplus stocks;
- locating stores in the most suitable place;
- storage systems and practices;
- good housekeeping practices;
- materials handling system;
- freight management.

4.1 Identification and disposal of obsolete and surplus stocks

The major causes of obsolete and surplus stocks are the overestimation of requirements, changes in product design, standardization, and bulk purchases. The following measures are suggested to reduce obsolescence:

- Changes in design and production schedules should be made when stocks are at a minimum level.
- Estimates of requirements should not be based on historical consumption data alone.
- Planning for A and B items must be done more accurately than for C items.
- Discounts should be negotiated only if the additional items are absolutely essential.
- Standardization must be implemented when stocks are low.
- The volume of orders for spare parts should be examined when new equipment is bought. Information on consumption of spares for similar equipment should provide guidance and other organizations may be consulted.

The following steps should be taken to identify and dispose of useless stocks.

a) A periodic review of stocks is carried out to identify slow-moving and non-moving items which need not be kept in stock. Slow-moving items are those which have been kept for at least one year and non-moving items are those which have been kept for two or three years. In addition, there may be excessive stocks (which will last for more than a year) of certain items. A list of slow- and non-moving items and excessive stock items should be prepared, indicating the value of these stocks and when they were last issued.

b) Since the list may include items which could be required in future, it has to be circulated so that all departments can identify items which might be used, items which need modification and items which cannot be used.

c) It is then necessary to prepare a list of items which cannot be used within the organization.

d) This list should be sent to similar organizations, suppliers, dealers and other probable users for sale or exchange.

e) If there is no possibility of sale or exchange, the items may be donated to educational institutions or sold to employees.
f) Items which cannot be disposed of otherwise should be offered at auction.

4.2 Location of stores

The basic principle is to locate stores nearest to the point of use to reduce handling costs and time. Badly located stores may add to costs because of extra handling, damage, delay, and loss in transit. A decentralized system of stores would reduce handling costs while a centralized system would permit better control of inventories and save on space, equipment and manpower. Normally, both systems are used in an organization, depending on its size. It may be desirable to have one to three centralized stores to stock small items, packaging materials, material required ordered (MRO) supplies, while bulky and heavier items are kept nearest to the point of use. Factors such as work flow pattern, distance, frequency of movement, storing conditions, and nature of the items should be considered when the factory layout is prepared. The implementation of JIT systems involving long-term contracts with suppliers facilitates delivery of items nearest to the point of use.

4.3 Proper storage methods

Proper stores layout permits easy access to materials, better space utilization and reduced need for handling within the stores; it also minimizes damage, deterioration and pilferage, and permits easy checking.

Racks and other facilities are arranged to minimize the distance travelled when materials are received and issued. The method of storage will depend on the size, shape, type and quantity of the item. Optimum space requirements can be worked out for each type of item and matched with the floor layout of the stores to indicate the best arrangement of stocks and placement of facilities. Items requiring specific conditions such as refrigeration should be identified. Items should be grouped according to frequency of use, shape, size, and weight to determine overall layout and storage methods. Fast-moving items are stored nearest to the issue window while slow-moving and other items are kept upstairs and on the top or bottom shelves of the racks to save labour cost. Some of the rules for developing proper stores layout are as follows.

- Space utilization should be maximized by making full use of the vertical dimension.
- Items should be binned by groups or classes to reserve space for each group.
- Materials should be properly labelled showing class and code to permit easy identification. The principle of “first in-first out” will help reduce deterioration, particularly for perishable goods.
- As far as possible binning should facilitate counting of materials.
- Materials should be obtained, stored and issued in unit loads to reduce handling.
- Proper storage and preservation methods should be used for each item. For example, in-flammable materials must be stored in tightly closed containers away from the main building.

Some measures to improve materials productivity are as follows:

a) Random access storage system
In this system, there is no fixed location for any item and goods are stored in the first available space. This may mean that the same item is stored in different places, although spaces are reserved for similar types and sizes of items. A computer is used to record the location of each item. While space is well-utilized in this system, it does not permit visual control of items. Random access storage is most suitable for large organizations.

b) Automated warehousing

Automated warehousing has been developed to minimize labour, space and operating costs. Normally, goods are stored in standard pallets and containers. Handling machines and computer controlled systems used with random access storage permit automatic storage and retrieval of items. Normally, the handling machines are controlled by computer; linking with the production, planning and control systems will considerably enhance capability.

c) Codification systems - bar codes

Each organization develops its own code for materials. The codification system becomes a means of communication between different departments and minimizes clerical errors. It also facilitates standardization. Bar codes are increasingly being used to identify materials in industry and trade. The code consists of solid bars of different sizes with spaces between. A laser scanner sends electrical signals by which the computer locates the record in its memory. This improves the speed and accuracy of operations in a store.

d) Insurance

Risk and loss can be minimized by arranging proper insurance for materials in transit, storage and dispatch. The average cost of insurance is about 2 to 3 per cent of the cost of materials. The insurance premium depends upon value, type of goods, nature of packing, mode of transport and risks to be covered. The sum insured should, preferably, include incidental expenses, taxes, customs duty and reasonable profit. The scope of the insurance cover should be clearly spelt out; for example, if leakage from drums or losses from gunny bags are to be covered, this should be specifically mentioned in the policy. A careful study of the insurance policy can stimulate ideas on reducing the cost of insurance. Improving conditions such as packing, care in storage and handling of materials could help reduce premiums. Detailed discussions should be held periodically with the insurance company to review the costs and benefits of different options. In some countries, insurance brokers handle all matters relating to insurance and provide guidance on negotiating policies and filing claims.

4.4 Good housekeeping practices

Adequate measures are needed to prevent damage, deterioration, theft and pilferage of materials. Some good housekeeping practices are listed below.

i) Adequate protection and security staff should be provided.
ii) Measures such as locking windows and restricting the entry of outsiders to the stores should be taken.
iii) Ball-bearings, brass, copper and other expensive items should be stored in a steel cupboard.
iv) Proper insurance cover should be arranged against theft, fire etc.
v) The materials most prone to pilferage are small volume, fast moving, high price, A class...
items. Such items should be kept under lock and key. Issues should be strictly controlled with frequent physical verification to detect pilferage.

vi) Expensive articles should be stamped with the name of the firm.

vii) Control on consumption of costly items should be exercised; observance of consumption norms will stop unauthorized issue.

viii) Containers which leak or spill their contents should be replaced.

ix) Staff should be trained to handle materials properly to avoid damage.

x) Fire-fighting equipment should be installed and checked regularly.

xi) Materials such as empty boxes which are liable to catch fire should not be allowed to collect.

xii) Proper conditions should be provided to store goods requiring air-conditioning or protection from damp.

xiii) Materials should be repacked properly after inspection.

xiv) Proper lighting and ventilation arrangements should be made.

4.5 Materials handling

Materials handling concerns the delivery of materials to the right place at the right time within the plant. It includes preparing and positioning materials to facilitate transfer. Obviously, no value is added to the product but poor materials handling will add to costs and reduce productivity. The importance of handling is illustrated by the points below.

In the pharmaceuticals industry labour costs for materials handling account for 30 to 40 per cent of total labour costs, and add up to 50 per cent to cycle time. About 40 per cent of industrial accidents occur because of faulty materials handling. Materials handling may account for as much as 40 per cent of production costs.

The specific details of a materials handling system will depend on the nature and quantity of materials, the distance and frequency of movement and considerations such as safety, reliability and the economics of the proposed system. The relative location of various departments and stores will also influence materials handling and costs. Therefore, it is important to consider the materials handling system while developing the production system and layout to minimize overall production costs. Specialists should be consulted when the production system and layout are being developed.

The nature of production planning and control and relations with suppliers will help reduce handling costs. In a JIT environment or when there are frequent deliveries of A class fast-moving items, it may be preferable for the supplier to deliver materials on trolleys so that they can be delivered straight to the point of use, thus eliminating materials handling altogether.

- Buying new handling equipment is not a substitute for developing a materials handling system. The nature of the materials and frequency of movement should be examined in order to minimize handling and simplify methods. An analysis of requirements can be carried out with the help of industrial engineering techniques such as a flow process chart, operation process chart, flow diagram, activity-relationship chart and product-quantity analysis. The mode of transportation and size of unit load should be decided.
Some guidelines for reducing materials handling cost:

- Arrange for suppliers to deliver materials in standard containers suitable for storing and issuing.
- Hardware items such as nuts and bolts can be ordered in standard quantities, then stored and issued in the original containers.
- Items such as castings can be made up into standard pallet loads.
- After inspection items may be put into containers of standard quantity.
- Whenever possible a gravity-feed system should be used, as it requires no power.
- Handling equipment should be standardized as far as possible for interchangeable usage, better utilization and reduction in spares inventory.
- A preventive maintenance programme should be implemented for materials handling equipment.
- Versatility and adaptability of equipment will ensure that investments are kept to a minimum.
- Part loads should be avoided so that each handling trip is productive.
- Stores should be as close as possible to the plant.
- Operations research techniques such as queuing theory can be very effective in optimizing the use of materials handling equipment.

4.6 Freight management

Transport costs can be as high as 40 per cent of total product costs in some heavy industries, or as low as 1 per cent in the case of electronics. The timely movement of materials from supplier to factory is vital for ensuring that materials are available at optimum cost. Delivery times are influenced by the reliability of the transport agency; delays in transport could lead to increased inventories and production stoppages. To reduce transport costs the following points should be considered.

- Location of the supplier i.e., distance from the factory, will have a direct impact on the transportation bill. Purchasing and transport personnel should work out a common strategy for maximizing organizational performance.
- Selecting the right mode of transport, carrier and routing will influence the cost and level of services. Generally, faster transport costs more than slower methods. Sometimes a combination of methods could be considered to suit the cost and service requirements. Freight charges should be considered while selecting modes of transport because some indirect costs such as packing, warehousing and inventory will depend upon the mode selected. Considerations for selecting suppliers are equally relevant to selecting carriers. The objective here would also be to develop a long-term relationship. Factors such as capacity, equipment available for loading and unloading and past performance should be considered. In some countries, transport is state controlled and there may be little choice, but efforts should still be made to ensure the best service available. Routing will determine the actual time in transit, which is especially important for imported items. Generally, routing is determined by the supplier, although the buyer can indicate a preferred route before placing an order.
- Freight rates and auditing of bills
  The rates charged by carriers depend on the materials, distance, value, competition and
services required during transit. Bills should be audited to check that the correct rates have been charged. Continuous monitoring of rates should be undertaken to minimize freight costs.

- **Close monitoring of unloading operations** on arrival of consignments should be undertaken to minimize demurrage charges.
- It is natural that some consignments will be lost or damaged during transit. Claims must be filed at once in the proper format along with all relevant documents. A checklist should be prepared to ensure that all points have been covered in the claim. Depending on the volume of work, specific personnel could be made responsible for this job.
- **Clear instructions** should be given to the supplier on packing. The cost will depend on specifications for the packing material and method of packing. The lightest possible packing will reduce transport costs, but a balance has to be struck between the cost of damaged goods and packing costs. Special projects may be undertaken to reduce packing costs through the use of value engineering. Reusable containers should be used as far as possible.

### 4.7 Exercises

**Exercise 1**

The attached sheet illustrates the operation sequence required to manufacture part 'X' and the factory layout in a batch manufacturing plant making a variety of different components. The layout also shows the operating rate for each process. Assuming a single shift operation and 4 hours transport time from one spot to the next, calculate the total cycle time for a batch size of 600 and work out the value adding ratio, i.e., the ratio of time taken for value adding operations to total cycle time.

**Exercise 2**

1. You have been asked to identify and dispose of surplus stocks in your organization. What action would you take?
2. "Materials handling significantly influences the cost of production". Comment on this statement and mention two important factors influencing the cost of materials handling. Compare your answers with those provided in the annex to this unit.
LAYOUT
OPERATION SEQUENCE

Cut to length → Mill → Drill → Deburr → Store → Heat treatment → Finish grind → Magnetic inspection → Assembly → Store

<table>
<thead>
<tr>
<th>RAW MATERIAL STORE</th>
<th>STORE</th>
<th>PLATING SHOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUT TO LENGTH</td>
<td></td>
<td>DEBurr</td>
</tr>
<tr>
<td>600/HR</td>
<td></td>
<td>1000/HR</td>
</tr>
<tr>
<td>INSPECTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40/HR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSEMBLY</td>
<td>HEAT TREATMENT</td>
<td>MACHINE SHOP</td>
</tr>
<tr>
<td>20/HR</td>
<td>1000/HR</td>
<td>MILL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100/HR</td>
</tr>
<tr>
<td>STORE</td>
<td>GRIND</td>
<td>DRILL</td>
</tr>
<tr>
<td></td>
<td>50/HR</td>
<td>200/HR</td>
</tr>
</tbody>
</table>

19 - 52
Exercise 1

<table>
<thead>
<tr>
<th>S1.No</th>
<th>Operation</th>
<th>Batch Size 600 Hrs.</th>
<th>One Component Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cut to length</td>
<td>1</td>
<td>0.0017</td>
</tr>
<tr>
<td>2.</td>
<td>Mill</td>
<td>6</td>
<td>0.01</td>
</tr>
<tr>
<td>3.</td>
<td>Drill</td>
<td>3</td>
<td>0.005</td>
</tr>
<tr>
<td>4.</td>
<td>Deburr</td>
<td>0.60</td>
<td>0.001</td>
</tr>
<tr>
<td>5.</td>
<td>Store</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Heat treatment</td>
<td>0.60</td>
<td>0.001</td>
</tr>
<tr>
<td>7.</td>
<td>Finish grind</td>
<td>12.00</td>
<td>0.02</td>
</tr>
<tr>
<td>8.</td>
<td>Magnetic inspection</td>
<td>15</td>
<td>0.025</td>
</tr>
<tr>
<td>9.</td>
<td>Assembly</td>
<td>30</td>
<td>0.05</td>
</tr>
<tr>
<td>10.</td>
<td>Transport</td>
<td>32.00</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Total cycle time</td>
<td>103.20</td>
<td>0.1137</td>
</tr>
</tbody>
</table>

Value added ratio = \[
\frac{\text{Value adding time}}{\text{Total cycle time}}
\]

= \[
\frac{0.1137}{103.20} \]

= 0.0011

Exercise 2

1. The following actions will be required:
   a) Carry out a review of stocks and list all the items which have not been issued for more than one year or for which stocks exist for more than one years’ consumption.
   b) Circulate the list so that all departments can identify items which are usable: prepare a final list of items which cannot be used.
   c) Send this list to similar organizations, suppliers, dealers and other probable users for sale or exchange.
   d) Donate items which can not be sold or exchanged to educational institutions or sell to employees.
   e) Auction all remaining items.
2. Materials handling adds cost but no value to the product. The following are the direct and indirect costs of materials handling:
   - labour costs;
   - costs due to increased cycle time;
   - cost related to industrial accidents.

The two major factors influencing the cost of materials handling are:
- the distance over which materials are moved, which depends on layout and stores system;
- the nature and quantity of materials moved, which depends on production planning and control as well as the stores system.
UNIT 5: REDUCING WASTE

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the concept of waste and its impact on the organization.
2. Identify sources of waste.
3. Design a waste management programme.
4. Use waste minimization techniques.

UNIT 5: CONTENTS

5.1 Introduction
5.2 Sources of waste
5.3 Approach to reducing waste
5.4 Strategy to combat waste
5.5 Waste-reducing techniques
5.6 Exercises
UNIT 5: REDUCING WASTE

5.1 Introduction

In the process of converting raw materials into finished products the production system generates waste in the form of scrap, rejects and pollutants. Waste is made up of direct materials which do not go into the end product or its components and indirect materials and consumables which remain unused or are consumed to excess. Waste also consists of packing and any other material employed in manufacturing, transporting, using and disposing of products after use. Pollutants can be considered as another form of waste (see figure 19.12). Waste leads to poor economic performance and damages the environment. It reduces the competitiveness of an enterprise and affects the quality of life.

5.2 Sources of waste

Major sources of waste include domestic and agricultural activities, but industrial waste poses the biggest challenge because of the vast variety of materials used in the production process. Waste occurs during manufacturing operations, product use, and as a result of disposing of the product after use.

Figure 19.12: Materials waste - A conceptual framework
Since inputs cannot be completely converted into finished products at present, a certain amount of waste will occur. Waste of materials during processing can usually be traced to one of the following causes:

i) poor product design  
ii) inappropriate technology  
iii) wrong choice of materials and other inputs  
iv) carelessness  
v) poor maintenance of plant and equipment  
vi) improper work methods and practices  
vii) lack of proper process planning  
viii) lack of training, motivation and incentives  
ix) little emphasis on quality control  
x) inadequate supervision and control  
xi) lack of understanding of the concept and impact of waste  
xii) poor management policies and structure  
xiii) lack of information on waste  
xiv) poor environmental conditions

5.3 Approach to reducing waste

Economists define a waste product as a substance which is cheaper to throw away than to make further use of. However, a critical examination of production systems can lead to the reduction, elimination, or alternative use of waste. A preventive approach focused on avoiding waste at source has been found to be most effective. This requires a complete re-examination of the way a product is designed, manufactured, used and discarded. To reflect this total approach UNEP (the United Nations Environment Programme) has coined the term “cleaner production” rather than “waste minimization” or “clean technologies”. The UNEP programme emphasizes a global approach to production in which all phases in the life cycle of a product or of a process are addressed with the objective of minimizing short- and long-term risks to humans and the environment. This includes a “cradle to grave” approach minimizing emissions into air, water and soil as well as reducing energy consumption and the use of raw materials. It has been proved beyond doubt that such an approach is economically viable, technically feasible and compatible with environmental protection. This is an area where national ecological goals and industrial economic interest are not in conflict.

5.4 Strategy to combat waste

A multipronged strategy is needed to mount an effective attack on waste. This strategy requires a problem-solving managerial style, an innovative environment, continual organized effort and above all commitment on the part of management and employees. A waste-management programme should reflect management goals and policies on waste minimization. The programme should be an ongoing effort making waste minimization a part of the company’s operating philosophy. The focus of the programme could be on hazardous materials, critical materials or other materials, depending on the priorities and objectives of waste management. The essential components of the strategy are:
top management support;
involvement of employees;
organizational mechanisms;
waste measurement and identification.

Top management support

The commitment of top management is crucial to the success of waste-management programmes. Allocation of the resources required for developing and implementing a waste-management strategy can be ensured only if management is convinced that the benefits will outweigh the cost. A waste-management policy is necessary to integrate the efforts of all departments and employees. Management concern about avoiding or reducing waste should be conveyed to employees through a policy statement laying down specific goals. Waste-management goals should be measurable; they should also be motivational, flexible and comprehensible to employees. They will need periodic review so the waste-management programme focuses on current concerns and problems facing the enterprise and society in general.

Involvement of employees

Creating a no-waste culture and involving employees will go a long way towards making a waste-management programme effective in the long term. Specific waste-management goals for employees and their periodic evaluation will help. Concepts such as quality circles should be implemented.

Organizational mechanisms

A special task force may be created to identify waste and implement a waste-management programme on a continual basis. In a small organization, one of the senior managers could be made responsible for the programme, with the participation of personnel from production, quality, maintenance and purchasing. The activities would include assessing the quantity and quality of waste materials, developing uses for them or disposing of them if necessary. The programme would also include the reclamation of spares and damaged equipment.

Waste measurement and identification

Waste measurement is essential for setting standards, identifying the present level of waste and monitoring the effectiveness of waste-management efforts. Productivity indices generally do not reflect the value of materials which have gone into the final product. The concept of "wastivity" has been evolved to measure the level of waste in a system. It is defined as a ratio of waste to input, i.e., Wastivity (WW)=Waste(W)/Input(I). This measure can be used for all types of resources and a reduction in wastivity will lead to an improvement in productivity.

Waste indices can be developed to identify areas of action for improving materials productivity. The approach outlined in Unit 1 can be used to develop indices for comparing actual performance with the standards set or with a competing organization, in order to identify areas where waste management efforts have to be concentrated. Waste indices have been proposed for reduction, collection, recovery, and disposal, as given below.
**Waste management indices**

- **Reduction index** - Ratio of waste generated during the current period and the previous period.
- **Collection index** - Ratio of waste collected and waste generated during a particular period.
- **Recovery index** - Ratio of waste recycled or recovered and waste generated during a particular period (if multiplied by a value increment after recovery this can show the cost of recovery and the value of by-products).
- **Disposal index** - Ratio of net gain in the base (control) period and benefits in the current period (the net gain is the difference between the value realized and the cost of disposal).

These indices can be developed for processes, departments and materials.

The first step in the waste management programmes is to identify waste at different stages in the process. Industrial engineering techniques such as method study can also be applied to identify waste. For example, the operation process chart and the flow process chart can have a column for waste generated during each operation and the major cause of waste at that stage.

### 5.5 Waste-reducing techniques

The specific tools and techniques available are:

- redesigning the product;
- changing the production process;
- recycling waste material;
- operating and maintenance practices;
- process planning;
- quality management;
- consumption norms.

**Redesigning the product**

Products should be designed in such a way that minimum waste occurs in manufacturing, use and disposal. Substituting materials which perform the same function can reduce wastage. Sound product design should satisfy multiple criteria as shown in the box below.
Module 19
Unit 5

Product design

a) Have minimal life cycle costs - costs to the enterprise and society over the life of the product should be minimized, including total cost of labour, materials and other resources used for manufacture, sale, use and disposal.

b) Needs satisfaction - for health, shelter, transport and food.

c) Benefit society - develop a healthy and sound environment which improves the quality of life.

d) High quality - to avoid quick obsolescence, breakdown and wastage.

e) Conservation of resources - have low waste and high recycling potential during manufacture, use and disposal (a poor product specification allows excessive waste and pollution).

f) Easy maintenance - low cost maintenance rather than easy replacement.

Note: In developing countries products remain unused for long periods for lack of maintenance resources. In industrialized countries, many products are designed to be replaced rather than maintained; what is “economic” for the enterprise may not be economic for society as a whole.

g) Recycling possibilities - product specifications that use waste materials, product components and packaging that can be economically recycled.

Note: Choice of product design may be guided not only by technological or economic criteria, but also by the availability of raw materials, energy requirements and pollution likely to be created by the disposal of products after use.

h) Consumer information - on the use of the product; risks to the user and to children; disposal requirements and possible effects of pollution; management can be held responsible even for consumer negligence.

i) Adequate packaging - not excessive; biodegradable to avoid pollution; useful to the consumer after product consumption.

Changing the production process - clean technologies

Use of low- and non-waste technology is the single most important way to conserve materials. It has been proved that such technologies not only reduce costs but also lead to a better quality of life through improving the environment. Clean technology reduces or eliminates waste and pollutants and conserves natural resources. It will improve yield, recycle materials, minimize waste and re-use waste from other processes. Manufacturing should be modified to make production more efficient through changes in the process, changes in equipment, layout or piping, use of automation and changes in operating process conditions.

Recycling and re-use of waste material

This methodology emphasizes returning waste materials either to the originating process or
to another process as an input. Recycling also involves reclaiming recoverable materials from waste. Worn-out spare parts can be reclaimed through machining and modern welding techniques can be used to build up worn components. Coating and brush plating can be used to prolong the life of spare parts.

Operating and maintenance practices

Improving housekeeping practices is a significant aspect of waste reduction. Good operating and maintenance practices can often be implemented with little additional cost.

Some actions to promote good operating and maintenance practices are listed below.

- Implement Japanese 5 S measures, as described in the box.

<table>
<thead>
<tr>
<th>Original Japanese</th>
<th>Meaning in English</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEIRI</td>
<td>Sort out unnecessary items in the workplace and discard them</td>
</tr>
<tr>
<td>SEITON</td>
<td>Arrange necessary items in good order so that they can easily be found</td>
</tr>
<tr>
<td></td>
<td>* A place for everything</td>
</tr>
<tr>
<td></td>
<td>* Everything in its place</td>
</tr>
<tr>
<td>SEISO</td>
<td>Clean the workplace thoroughly so that there is no dust on the floor, machines or equipment</td>
</tr>
<tr>
<td>SEIKETSU</td>
<td>Maintain a high standard of housekeeping and workplace organization at all times</td>
</tr>
<tr>
<td>SHITSUKE</td>
<td>Train people to follow good housekeeping practices autonomously</td>
</tr>
<tr>
<td></td>
<td>The Japanese 5-S approach to good housekeeping</td>
</tr>
</tbody>
</table>

- Develop an incentive and bonus scheme with waste reduction as one of the parameters.
- Inspect parts before they are processed further to reduce the number of rejects. Group types of equipment or chemicals to reduce the quantity and variety of waste.
- Develop employee training procedures on waste reduction.
- Evaluate the need for each operational step and eliminate steps that are unnecessary.
- Improve cleaning procedures to reduce mixed waste.
- Separate different types of waste.
- Optimize operational parameters (such as temperature, pressure, reaction time, concentration of chemicals) to reduce waste generation.
- Improve storage methods to reduce leaks, spills, deterioration, obsolescence. Collect
spilled or leaked material for re-use.

- Schedule production to reduce equipment cleaning. For example, mix light to dark paint so that vats do not have to be cleaned out between batches.
- Carry out a performance appraisal on employees’ efforts to reduce waste.
- Allocate waste costs including disposal and treatment directly to departments.
- Set waste standards and monitor performance.
- Monitor the condition of plant and machinery.

Process planning

Scrap is generated during manufacturing operations in the engineering industry. It is not always possible to eliminate, but it can be minimized through proper planning of raw materials, purchase of correct materials, efficient maintenance and use of machines, and proper care on the part of the workers. In the chemical and allied industries, developing and maintaining proper process parameters and control of raw materials quality will improve yield.

During process planning care should be taken to choose the right size and specification of materials and the right type of manufacturing process, and also to maintain process parameters such as speed, temperature and pressure.

Consumption norms developed after considering scrap rates in similar organizations, will locate areas of excess consumption. The training and experience of employees will help reduce scrap rates because of the learning curve.

Quality management

The production of defects is a source of waste. Defects are produced because of uncontrolled processes, faulty machines, lack of skill and proper attitude, bad housekeeping and poor supervision. The practice of total quality management (TQM) creates a culture which emphasizes the quality of work at each stage. The following measures will contribute to reducing defects:

- using process automation to control temperature, pressure and other parameters;
- laying down and enforcing quality standards;
- insisting on preventive maintenance to keep machines in good condition;
- using statistical quality control and other tools;
- standardizing work methods;
- creating quality consciousness among employees;
- developing special projects to solve common problems.

Consumption norms

i) Developing norms for materials consumption aids waste control. Excess consumption of materials may also lead to stock-outs resulting in idle time. The various steps required are to:
- identify items which should be subject to consumption control;
- obtain actual consumption figures;
- calculate the difference between norms and actual consumption;
• initiate action to reduce the difference.

ii) Since large numbers of different items are generally in use, consumption control should be exercised on A items to optimize time and effort. Analysis of past consumption of major materials would also help identify the items most susceptible to fluctuation.

iii) The methodology of developing norms will depend on the items.

Consumption of direct production inputs such as raw materials will depend on the quantity to be produced and manufacturing methods. Sufficient allowance for offcuts, trimming, and turning should be made when working out the norms.

Norms for the consumption of indirect production inputs such as electrodes or paints can be developed through identifying the variables which determine their consumption, such as the surface area to be painted or electroplated.

Consumption of indirect materials such as cotton waste, soap, uniforms may be related to the number of workers, floor area etc. Information on past consumption makes it possible to establish fairly reliable norms.

iv) An information system may be designed to obtain actual consumption figures from the user. This system should include flow of information, frequency and format of reports, naming the departments responsible. The reports could be ready prepared with lists of materials, consumption norms and spaces for recording actual consumption to minimize clerical errors.

v) The next step consists of identifying the materials for which consumption is significantly more or less than the norm. If the deviation is more than 5 per cent reports are submitted to the department concerned with a request for action.

vi) The reasons for the deviation are investigated and action is taken to reduce overall consumption. The possible reasons could be employee-centred (skills), machine-centred, (malfunctioning, poor maintenance) or materials-centred (poor quality). In the case of persistent deviations, special projects could be launched to investigate the reasons and recommend the action to be taken.

vii) In some organizations, the consumption of materials is controlled at the issue stage. The issues are based on slips which have the norms printed on them, and the stores only issue quantities equal to the norms. If larger quantities are required, a special requisition slip with an authorization from higher management is required. In any case, the stores should also submit periodic reports if issues are significantly larger than normal.

5.6 Exercises

These exercises have been adapted from the ILO - Environmental Management Training Module (16). The answers are given in the annex to this unit.

1. CHOOSE THE MOST CORRECT ANSWER

1. Sound product design can be judged by the:
   a) quality of raw materials
   b) high manufacturing standards
   c) careful use and disposal of waste
   d) minimal life cycle cost

2. The quality and quantity of packing and other components of a product likely to be discarded after use:
Module 19
Unit 5

a) should be considered in the design stage to minimize wastage
b) does not usually concern enterprise management
c) are the concern of local government officials
d) are the users' responsibility

3. “Due to poor product design materials waste may be a resource in the wrong place”. This statement is
a) false
b) sometimes true
c) always true
d) hopeful

4. The key advantage to the enterprise of low waste and low pollution is
a) high profitability
b) zero environmental damage
c) resource usage efficiency
d) trouble-free manufacturing

5. Waste management is best considered at which stage of production?
   a) plant selection
   b) plant installation
   c) product design
   d) product selection

6. For technology choice in manufacturing, the production manager seeks to
a) maximize discounted cash flow
b) select technology which is appropriate to the environment and which reduces waste
c) use the latest technology
d) reduce manufacturing costs to the lowest possible level

7. Waste generated by an enterprise is:
   a) an indication of non-productive use of resources
   b) unavoidable in manufacturing
   c) generally due to poor design of the production system
   d) unavoidable pollution

8. A waste identification system usually relates waste to all of the following except
   a) resources used
   b) products manufactured
   c) workers
   d) capital utilization

9. A waste recovery index measures waste by:
   a) recycles against generated
   b) collected against generated
   c) reduced against generated

10. A production system is mainly designed to
    a) achieve maximum technical outputs
    b) protect the internal and external environment
    c) achieve enterprise objectives
    d) minimize waste

11. Facilities and layout planning seek to achieve all of the following except
    a) low material losses in transport
    b) maximization of waste for recycling
    c) safe and healthy working environment
12. The design of a production system usually has the greatest impact on the
   a) economic environment
   b) political environment
   c) physical environment
   d) cultural environment
13. Poor maintenance can lead to waste by all except
   a) leakage
   b) more frequent breakdowns and down time
   c) higher fuel consumption
   d) higher rejection rates of products
14. Waste is the ______ output from a conversion process and represents ______ of resources to their optimal extent:
   a) desired, non-utilization
   b) undesired, non-utilization
   c) productive, efficient utilization
   d) negative, proper utilization
15. In acquiring technology production managers do not usually investigate matters affecting workers’ safety and health because
   a) they fail to see this as a critical factor
   b) if the equipment is safe to use in the country of origin, it will be safe to use anywhere
   c) workers’ safety and health are not their responsibility
   d) reputable suppliers will always provide equipment which complies with national health and safety requirements

2. THE INCENTIVE SCHEME

   The management of a thermal power station operating three 210MW units wishes to design an incentive scheme to motivate employees to achieve higher productivity. Investigations carried out by management revealed that:
   a) the overall plant utilization factor (OPUF) achieved during the last three years was 48 per cent;
   b) the ratio of labour costs to sales and fuel costs to sales were 6 and 60 per cent respectively;
   c) average consumption of coal and furnace oil was more than 20 per cent above the design value;
   d) break-even point at design and average fuel costs was 52 per cent and 62 percent OPUF respectively.

   What are the key problems? How can an incentive scheme be designed to resolve these problems?

3. LUBRICATING OIL

   In view of increasing competition in the tractor market and the rising cost of petroleum products, the Macdonald Tractor Company decided to cut costs by reducing consumption of petroleum products. Management collected data on the use of petroleum products and observed that usually, when the test bed running of an engine was over and all performance parameters
had been tested, the lubricating oil was drained off and fresh oil used to fill it up.

What investigation should management make before ordering equipment to recycle the waste oil for reuse in the original process?
ANNEX TO UNIT 5

The solutions to exercises

Exercise 1

Most correct answers are:
1. (d), 2. (a), 3. (c), 4. (c), 5. (c), 6. (b), 7. (a), 8. (d), 9. (a), 10. (d), 11. (b), 12. (c), 13. (b), 14. (b), 15. (a)

Exercise 2 The incentive scheme

a) Problems - low plant utilization, low labour costs and high fuel costs, excessive fuel consumption, low generation level which is below break-even point.
b) Investigation - management should consider the cost structure of generating power, past performance regarding generation and employee views on the subject. Linking incentives to output generated, expressed either in power generated or overall plant utilization factor (OPUF), may not be sufficient because increased power generation associated with energy consumption will benefit neither the company nor society. The twin objectives of the incentive scheme should be to maximize power generation and minimize fuel consumption. Emphasis should be placed on saving energy resources that use foreign exchange and significantly affect the economic performance of the company.
c) Solution - performance standards should be determined for OPUF and fuel consumption for the power station. The incentive paid to workers could then be in two parts, related to (i) OPUF standards achievement and (ii) fuel consumption standards per unit of power generated.

Exercise 3 Lubricating oil

a) The production manager should determine the nature and amount of other matter that is deposited in the oil as a result of test-bed running.
b) The manager should calculate the savings to be made by reducing oil wastage.
c) It may be possible to drain the oil through a micronic filter after test-bed running and use a magnet to remove foreign particles and dust. The oil could then be put back into the engine and topped up with fresh if necessary. Note: In several cases oil samples were checked after running and they showed no variation in physical or chemical properties.

British Productivity Council: *Team report: Productivity freight handling*.


Burt, David N.: *Proactive procurement - The key to increased profits, productivity and quality* (Englewood Cliffs, Prentice Hall, 1984).


MODULE 20

USING ENERGY EFFICIENTLY
MODULE 20: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand and explain how to manage an energy-efficiency programme.
2. Quantify energy efficiency and perform an energy audit in the enterprise.
3. Contribute to organizing and funding an energy-efficiency programme.
4. Benefit from the energy-efficiency programme.

MODULE 20: CONTENTS

UNIT 1: Assessing the benefits of energy efficiency
UNIT 2: Energy audits
UNIT 3: Energy-efficiency programme checklist
UNIT 4: Interactive plan for different operational levels
UNIT 5: Innovative financing for energy-efficiency projects

Bibliography
UNIT 1: ASSESSING THE BENEFITS OF ENERGY EFFICIENCY

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the principles of energy efficiency.
2. Appreciate the possible benefits of an energy-efficiency programme.
3. Assess energy productivity.
4. Distinguish between energy conservation and energy efficiency.

UNIT 1: CONTENTS

1.1 Benefits of energy efficiency
1.2 Measuring energy productivity
1.3 Exercises
UNIT 1: ASSESSING THE BENEFITS OF ENERGY EFFICIENCY

1.1 Benefits of energy efficiency

The dramatic increase in oil prices since 1973 has brought into sharp focus the need to use energy efficiently. To start with, oil importing nations adopted energy conservation strategies to curtail conspicuous waste by raising prices and/or changing habits. Conservation is synonymous with a marginal reduction in the accepted quality of life. Although these measures were only partly successful, the concept of energy efficiency caught on during the 1980s. Energy efficiency means producing as much as possible with limited energy resources. Energy efficiency is a more dynamic concept than conservation, relying on systematic energy management and the introduction of technological innovations where feasible. A number of countries have been fairly successful in reducing dependence on imported or scarce energy. However, there is clear evidence that much more could be done, especially in developing economies; reducing waste in energy consumption will contribute to sustainable development.

Energy management as a productivity tool

Saving energy is particularly important for the manufacturing sector, where energy accounts for a significant portion of overall costs. Strategies for energy efficiency at enterprise level are linked with the productivity concepts involved in technology management and managerial efficiency. Implementing energy management involves the application of all productivity methods and techniques.

Contribution

Energy management has emerged as a powerful tool for maintaining competitiveness and increasing profitability. Energy savings can be achieved quite easily and quickly, as shown by the experience of thousands of industrial firms in both developing and developed countries. Modest investments in energy-efficiency programmes usually have a payback period of 1 to 3 years, which is close to other sound business propositions.

Other spin-offs

More efficient energy use will reduce emission losses all along the energy conversion chain, reducing consumption of fossil fuels. Attacking the causes of pollution and waste is more efficient than curing the symptoms, and it is easier to include measures for long-term environmental protection. Therefore, energy-efficiency will improve the environmental performance of an enterprise. Other distinct advantages of energy efficiency programmes are:

- better performance of the plant as a consequence of improved operational and maintenance practices which contribute to higher productivity and reduced down time;
- better quality products due to rigorous control of process parameters;
- enhanced safety of operations;
- rational use of alternative fuels, including waste streams.
1.2 Measuring energy productivity

Energy productivity (the ratio of energy consumption to productive activities) is an important element in total factor enterprise productivity. Measuring energy productivity is a basic element in a systematic energy-efficiency programme. It involves establishing a baseline or reference point against which trial efforts can be judged or inter-plant comparisons established. It is important to achieve a fair degree of accuracy in establishing the basic data or indices for productive activities and energy consumption. Indices should be clearly defined, not only for the system as a whole but also for individual process units or sections. This is quite important in the case of energy hogs which consume enormous amount of energy (of the order of 10 per cent or more of gross energy consumption). The cost of energy inputs for each department should be determined and ranked; this will identify any energy hogs in the enterprise.

Aggregation of energy inputs

All the energy that is externally supplied in the form of fuel, electricity, waste heat, etc. is listed on the input side. Residues such as bagasse, which can be used as a fuel, are also considered as inputs. Heat released from exothermic processes should also be included. The energy content of fuel, often termed its calorific value is stated in two ways - gross (or higher) calorific value and net (or lower) calorific value. The difference between the values is the heat lost through evaporation; it is most common to use net calorific value.

Energy balance

In theory, energy inputs are balanced by energy outputs. A real energy balance may make sense only at the process level, but the calculations help to identify energy hogs in larger systems. The following steps are involved in calculating the energy balance:

i. Definition of the system boundary
ii. Quantification of input and output flows and other related parameters
iii. Conversion of the respective energy equivalents to a common unit
iv. Estimation of losses

If an energy balance is to serve as a basis for feasibility studies, the data should be presented in tabular form. In other cases, a graphic presentation is useful. For example, it may be useful to show how fuel oil is used in different facilities. The distribution diagram (figure 20.1) which provides an overall view of the energy situation at a plant is the best way to present an energy balance.

Correlation - Case for multi-product manufacturing unit

Energy consumption is related to production. A correlation is established through a statistical analysis of the energy and production figures, establishing indices for energy productivity levels. Often the correlation may not be linear and the data should be analysed using the least square method. For a company manufacturing many different products, this exercise involves establishing the relationship between energy consumption and production figures separately for each product, and solving a series of equations depicting functions for production and energy consumption figures based on the historic data for time intervals with varying production levels.
Access to the microcomputer for this exercise is quite useful. While performing this analysis, discrete variables affecting energy consumption such as ambient variations, power interruptions, etc., also need to be quantified so as to improve accuracy. Targeted energy consumption figures are computed and related with actual production values.

The example which follows shows how energy productivity can be expressed concisely.

1. Energy productivity improvement (at rated production)
   a. Consumption reduces by 15 per cent per hour
   b. Output increases by 5 per cent per hour

**Figure 20.1: Distribution diagram depicting energy balance for an industry**

2. Net output energy productivity increase MJ*/unit output.
   The computation of energy productivity indices is illustrated in the box overleaf.

* MJ = Mega Joule = a measure of the amount of energy
COMPUTATION OF ENERGY PRODUCTIVITY INDICES: 
CASE OF AN ENTERPRISE MANUFACTURING THREE PRODUCTS

Energy consumption, E is given by equation (i) below

\[ E = K + P_1 EP_1 + P_2 EP_2 + P_3 EP_3 \] (i)

Where \( K \) = Constant,

\( P_1, P_2, P_3 \) are production levels for three products

\( EP_1, EP_2, EP_3 \) are energy productivity levels for the three products.

For evaluating \( K, EP_1, EP_2, EP_3 \), four simultaneous equations have to be established and solved.

Example: For three products A, B, C, the following historic information is tabulated from the production logs.

<table>
<thead>
<tr>
<th>WEEKLY PRODUCTION (IN TONNES)</th>
<th>PRODUCT</th>
<th>PRODUCT</th>
<th>PRODUCT</th>
<th>ENERGY CONSMP.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>300</td>
<td>350</td>
<td>250</td>
<td>1.33</td>
</tr>
<tr>
<td>1st week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd week</td>
<td>250</td>
<td>200</td>
<td>300</td>
<td>1.02</td>
</tr>
<tr>
<td>3rd week</td>
<td>300</td>
<td>250</td>
<td>300</td>
<td>1.18</td>
</tr>
<tr>
<td>4th week</td>
<td>350</td>
<td>300</td>
<td>300</td>
<td>1.34</td>
</tr>
</tbody>
</table>

Establishing the simultaneous equation for energy consumption - production functions.

\[ 300 EP_1 + 350 EP_2 + 250 EP_3 + K = 1.33 \]
\[ 250 EP_1 + 200 EP_2 + 300 EP_3 + K = 1.02 \]
\[ 300 EP_1 + 250 EP_2 + 300 EP_3 + K = 1.18 \]
\[ 350 EP_1 + 300 EP_2 + 300 EP_3 + K = 1.34 \]

Solving the above equations,

\[ EP_1 = 0.0012 \text{ GJ/T, } EP_2 = 0.002, \text{ GJ/T} \]
\[ EP_3 = 0.001 \text{ GJ/T, } K = 0.02 \text{ GJ} \]
1.3 Exercise

1. In what way is energy efficiency relevant to developing countries with very low per capita consumption levels?
2. Is an energy-efficiency programme necessary for small firms where energy accounts for about 5 per cent of production costs?
3. How do energy-efficiency programmes contribute to environmental strategies?
4. What basic steps are essential to establish accurate energy productivity indices for medium process industries?

Compare your answers with those suggested in the Annex to this unit.

Questions for discussion

1. The first oil shock in 1973 was an important landmark in the development of an energy-efficiency culture. Why?
2. Why does the term “conservation” have negative connotations?
3. Do you agree that strategies for energy efficiency and environmental management are complementary? In what way?
4. Why should enterprises try to achieve energy productivity?
1. In their quest for economic growth, developing countries are poised for rapid increases in energy consumption. These economies have to adopt energy efficiency as a complement to augmenting energy supply. Energy efficiency, the least-cost option is relevant in most developing countries.

2. The contribution of energy to value added is quite substantial in many manufacturing companies. Energy-efficiency programmes offer a valuable opportunity for reducing production costs and increasing profitability.

3. Energy-efficiency programmes reduce the pressure on fossil fuels by enhancing conversion efficiencies at various stages. Further, the load on pollution control devices is reduced when an energy-efficiency programme is implemented. As a result, the cost of anti-pollution measures is minimized.

4. i. Establishing accurate consumption levels for all major departments.
   ii. Aggregating energy consumption into common units linked to production figures.
   iii. Correlating energy consumption and production figures.
UNIT 2: ENERGY AUDITS

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the role of the energy audit.
2. Explain the general approach to conducting an energy audit.
3. See the links between energy audits and energy management.
4. Understand the differences between preliminary and detailed audits.

UNIT 2: CONTENTS

2.1 Types of audit
2.2 Approach
2.3 Scope
2.4 Data collection and analysis
2.5 Instruments
2.6 Timing of the audit
2.7 Exercises
UNIT 2: ENERGY AUDITS

An energy audit is the key to a systematic and comprehensive energy-management programme. The audit identifies areas where waste occurs and indicates solutions which are viable within the limits of financial and organizational constraints. It fixes the coordinates for an energy-management programme by evaluating proposals on energy efficiency for presentation to management. The link between energy audits and energy-management programmes is illustrated in figure 20.2.

2.1 Types of audit

There are two types of energy audit, a preliminary and a detailed audit (see figure 20.3). A preliminary audit focuses on major sources of supply and demand, which account for at least 70 per cent of total energy requirements. A preliminary audit can be an effective way of measuring the progress of a plant-energy management programme. It may also be used to decide the modalities of a detailed audit, which goes beyond quantitative estimates to costs and savings. It includes recommendations for engineering work and defines priority projects. A detailed audit accounts for approximately 90 per cent of the energy utilized in the plant. A long-range energy plan can be drawn up on the basis of information generated and analysed by the audit.

2.2 Approach

Before starting an energy audit-programme, management should assign responsibility for energy accounting, auditing and analysis to an internal and/or external group. Executives from departments such as production, utilities, maintenance and finance should be brought together to review the findings at regular intervals. The involvement of different departments and of worker representatives is necessary for an effective energy-audit programme. Financial, organizational and infrastructural support for energy conservation measures should also be ensured.
Figure 20.2: Link between energy audit and energy-management (EM) programme

1. Set up EM team
2. Define scope and objective of the programme
3. Gather data on energy consumption and performance
4. Determine potential for waste elimination
5. Establish priorities for implementation
6. Initiate strategies
7. Monitor savings achieved
Figure 20.3: Comparison of preliminary and detailed unit

<table>
<thead>
<tr>
<th></th>
<th>PRELIMINARY AUDIT</th>
<th>DETAILED AUDIT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Set priorities for optimizing</td>
<td>a. Quantify energy consumption/</td>
</tr>
<tr>
<td></td>
<td>energy consumption</td>
<td>utilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Evolve detailed engineering options to reduce</td>
</tr>
<tr>
<td></td>
<td></td>
<td>energy costs/consumption</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Highlight energy costs and</td>
<td>Formulate a detailed plan on the basis of</td>
</tr>
<tr>
<td></td>
<td>wastage in major equipment/</td>
<td>quantitative and control evaluation</td>
</tr>
<tr>
<td></td>
<td>processes</td>
<td></td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>2 to 10 days</td>
<td>1 week to 10 weeks</td>
</tr>
<tr>
<td></td>
<td>Audit frequency</td>
<td>Difficult to decide</td>
</tr>
<tr>
<td><strong>Preparation</strong></td>
<td>a. No pre-audit visit required</td>
<td>One/two pre-audit visits required.</td>
</tr>
<tr>
<td></td>
<td>b. Detailed questionnaire to be</td>
<td>In addition to points for preliminary audit, the</td>
</tr>
<tr>
<td></td>
<td>compiled before the audit</td>
<td>following points have to be taken care of:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Advance notice to departmental heads</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Arranging for office and secretarial support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Advance tentative schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Audit kit to be meticulously planned/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arranged</td>
</tr>
<tr>
<td><strong>Due date</strong></td>
<td>Within 2 weeks of completion of</td>
<td>Within 3 months of completion of field work</td>
</tr>
<tr>
<td></td>
<td>field work</td>
<td></td>
</tr>
</tbody>
</table>

* For energy-intensive industries, it may be on an annual basis.

2.3 **Scope**

The needs and objectives of the energy audit have to be identified. The functional areas to be studied are selected according to the energy consumption figures and priorities. The exercise should include the following activities:

- Check the capacity and efficiency of equipment;
- Examine the need for automatic controls;
- Determine the adequacy of maintenance;
- Examine the need for improved instrumentation;
- Review new projects with respect to energy use;
- Introduce life-cycle costing;
- Develop energy use indices to compare performance;
- Examine the need for energy saving incentives.
2.4 Data collection and analysis

Data should be collected on energy costs and production figures for the previous three years. These figures show the trend in energy consumption and its cost per unit of production over the years.

When sufficient data have been collected, consumption records should be reviewed. The energy consumption and production figures available should be presented in an appropriate form. A pie chart (see figure 20.4) can be used to indicate the different forms of energy consumed in the unit.

Figure 20.4: Pie chart: Energy consumption pattern in an industry

A sankey diagram, as illustrated in Unit 1, figure 20.1, can be drawn for accounting energy use and losses in the plant. This can be accompanied by measures to reduce consumption.

2.5 Instruments

The accuracy of an energy audit depends on the metering system. Meters by themselves do not save energy but accurate consumption figures are needed in an energy programme. This means installing good metering devices and supplementing them with portable diagnostic instruments. Below is a list of important instruments deployed by most small and medium firms for preliminary and detailed energy audits.

Important energy-measuring instruments

- Digital thermometers
- Oxygen or carbon dioxide meters
- Pressure gauges
- Meters to measure water, oil and steam
- Electrical energy meters
- Optical pyrometers
- Luxmeters
- Hygrometers
- Pitot tube
- Digital manometers

Reliable instruments, correct sampling techniques and precise methods of computation are needed to obtain accurate results.

2.6 Timing of the audit

The timing of an energy audit depends on the type of audit undertaken previously and on the pace of implementation of the energy-conservation programme. The date of the audit is decided by the professionals involved in the latest energy audit undertaken in the plant, or on the basis of a preliminary audit undertaken specifically to decide on the timing of the detailed audit.

To sum up, an energy audit evaluates ideas for improving energy efficiency. Although enterprises do not conserve energy simply by performing an audit, the time and money spent on the audit strengthens the energy-efficiency programme and raises overall potential for energy conservation. A typical energy consumption pattern is illustrated in table 20.1.

### Table 20.1 ENERGY CONSUMPTION PATTERN IN TYPICAL PROCESS (DAIRY) INDUSTRY

<table>
<thead>
<tr>
<th>DEPARTMENT</th>
<th>TYPE</th>
<th>UNITS</th>
<th>CONSUMPTION</th>
<th>MEGAOULE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw milk storage</td>
<td>Elec.</td>
<td>kwh</td>
<td>4.26</td>
<td>15.35</td>
<td>1.70</td>
</tr>
<tr>
<td>Separation</td>
<td>Elec.</td>
<td>kwh</td>
<td>4.39</td>
<td>15.81</td>
<td>1.75</td>
</tr>
<tr>
<td>Pasteurization</td>
<td>Elec.</td>
<td>kwh</td>
<td>1.48</td>
<td>5.31</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>litre</td>
<td>0.92</td>
<td>34.88</td>
<td></td>
</tr>
<tr>
<td>Homogenization</td>
<td>Elec.</td>
<td>kwh</td>
<td>2.91</td>
<td>10.46</td>
<td>1.16</td>
</tr>
<tr>
<td>Pasteurizing cooling</td>
<td>Elec.</td>
<td>kwh</td>
<td>1.87</td>
<td>6.74</td>
<td>0.75</td>
</tr>
<tr>
<td>Bottling and capping</td>
<td>Elec.</td>
<td>kwh</td>
<td>11.17</td>
<td>40.23</td>
<td>9.11</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>litre</td>
<td>1.11</td>
<td>41.86</td>
<td></td>
</tr>
<tr>
<td>Processed milk storage</td>
<td>Elec.</td>
<td>kwh</td>
<td>5.36</td>
<td>19.30</td>
<td>2.14</td>
</tr>
<tr>
<td>Lighting</td>
<td>Elec.</td>
<td>kwh</td>
<td>25.59</td>
<td>90.69</td>
<td>10.06</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>Elec.</td>
<td>kwh</td>
<td>172.43</td>
<td>620.91</td>
<td>68.87</td>
</tr>
<tr>
<td>TOTAL</td>
<td>Elec.</td>
<td>kwh</td>
<td>229.05</td>
<td>824.80</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>litre</td>
<td>2.03</td>
<td>76.74</td>
<td></td>
</tr>
</tbody>
</table>

Note: Energy hogs are given in bold.

20 - 13
2.7 Exercises

Exercise 1

The services of a consulting firm have been retained to check the impact of an energy-efficiency programme in a well-managed enterprise. As energy manager of the company, how would you react to the following observations made by a joint team from the production and utilities departments before the energy audit began?

1. There is no need to share our data for the past three years with the consulting firm, as it is rather complex and inaccurate.
2. All key personnel involved in energy management should be briefed by top management and by the consultants on the objectives of this exercise.
3. The energy audit team should install their own diagnostic and on-line measuring instruments. The calibration of these instruments can be checked by equipment at the plant.
4. The energy audit team should focus on implementing the suggested measures. Working with the plant supervisors, they should take over the operation of boilers, furnaces, and other major energy consumers for a short time in order to judge their performance and efficiency.

Exercise 2

1. Is an energy audit a one-time activity or a continuing process?
2. What is the advantage of associating internal technical and managerial staff with external energy auditors?

Please compare your answers with those given in the Annex to this unit.

Questions for discussion

1. What do an energy audit and a cost audit have in common?
2. Would it be useful to skip a preliminary energy audit in order to implement a programme to reduce energy wastage?
3. Would it be useful to repeat an energy audit exercise periodically? Why?
SOLUTION TO EXERCISES

Exercise 1

1. Historic data about plant performance has to be shared with the consultants. Together, professionals from inside and outside the firm can draw up an effective action plan for strengthening the energy-efficiency programme.

2. Briefing the departmental heads about the objectives of the energy audit would dispel misgivings and promote joint strategies.

3. The energy audit is not a competition between the external consultants and the in-house team. As metering by itself does not save energy, the energy audit has to be based on practicable and mutually agreeable monitoring techniques. The tests performed by the energy audit team complement the activities of the plant personnel. It is more useful to emphasize practical techniques to quantify avoidable losses and to reduce such losses as far as possible, rather than to insist on accurate measurements.

4. Implementing measures to save energy is the primary responsibility of plant management. In training plant personnel it would be useful to focus on demonstrating relevant short-term measures. Energy audits based on mutual faith between internal and external teams are found to be more effective.

Exercise 2

1. An energy audit is a continuing exercise needing review and repetition at regular intervals after the recommendations arising from the previous audit have been implemented.

2. The internal team would be able to provide useful information to the external energy auditors, thus improving the efficacy of the exercise. Further, it would facilitate better understanding of the recommendations, resulting in an action plan which would be more acceptable to plant personnel.
UNIT 3: ENERGY-EFFICIENCY PROGRAMME CHECKLIST

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Identify the main features of energy efficiency programmes.
2. Understand and explain the main principles of increasing energy efficiency in housekeeping, retrofitting and process modification.

UNIT 3: CONTENTS

3.1 Housekeeping measures
3.2 Retrofit measures
3.3 Process modifications
3.4 Exercises
UNIT 3: ENERGY-EFFICIENCY PROGRAMME CHECKLIST

Energy-efficiency programmes in industry fall into three groups:

- Housekeeping measures
- Retrofit measures
- Process modifications

The activities which should be covered by an energy-efficiency programme are reflected in the three checklists below.

3.1 Housekeeping measures

These involve improved monitoring and controls aimed at reducing waste; they require no significant investment. The measures which should be included in housekeeping programmes are reflected in the following checklist.

HOUSEKEEPING MEASURES - CHECKLIST

<table>
<thead>
<tr>
<th>SUB-AREA</th>
<th>SPECIFIC EXAMPLES/SOLUTIONS</th>
<th>CONSERVATION SCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fuel preparation</td>
<td>- Avoid oversized coals</td>
<td>1 to 2 per cent</td>
</tr>
<tr>
<td>2. Combustion equipment</td>
<td>- Avoid fuel leaks</td>
<td>2 to 5 per cent</td>
</tr>
<tr>
<td></td>
<td>- Reduce excess air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Control dampers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reduce unburnts in ash and stack</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid excessive blow-down</td>
<td></td>
</tr>
<tr>
<td>3. Steam distribution and use</td>
<td>- Avoid steam leaks</td>
<td>2 to 5 per cent</td>
</tr>
<tr>
<td></td>
<td>- Avoid undersized steam pipes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Install the correct steam traps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Repair faulty traps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid opening trap bypass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Install air vents</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid overdrying of products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Control steam parameters</td>
<td></td>
</tr>
<tr>
<td>4. Power consuming equipment</td>
<td>- Avoid overilluminated work area</td>
<td>2 to 5 per cent</td>
</tr>
<tr>
<td></td>
<td>- Clean dirty lamps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tighten belts and pulleys</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Install proper lubrication and maintenance system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid undersized cables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid excessive heating/cooling in HVAC systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Avoid compressed air leaks</td>
<td></td>
</tr>
</tbody>
</table>
3.2 Retrofit measures

Retrofitting often involves only small investments with big paybacks in improved efficiency of existing equipment. The most important retrofit measures are indicated in the checklist given as an example below.

RETROFIT MEASURES - CHECKLIST

1. **Combustion and steam system**
   - Convert natural to forced draught
   - Install automatic feeding coal/solid fuels
   - Use low excess air burners
   - Install mechanical - travelling, spreader stokers
   - Convert to fluidized bed combustion for coal
   - Install condensate recycling system
   - Modify steam distribution system
   - Provide adequate insulation for steam mains/hot surfaces
   - Install appropriate boiler feed water treatment to reduce fouling of boilers/heat exchangers

2. **Heat recovery devices**
   - Install heat recovery devices in stacks - boilers, furnaces, kilns, engines
     - economizers and air preheaters
     - recuperators and regenerative burners
     - waste heat boilers
   - Preheat stock, raw material with the heat from exhaust gases
   - Recover heat from process streams and exothermic reactions
     - heat exchangers
     - wasteheat boilers
     - heat pipes
   - Install low-grade heat recovery devices
     - heat pumps
     - mechanical vapour recompression systems
     - thermo-compression
   - Integrate utilizing pinch analysis

3. **Electricity-saving devices**
   - Install capacitors to reduce power factor
   - Install load management controls (max.demand charges)
   - Install high efficiency motors
   - Install high efficiency lighting devices
   - Install high efficiency electrolytic cells
   - Install high efficiency induction/arc furnaces
   - Install variable speed control devices
   - Install right size of impellers for fans and pumps
   - Install efficient pumps, fans, compressors

- Convert natural to forced draught: 5 to 10 per cent
- Install automatic feeding coal/solid fuels: 5 to 10 per cent
- Use low excess air burners: 10 to 15 per cent
- Install mechanical - travelling, spreader stokers: 10 to 15 per cent
- Convert to fluidized bed combustion for coal: 10 to 15 per cent
- Install condensate recycling system: 2 to 20 per cent
- Modify steam distribution system: 10 to 20 per cent
- Provide adequate insulation for steam mains/hot surfaces: 2 to 20 per cent
- Install appropriate boiler feed water treatment to reduce fouling of boilers/heat exchangers: 10 to 20 per cent
- Install heat recovery devices in stacks - boilers, furnaces, kilns, engines: 5 to 20 per cent
- Preheat stock, raw material with the heat from exhaust gases: 10 to 15 per cent
- Recover heat from process streams and exothermic reactions: 10 to 15 per cent
- Install low-grade heat recovery devices: 2 to 20 per cent
- Integrate utilizing pinch analysis: 10 to 20 per cent
- Install capacitors to reduce power factor: 0 to 1 per cent
- Install load management controls (max.demand charges): 2 to 5 per cent
- Install high efficiency motors: 10 to 25 per cent
- Install high efficiency lighting devices: 10 to 25 per cent
- Install high efficiency electrolytic cells: 15 to 20 per cent
- Install high efficiency induction/arc furnaces: 15 to 20 per cent
- Install variable speed control devices: 10 to 15 per cent
- Install right size of impellers for fans and pumps: 10 to 15 per cent
- Install efficient pumps, fans, compressors: 10 to 15 per cent
Module 20
Unit 3

- Install energy-efficient air handling devices 10 to 15 per cent

4. **Cogeneration**
- Install combined heat and power plants in process industries 10 to 25 per cent
- Combined cycle to include a gas turbine - gas waste heat boiler - topping turbine/absorption chiller.
- Install captive DG set - hot water system/absorption chillers
- Install bottoming cycle - waste heat boiler - power recovery, organic rankine cycle plants

5. **Process controls**
- Install reflux level control and additional distillation trays 5 to 10 per cent
- Install instrumentation and control devices
- Install combustion control 5 to 10 per cent
- Install computerized process controls 3 to 5 per cent
- Install computerized energy management systems 3 to 5 per cent
- Install energy expert systems 5 to 10 per cent

3.3 Process modifications

Modifications to process technology involve major investments that significantly alter production processes by the introduction of new and efficient equipment and control systems. Such measures entail plant redesign and would obviously need an in-depth study. A few examples of these measures as practiced in manufacturing are given in the following checklist:

**PROCESS MODIFICATIONS - CHECKLIST**

- Replace mercury cells by membrane cells 30 per cent
- Install precalcinator on cement plants 10 to 15 per cent
- Install dry instead of wet cement plants 20 to 25 per cent
- Install continuous casting process for steel manufacture 20 to 25 per cent
- Install PUK process for smelting aluminium in place of halls process 20 to 25 per cent
- Go in for foam dyeing and printing in textile plants.

3.4 Exercises

**Exercise 1**

For the five areas listed below cite a few examples of:

a. Short-term low-cost measures
b. Mid-term or retrofitting measures involving moderate investment
c. Long-term or technology modification measures for:
   1. Combustion controls
2. Water chemistry  
3. High grade heat recovery  
4. Instrumentation  
5. Monitoring and targeting  

Exercise 2

You are the energy manager in a medium process industry which has considerable potential for energy saving. What criteria would be useful in drawing up a short energy-efficiency checklist? You may check your answers in the Annex to this unit.

Questions for discussion

1. Suggest at least five housekeeping measures to save energy in commercial establishments.
2. Give three examples of measures to retrofit energy-efficiency devices in industrial enterprises.
3. Quote two instances of energy-saving devices to reduce (a) thermal energy (b) electrical energy through process modifications.
Exercise 1

<table>
<thead>
<tr>
<th>Exercise</th>
<th>SHORT-TERM MEASURES</th>
<th>MID-TERM MEASURES</th>
<th>LONG-TERM MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Monitor stack</td>
<td>2. Low excess air burners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Fire little and often (coal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Water chemistry</td>
<td>1. Control blow internal treatment</td>
<td>Replace damaged anion/cation exchange</td>
<td>DM plant</td>
</tr>
<tr>
<td>3. High grade heat recovery</td>
<td>1. Reduce fouling of heat exchanger</td>
<td>Install heat exchangers</td>
<td>Optimal heat recovery</td>
</tr>
<tr>
<td></td>
<td>2. Minimize air infiltration/ex filtration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Instrumentation</td>
<td>Recording &amp; manual control of critical parameters</td>
<td>Closed loop control for critical parameters</td>
<td>Digital process controls</td>
</tr>
<tr>
<td>5. Monitoring and targeting</td>
<td>Manual logging</td>
<td>Data logging</td>
<td>Interactive computer-controlled plants</td>
</tr>
</tbody>
</table>

Exercise 2

The first priority would be to identify measures involving little capital investment. Attention should focus on quantifying energy savings, selling the ideas at various levels, and starting a reporting system on the efficacy of these measures. Measures with a quick payback and modest investment would be short listed for agreement from higher management.
UNIT 4: INTERACTIVE PLAN FOR DIFFERENT OPERATIONAL LEVELS

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Identify the main elements of an energy-management system.
2. Advise on strengthening energy management in the enterprise.
3. Define the need for an energy coordinator or energy programme manager.
4. Understand the top-down and bottom-up approach in energy management.

UNIT 4: CONTENTS

4.1 Top-down approach
4.2 Bottom-up approach
4.3 Feedback system
4.4 Training
4.5 Exercises
UNIT 4: INTERACTIVE PLAN FOR DIFFERENT OPERATIONAL LEVELS

Some major barriers to improving energy efficiency lie in management attitudes, practices and policies. Managers often fail to appreciate the potential of energy productivity improvement programmes; there is also a lack of responsibility at all levels of management, which demotivates improvement in energy efficiency. Organizations should consider the appointment of an energy coordinator, energy manager or energy committee, with specific responsibility for the efficient use of energy and the introduction of the most appropriate equipment. The efficiency of energy programmes depends on the full commitment and continuing support of senior managers, who must participate in the development of corporate energy policy and initiate multidisciplinary activities regarding energy management.

4.1 Top-down approach

There are two principal approaches for an effective energy management programme. A top-down approach helps to get commitment from top management in formulating a realistic energy policy. Responsibility for monitoring and targeting is vested in senior managers who have the necessary authority to ensure that the energy management team operates smoothly and efficiently. In large organizations, an energy committee is set up to review energy management; committee members should include senior functional managers from engineering, utilities, production and finance. The chairman of the committee should be a senior executive with sufficient authority to ensure that all necessary resources are available and to see that action is taken on:

* developing the corporate energy-efficiency policy;
* instituting an effective monitoring and targeting system;
* vetting energy-efficiency improvement schemes;
* ensuring that projects are implemented.

4.2 Bottom-up approach

This approach is based on a comprehensive knowledge of the energy needs of different sections. The approach relies on shop floor workers and supervisors responsible for energy use. The blue-collar workers interact with middle and senior managers by providing reports, analysing energy data, developing performance standards, identifying targets, noting achievements and making positive suggestions for removing bottlenecks. This approach usually involves appointing a coordinator responsible for setting up the monitoring system, analysing energy productivity indices and conceiving schemes for energy efficiency. Energy efficiency concerns should be included in the mandate of quality circles and suggestion schemes.

4.3 Feedback system

The impact of an energy management programme depends on interactive feedback. The essential elements of the feedback system are:
* **Monitoring**
  The basic requirement is a system to log energy consumption figures and production data; accurate metering devices have to be installed and maintained.

* **Reporting**
  Reporting should be done on a shift, daily or weekly basis depending on energy consumption, extent of variation and inefficiencies encountered. Reports are issued to managers responsible for operations and performance, who can provide sufficient motivation to intensify energy productivity improvement programmes.

* **Action plan**
  Action programmes usually start by changing operating procedures or housekeeping practices and then move on to low-cost improvements such as installing new insulation. Strategies for energy management may be reviewed from time to time, to reflect developments within the firm and across the industry as a whole. Figure 20.5 below shows a typical feedback system.

**Figure 20.5: Feedback system on energy management in a typical industry**

[Diagram of feedback system]
4.4 Training

Training in energy management is necessary at all levels, for operators, supervisors, middle managers and top management. Training needs to connect theory with practice and integrate productivity concepts with work; such programmes can also provide important feedback throughout the hierarchy. The competence of individual workers is developed by role plays and simulations, brainstorming and discussions, and other activities which involve problem solving and decision making. Training sessions should be short and the content should be directly applicable to real work situations. Good energy management organization would ensure the necessary follow up for trainees to put their new knowledge into practice.

To sum up, effective energy management is crucial for sustaining an energy-efficiency programme. The management structure should be simple, with clearly defined roles and effective feedback mechanisms. The efficiency of energy management can be gauged by its progress in promoting the skills needed to execute a complex energy-efficiency programme.

4.5 Exercises

Exercise 1

Give two examples each of top-down and bottom-up approaches to energy efficiency.

Exercise 2

1. What is the relative merit of a bottom-up approach to an energy-management programme?
2. What would be the consequences of a poor feedback mechanism for an energy-efficiency programme?

Please compare your answers with those provided in the Annex to this unit.

Questions for discussion

1. Would you recommend a special department to look after energy efficiency? Enumerate the various options.
2. How do you rate the chances of success for a bottom-up approach to energy-efficiency programmes?
3. Discuss the elements needed in a programme to train existing plant personnel in energy efficiency.
Solutions to exercises

Exercise 1

TOP-DOWN APPROACH

1. Fixing targets/norms for energy consumption levels.
2. Launching a goal-oriented programme to reduce energy consumption levels.
3. Appointing energy monitors to coordinate various efforts.
4. Sanctioning corporate plans with fiscal resources.

BOTTOM-UP APPROACH

1. Suggestion scheme from employees.
2. Rewarding departments for improving their energy efficiency.
3. Setting up a reporting system between:
   (a) various departments and head office
   (b) industrial units and government.

Exercise 2

1. A bottom-up approach takes the path of least resistance as ideas spring from the shop floor. Therefore it is not difficult to sustain efforts to enhance energy efficiency as the action plan involves participation at the operational level.

2. The lack of adequate information would stall the programme as localized activities relating to energy efficiency would not find wider acceptance. Further, many relatively complex activities may be undermined by a lack of understanding.
UNIT 5: INNOVATIVE FINANCING FOR ENERGY-EFFICIENCY PROJECTS

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Finance an energy-efficiency programme.
2. Understand the essence of contract energy management.
3. Cope with any financial barriers impeding an energy-efficiency programme.
4. Benefit from tax incentives for energy-efficiency programmes and understand their limitations.

UNIT 5: CONTENTS

5.1 Barriers to energy efficiency
5.2 Fiscal incentives
5.3 Energy management contracting
5.4 Management of energy contract service companies
5.5 Exercises
UNIT 5: INNOVATIVE FINANCING FOR ENERGY-EFFICIENCY PROJECTS

5.1 Barriers to energy efficiency

Despite the benefits of energy efficiency from the technical, economic and environmental points of view, investment in such projects often fails to materialize. The following constraints are typical of energy projects:

i. Energy users frequently lack technical expertise and do not appreciate the savings which could be made through energy-efficiency measures.
ii. Key staff are not well informed about technological innovations.
iii. Energy costs are too low to justify high priority for energy-efficiency projects.
iv. Energy-efficiency projects have low priority when capital is allocated for plant modernization programmes.

The availability of finance is particularly important in the case of small or medium-sized enterprises. Applying to banks for funding usually entails cumbersome and time-consuming procedures. The financial barriers to energy-saving programmes vary from sector to sector and from country to country.

5.2 Fiscal incentives

In market economies, an appropriate energy-pricing policy can provide an inducement to pay the opportunity cost of energy. Such economies have experimented with innovative pricing policies to encourage the adoption of energy-efficiency programmes. In mixed or centrally planned economies, however, the development of pricing policies presents more of a challenge.

Fiscal incentives have been introduced in many countries to promote investment in energy-efficiency projects. Direct financial assistance (grants), subsidized energy audits, soft loans for installing energy-efficient devices or equipment, tax rebates for manufacturers of energy conservation equipment, and duty rebates for importers of energy-saving equipment are among the usual incentives to investment in energy-efficiency programmes.

Many countries have introduced tax concessions; for example, an accelerated capital cost allowance which allows a fast tax write-off on equipment promotes investment in energy-efficient projects. Another example is accelerated depreciation of investment in energy-saving equipment which induces end users to invest in such programmes.

 Managers should be well aware of national legislation and industry rules concerning fiscal incentives to encourage the efficient use of energy.

5.3 Energy management contracting

One innovative approach to overcome the financial constraints on energy-efficiency programmes is the packaging together of technical aid and funding for energy-saving
programmes, using the savings produced to pay for the investment. There are different ways of doing this, but they all share a number of elements. The energy service company which arranges the package will conduct an initial audit, on the basis of which the parties will negotiate a contract. A detailed audit will establish the measures to be implemented, and the energy service company will supervise the design, installation and subsequent maintenance of the equipment provided. Among the important techniques used are:

a. **Shared savings**

   A shared savings contract is one where the energy service company installs and finances equipment, being paid a fixed percentage of the energy savings that result over the period of contract. This approach is used in the UK for both tax and historical reasons, and it is also being adopted in the European Union.

b. **Energy management contracts**

   Under an energy management contract, an energy service company takes over responsibility for the fuel bills and is reimbursed by the consumer at an agreed percentage of previous energy costs. Thus, for example, the consumer will be given guaranteed savings of 5 per cent. As with a shared savings arrangement, the service company carries out a detailed engineering audit of the facility and recommends improvements which it procures, installs and usually maintains. Contracts of this type are typically of seven years duration. Thus the end user is guaranteed a certain percentage reduction on previous energy bills. All additional savings up to a certain figure belong to the energy service company (for example above 25 per cent); all incremental savings are shared between the energy service company and the consumer. The following potential problems should be mentioned. If the user is unhappy with the performance of the contractor, it may be difficult to switch to a different company in mid-contract. In addition, there may be disagreement over the calculation of energy savings, based on certain assumptions about consumption. Often, the energy service company and the user may disagree about who is responsible for a decline in consumption. For energy users who possess the necessary technical skills and have a low discount rate, energy performance contracting is unlikely to prove a financially attractive option.

### 5.4 Management of energy contract service companies

The principal advantage of the contract approach is that the investment is made at no initial cost to the energy user, and that the risk is transferred to the service company which has expertise in auditing, installation and financing. The technical skills of the service company are crucial to the profitability and even the continued existence of the venture. If the company does not have all the necessary technical expertise it may hire services in certain areas. However, it is expected to meet marketing and administrative overheads and to possess financial expertise since its primary function is to raise substantial funds.

Energy contracting is not a panacea. Its performance is directly proportional to the level and timing of savings produced by technical improvements. Typical contracts are of 5 to 10 years duration, with the savings divided between the parties according to payback on the project, length of contract, and costs. A typical split may be 70:30 (70 per cent to the energy service company) or 80:20. This approach has been widely used in the United States.
In the USA and Canada, energy performance contracting has made a significant contribution to improving energy efficiency, while it is slowly being established in Europe and other areas. Energy performance contracting is emerging as an important tool in overcoming lack of capital and confidence which are impediments to energy-efficiency projects. This form of contracting is likely to become popular in the near future as a positive offshoot of the energy-efficiency culture.

5.5 Exercises

Exercise 1

As part of a project funded by a new energy contract service company, a dairy plant processing 1 million litres of milk per day has installed a gas turbine cogeneration plant to meet its heating, cooling and electric power needs. The service company has agreed to lease a 5 MW gas turbine-based system for 8 years if the dairy agrees to pay for natural gas and electricity on the basis of tariffs and consumption levels prevailing before the contract was negotiated. At the end of the lease, the plant would be handed over to the dairy free of charge.

Would such a contract involve technical and commercial barriers? What problems are expected?

Exercise 2

1. Why do industrial firms often hesitate to invest in energy-efficiency projects?

2. Tax incentives are not a panacea for overcoming barriers to energy-efficiency programmes. Comment.

3. What are the prerequisites for successful energy management contracting firms?

   Please compare your answers with those given in the Annex to this unit.

Questions for discussion

1. What factors impede investment in energy-efficiency programmes?

2. Is it feasible to plough back savings from energy-efficiency programmes to fund long-term projects? How?
Solutions to exercises

Exercise 1

The contract should be phrased in such a way as to safeguard against:

a. Disputes between the user and the service company in the event of malfunctioning, increase in demand or higher tariffs for heat and electric power, erratic supply or overdrawal of steam and electricity.

b. Disagreement on the residual life of plant and machinery, the required operational and maintenance skills, or staff needs at the stage of handing over the plant on completion of the lease.

c. Conflict in the case of abnormalities such as unscheduled stoppage of cogeneration plant, overdrawal or low load.

d. Inadequacy of the service company’s experience with similar ventures.

Exercise 2

1. Industrial firms are frequently unaware of the potential savings from energy-efficiency programmes. Since these programmes involve a certain degree of technical and financial risks they are usually given low priority compared with conventional business propositions. In addition, low energy costs do not attract sufficient attention to convince managers of the need for fairly complex projects.

2. Tax incentives such as accelerated depreciation are of benefit only to companies which have substantial tax liability. Such incentives deprive national governments of resources for implementing projects. Tax incentives are more or less attractive depending on the efficiency of tax collection machinery in the country.

3. Energy contracting firms need technical and managerial skills in conceiving, marketing and administering contracts, mobilizing funds, executing and staffing projects to the satisfaction of the client.


Kezai Koho Centre: *How Japan is curtailing energy consumption*, Case studies of 50 companies (Tokyo, 1981).


—: *Productivity through energy innovation* (New York, Pergamon, 1986).


MODULE 21

PRODUCTIVITY BY MAINTENANCE
MODULE 21: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand the economic importance of effective maintenance.
2. Explain the forms and functions of a maintenance system.
3. Establish and/or improve a maintenance system.

MODULE 21: CONTENTS

UNIT 1: Introduction to maintenance
UNIT 2: The maintenance function
UNIT 3: Implementing maintenance systems
UNIT 4: Preparing for implementation

Bibliography
UNIT 1: INTRODUCTION TO MAINTENANCE

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the connection between maintenance and safety, quality, productivity and environmental protection.

2. Respond to the challenge of maintenance.

3. Appreciate the economic importance of maintenance and understand the structure of maintenance costs.

UNIT 1: CONTENTS

1.1 The challenge of maintenance

1.2 Microeconomic considerations

1.3 Analysis and minimization of maintenance costs

1.4 Evaluating maintenance efficiency
UNIT 1: INTRODUCTION TO MAINTENANCE

1.1 The challenge of maintenance

Investment in production equipment can only be profitable if the following points are considered:

- productivity in terms of quantity, price and continuity;
- quality of final product or of service offered;
- safety of functioning and personnel;
- protection of the environment.

Good maintenance is a prerequisite for attaining these objectives. The relationship between these factors is illustrated in the chart below (figure 21.1).

Figure 21.1: The relationship between maintenance and other elements of production

In industrialized countries and even more in a developing economy, maintenance today faces challenges and problems which arise from six main sources:

- physical: natural degradation, wear and tear of components, climatic influences;
- technical: constant evolution, frequent introduction of new technologies;
- human: development of human resources, systems to motivate personnel, social and cultural evolution;
- organizational and managerial: new approach to management, development of computer-aided systems;
- economic and financial: fluctuations in world economy, evolution of the national economy, speeding up of privatization and rapid disengagement from the public sector, uncertain financial resources;
- the market: requirements of national and international markets which are in constant flux.
Finally, because the importance of maintenance has always been underestimated and often not accepted as a major component of profitability, it is given low priority in many companies. This position is not a favourable base from which to tackle the problems listed above. To sum up, the greatest challenge for maintenance is to adapt to a complex environment.

The efficient maintenance of production equipment obviously has an impact on both macro- and microeconomic levels. The following figures highlight this impact.

A survey made in 1977 of 50 industrial enterprises in the metalworking, food, chemicals, textiles and paper sectors, by the centre for inter-enterprise comparison in the UK showed that the amount spent on maintenance could vary considerably. The following ratios were obtained.

<table>
<thead>
<tr>
<th>Ratio Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance costs</td>
<td>varied between 5.3 per cent and 26.7 per cent</td>
</tr>
<tr>
<td>Fixed assets</td>
<td>varied between 2.5 per cent and 9.8 per cent</td>
</tr>
<tr>
<td>Turnover</td>
<td>varied between 3.8 per cent and 16.2 per cent</td>
</tr>
<tr>
<td>Added value</td>
<td>varied between 4.7 per cent and 16.9 per cent</td>
</tr>
</tbody>
</table>

In 1979 W.J. Marcelis carried out several surveys in various European industries. He compared maintenance costs with replacement costs for production equipment and obtained 7 per cent average. For buildings he obtained 1.5 per cent.

A survey made by DGS International in 1987 in three industrial sectors in Europe (cement, mechanical construction, petrochemicals) resulted in the following figures:

<table>
<thead>
<tr>
<th>Ratio Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance costs</td>
<td>varied between 7.98 per cent and 16.4 per cent</td>
</tr>
<tr>
<td>Fixed assets</td>
<td>varied between 10.44 per cent and 12.9 per cent</td>
</tr>
<tr>
<td>Added value</td>
<td>varied between 41.75 per cent and 58.35 per cent</td>
</tr>
<tr>
<td>Maintenance manpower costs</td>
<td>varied between 17.02 per cent and 44.64 per cent</td>
</tr>
<tr>
<td>Total maintenance costs</td>
<td>varied between 4.7 per cent and 16.9 per cent</td>
</tr>
</tbody>
</table>

On the macroeconomic level in industrialized countries, the following figures highlight the importance of money spent:

- in France, maintenance of production equipment costs 15 per cent of GNP. On average maintenance costs correspond to 12-14 per cent of GNP for European countries.
- 165 of the most important industrial companies in the USA spend an average 5 per cent of turnover every year on maintaining their production equipment.

The EFNMS (European Federation of National Maintenance Societies) has undertaken
several surveys in European countries. Annual maintenance costs compared to turnover produced the following figures (1990): Belgium 4.8 per cent, France 4.0 per cent, Ireland 5.1 per cent, Italy 5.1 per cent, Netherlands 5.0 per cent, Spain 3.6 per cent, UK 3.7 per cent.

1.2 Microeconomic considerations

a) Life cycle of equipment

Whatever the equipment, the life cycle represented in figure 21.2 is used as a base for assigning it an economic value in relation to the annual production of goods or services.

AC corresponds with the design (AB) and manufacturing (BC) phase of equipment and CF is in relation to the operation phase (exploitation).

CF starts with a section CD (which corresponds to the start-up of the equipment) DE represents the operation phase and EF descends in relation to the gradual obsolescence. Disposal (scraping) is at point F.

Figure 21.2: Life cycle of equipment

![Figure 21.2: Life cycle of equipment](image)

b) Failure rate

The failure rate shows the number of breakdowns that occur during a certain period of time e.g. weekly or monthly. The failure rate obviously depends on the age of the equipment. This can be seen in figure 21.3, the 'bath tub curve', which is divided into three zones.

Zone 1: during start-up a decreasing number of hidden construction failures, errors of assembly and running-in problems cause breakdowns;
Zone 2: during exploitation the failure rate is stabilized by controlling wear and tear but this will inevitably increase;  
Zone 3: obsolescence is characterized by an accelerated failure rate due to age and wear.

**Figure 21.3: Failure rate pattern**

1.3 Analysis and minimization of maintenance costs

There are two sorts of costs: direct and indirect. Direct costs determine actual maintenance practice and are all quantifiable. Indirect costs are also called failure costs. They result in the unavailability of equipment and cause production losses, which explains why they are called failure costs. Some of them can be quantified, others not.

a) Direct maintenance costs

The list below shows the various components of direct maintenance costs:
- Regular maintenance (controls and checks)
- Labour
- Equipment
- Consumables, spare parts and stock management
- Training
- Subcontracting
- Technological updating

b) Failure costs (indirect costs)

Failure caused by lack of maintenance represents a financial loss for the company. Although the cost of failure is not directly measurable, it can be very significant. Below is a list of failure costs.
- Loss of production or service
- Alteration in the quality of production or service
- Delivery delays
- Depreciation
- Work accidents
- Deterioration in the workplace and environment
The evaluation of failure costs (however approximate) is highly recommended and should always be part of management thinking.

c) Minimization of direct costs and failure costs

Maintenance activity can be measured by a ‘rate of maintenance’ indexed from 0 to 1. For direct costs, an increasing rate of maintenance means increasing costs. In figure 21.4 the evolution of direct costs is represented by a constant growth curve identified by index.

Failure costs are high if the maintenance rate is low, which means they should be considered as a decreasing function of the maintenance rate.

**Figure 21.4: Evaluation of direct and failure costs**

For management reasons, the two types of cost must be dealt with together. The total of both is shown in curve (3). The figure indicates that the management of maintenance and of post-investment is not a question of reducing costs but of minimizing them.

To minimize total costs two types of maintenance management should be considered. One is short term, i.e. from year to year, and is defined as maintenance policy; the other is long term, i.e. sufficiently long to cover the period of exploitation (or operational life of equipment), and is defined as ‘post-investment strategy’. Both types are elements in the maintenance management plan.

A maintenance policy covers both technical aspects (knowledge of equipment, prevention of breakdowns, carrying out of work, selection of the type of maintenance), and organizational aspects (definition of organization chart, administration of maintenance schedule, planning of studies and work, subcontracting), as well as accountancy procedures and financial evaluation.
For post-investment strategy, maintenance strategies have to correspond to the degree of obsolescence of the equipment. This often means adapting the maintenance policy, for instance by selecting different types of intervention or deciding on partial or total rehabilitation or technological updating. Interventions of this type will optimize the life cycle of the equipment. This procedure is part of a real strategy which turns post-investment — thus maintenance — into an actual profit centre for management.

1.4 Evaluating maintenance efficiency

a) Budgeting and budgetary control

Direct costs

Apart from some rare situations, budgeting for direct costs can be very precise, with reliable annual forecasts. All the costs are known or can be calculated from figures for previous years. A rigorous and detailed procedure for budgeting is only necessary in relatively exceptional cases when direct maintenance costs represent an important part of the added value. In other cases, it is sufficient to evaluate the cost of the main operations by grouping the smaller interventions under one separate and global budgetary position for each cost centre.

Failure costs

Failure costs are influenced by a number of parameters, some of which cannot be measured. This makes it difficult to budget for them. Fortunately, management principles allow a more general approach through forecasting the following indirect costs: production losses (profit losses), wages and salaries of idle production workers and depreciation of equipment during the period of inactivity.

Budgetary control is based on a calculation of real post-investment expenses and probable loss of profit, measuring the difference between actual results and earlier projections. This control highlights the need to anticipate maintenance work and allows for the improvement of future budgetary evaluation. For easy comparison, the difference should be measured for each cost allocation required for the forecast. The resulting information is then linked to successive deadlines (often monthly) which serve as a basis for evaluating the maintenance policy and the post-investment strategy.

b) Economic ratios

Due to its importance, post-investment should be evaluated on a periodic basis. As maintenance is an integral part of the production process, its efficiency is hard to appreciate in absolute values. Consequently, appreciation parameters cannot be chosen from the operational figures. They must be defined as relative values i.e. through ratios.

Maintenance will first be evaluated through internal performance indicators; these are discussed further in Unit 3 (Implementing maintenance systems). The most important indicators are ratios related to manpower, to spare parts and to stock.

In the same way, post-investment is evaluated as part of the whole production activity through the comparison of appropriate ratios; post-investment can then be included with other
financial topics which will result in a more global appreciation. The following indicators are particularly relevant:

- \[ \text{maintenance} = \frac{\text{total direct and indirect costs}}{\text{total investments}} \]

- \[ \text{post-investment} = \frac{\text{total maintenance, renewal and rehabilitation costs}}{\text{replacement value of the equipment}} \]

- \[ \text{weighing indicator} = \frac{\text{post-investment cost per production unit}}{\text{added value per produced unit}} \]

Other ratios exist; they are based on the same principle and aim at detailing a particular topic. All must be calculated on a periodic basis (for instance monthly), and are then presented as a time-base graph. This gives a clear illustration of the maintenance activity and its economic impact.
UNIT 2: THE MAINTENANCE FUNCTION

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Define and explain the maintenance function and its objectives.

2. Understand the main forms of maintenance and their application.

UNIT 2: CONTENTS

2.1 Introduction

2.2 Objectives of maintenance management

2.3 Forms of maintenance
UNIT 2: THE MAINTENANCE FUNCTION

2.1 Introduction

The purpose of maintenance is to ensure the maximum efficiency and availability of production equipment, utilities and related facilities at optimal cost and under satisfactory conditions of quality, safety and protection for the environment.

Maintenance was long considered as a subordinate function, entailing an inevitable waste of money. There was a tendency to lump it together with troubleshooting and repairing machinery that was subject to wear and obsolescence. However, enterprises today are realizing that maintenance is not merely a 'partner' in production: it is an indispensable requirement for producing. Its relation with equipment performance is a question of integrated strategy at senior management level. As such, the maintenance function becomes a management responsibility.

2.2 Objectives of maintenance management

The more specific objectives of maintenance management are as follows:

- to optimize the reliability of equipment and infrastructure;
- to ensure that equipment and infrastructure are always in good condition;
- to carry out prompt emergency repair of equipment and infrastructure so as to secure the best possible availability for production;
- to enhance, through modifications, extensions, or new low-cost items, the productivity of existing equipment or production capacity;
- to ensure the operation of equipment for production and for the distribution of energy and fluids;
- to improve operational safety;
- to train personnel in specific maintenance skills;
- to advise on the acquisition, installation and operation of machinery;
- to contribute to finished product quality;
- to ensure environmental protection.

2.3 Forms of maintenance

Maintenance has three major forms:

a) design-out maintenance;
b) preventive maintenance, which includes systematic (periodic) maintenance and condition-based maintenance;
c) corrective maintenance.

These are illustrated in figure 21.5.
Maintenance can also be divided into planned and unplanned maintenance (or scheduled and unscheduled). The following chart highlights the relation to the previous chart.

Below is a brief explanation of the terms used in the two charts.

**Maintenance**

Maintenance is the function whose objective is to ensure the fullest availability of production equipment, utilities and related facilities at optimal cost and under satisfactory conditions of quality, safety and protection of the environment.

**Design-out maintenance**

This is also known as plant improvement maintenance, and its object is to improve the operation, reliability or capacity of the
Preventive maintenance

The principle of preventive maintenance is anticipation. It is put into practice in two forms: systematic (periodic) maintenance and condition-based maintenance.

Corrective maintenance

Also called breakdown maintenance, palliative or curative maintenance. This form of maintenance consists of:
- troubleshooting on machines whose poor condition results in stoppage, or in operation under intolerable conditions;
- repairs.

Systematic maintenance

This consists of servicing equipment at regular intervals, either according to a time schedule or on the basis of predetermined units of use (hours of operation or distance travelled). The aim is to detect failure or premature wear and to correct this before a breakdown occurs. The servicing schedule is usually based on manufacturers' forecasts, revised and adjusted according to experience of previous servicing; this information is recorded in the machine file. This type of maintenance is also called periodic maintenance.

Condition-based maintenance

This type of maintenance, also called predictive or auscultative maintenance, is a breakdown-prevention technique which requires no dismantling, as it is based on inspection by auscultation of the equipment involved. It requires continuous observation of an item of equipment in order to detect possible faults or to monitor its condition.

Planned maintenance

Maintenance which is known to be necessary sufficiently in advance for normal planning and preparation procedures to be followed.

Unplanned maintenance

This is maintenance which is not carried out regularly as the need for it is not predictable; it is sometimes called unscheduled maintenance.

The seven forms of maintenance distinguished above are the main types currently used in practice.
UNIT 3: IMPLEMENTING MAINTENANCE SYSTEMS

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Enumerate the main maintenance activities and understand a maintenance organization chart.
2. Carry out a maintenance audit.
3. Design and introduce a maintenance management organization.

UNIT 3: CONTENTS

3.1 How to organize maintenance
3.2 Maintenance awareness and promotion
3.3 How to carry out a maintenance audit
3.4 Management tools for maintenance
3.5 The maintenance department: Activities and organization
UNIT 3: IMPLEMENTING MAINTENANCE SYSTEMS

3.1 How to organize maintenance

In a new plant

Since the maintenance department is generally overloaded with work from the start-up period onward, it is advisable to organize the maintenance function during construction of the plant.

- Engineers in the maintenance department have to study the proposed organization chart and prepare operational procedures.
- Mechanical and electrical maintenance teams can benefit from being involved in construction and start-up of the plant.
- The central workshop should be operational very early, before machines are installed.
- The maintenance methods office must be set up so that it is in operation when equipment arrives. Method officers should start establishing the preventive maintenance and lubrication file, checking the technical documentation and completing the spare parts forecasts.
- The rest of the central maintenance planning office (CMPO) should be gradually put in place, at least one year before start-up.
- The spare parts maintenance section (SPMS) can be put in place gradually, once the equipment and extra parts start arriving.
- Immediately after start-up the mechanical and electrical services should concentrate on ensuring the availability of the machines. Priority should be given as soon as possible to preventive maintenance.

The following priorities should be respected once the factory is in operation:

- Evaluation of machine data: updating of history cards, preventive programmes;
- Maintenance management performance indicators;
- Stock management;
- Improvement of work methods and planning;
- Updating of drawings, technical notices and other documents;
- Gradual introduction of a maintenance management information system (MMIS).

Restructuring the maintenance department in an existing plant

Restructuring should be decided on the basis of an in-depth audit. The audit should produce conclusions and recommendations, a plan of action and a cost-benefit analysis. The audit should help to obtain full commitment from general management for a plan of action. Maintenance should be assigned a position in the management hierarchy and the maintenance manager should be on the board of directors. A maintenance committee should be set up at factory level.

The activities involved in restructuring a maintenance department are summarized in table 21.1.
### Table 21.1: Restructuring a maintenance department

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTIONS</th>
<th>METHODOLOGY/OBSERVATIONS</th>
</tr>
</thead>
</table>
| 1    | GENERAL MAINTENANCE POLICY AND ORGANIZATION | - prepare a diagnostic report on maintenance  
- identify the actions to be taken, especially in the following fields:  
- sensitization/information  
- maintenance/production relationship  
- maintenance concept and policy  
- position of maintenance in the organizational structure  
- maintenance organization chart and job descriptions  
- setting up of data collection procedures (Maintenance Management Information System)  
- spare parts management  
- improving electromechanical intervention works  
- introduction of planned maintenance system  
- workshops/spare parts manufacturing  
- cost control/maintenance management  
- introduction of CMMS |
| 1.1  | define a plan of action to improve maintenance | - prepare a diagnostic report on maintenance  
- identify the actions to be taken, especially in the following fields:  
- sensitization/information  
- maintenance/production relationship  
- maintenance concept and policy  
- position of maintenance in the organizational structure  
- maintenance organization chart and job descriptions  
- setting up of data collection procedures (Maintenance Management Information System)  
- spare parts management  
- improving electromechanical intervention works  
- introduction of planned maintenance system  
- workshops/spare parts manufacturing  
- cost control/maintenance management  
- introduction of CMMS |
| 1.2  | obtain full commitment of General Management | - centralize all maintenance activities  
- give maintenance the same rank as production  
- tighten the links between maintenance and production  
- inform personnel about the maintenance policy and show the benefits resulting from it  
- launch a campaign of awareness creation at all levels — to develop maintenance-mindedness  
- develop corporate maintenance culture  
- devise a simple maintenance chart and clear job descriptions  
- define maintenance concept  
- introduce planned maintenance gradually, and strike a proper balance among condition-based maintenance, systematic maintenance and corrective maintenance  
- introduction of CMMS  
- improve maintenance staff motivation by devising a policy on productivity incentives and on implementing guidance measures  
- budget separately for maintenance and for investment in systems, skills and training  
- implement regular evaluation system |
| 1.3  | define and implement Corporate Maintenance Management Master Plan | - centralize all maintenance activities  
- give maintenance the same rank as production  
- tighten the links between maintenance and production  
- inform personnel about the maintenance policy and show the benefits resulting from it  
- launch a campaign of awareness creation at all levels — to develop maintenance-mindedness  
- develop corporate maintenance culture  
- devise a simple maintenance chart and clear job descriptions  
- define maintenance concept  
- introduce planned maintenance gradually, and strike a proper balance among condition-based maintenance, systematic maintenance and corrective maintenance  
- introduction of CMMS  
- improve maintenance staff motivation by devising a policy on productivity incentives and on implementing guidance measures  
- budget separately for maintenance and for investment in systems, skills and training  
- implement regular evaluation system |
| 1.4  | include maintenance managers on the executive board of directors | - centralize all maintenance activities  
- give maintenance the same rank as production  
- tighten the links between maintenance and production  
- inform personnel about the maintenance policy and show the benefits resulting from it  
- launch a campaign of awareness creation at all levels — to develop maintenance-mindedness  
- develop corporate maintenance culture  
- devise a simple maintenance chart and clear job descriptions  
- define maintenance concept  
- introduce planned maintenance gradually, and strike a proper balance among condition-based maintenance, systematic maintenance and corrective maintenance  
- introduction of CMMS  
- improve maintenance staff motivation by devising a policy on productivity incentives and on implementing guidance measures  
- budget separately for maintenance and for investment in systems, skills and training  
- implement regular evaluation system |
| 1.5  | establish a maintenance committee within the company, with the job of observing the implementation of actions for maintenance improvement and evaluating their results | - centralize all maintenance activities  
- give maintenance the same rank as production  
- tighten the links between maintenance and production  
- inform personnel about the maintenance policy and show the benefits resulting from it  
- launch a campaign of awareness creation at all levels — to develop maintenance-mindedness  
- develop corporate maintenance culture  
- devise a simple maintenance chart and clear job descriptions  
- define maintenance concept  
- introduce planned maintenance gradually, and strike a proper balance among condition-based maintenance, systematic maintenance and corrective maintenance  
- introduction of CMMS  
- improve maintenance staff motivation by devising a policy on productivity incentives and on implementing guidance measures  
- budget separately for maintenance and for investment in systems, skills and training  
- implement regular evaluation system |
### Table 21.1 (cont’d.)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTIONS</th>
<th>METHODOLOGY/OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>TRAINING</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1 devise a policy of human resources development for maintenance</td>
<td>- of practical type</td>
</tr>
<tr>
<td></td>
<td>2.2 recruit highly qualified staff for maintenance – provide for additional training if need be</td>
<td>- of specific type</td>
</tr>
<tr>
<td></td>
<td>2.3 establish training courses in maintenance, coordinated with production needs</td>
<td>- by apprenticeship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- vocational training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- at polytechnic or universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- on-the-job</td>
</tr>
<tr>
<td>3</td>
<td>TECHNICAL DOCUMENTATION</td>
<td>the following points must be incorporated in it:</td>
</tr>
<tr>
<td></td>
<td>3.1 draw up specific terms of reference on technical documentation</td>
<td>- itemized contents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- language of user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- presentation (illustrated with samples, perhaps even standard forms)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- delivery conditions (time schedule, amount, packing, place etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- conditions of acceptance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- penalties</td>
</tr>
<tr>
<td></td>
<td>3.2 set up a team of specialists (methods of officers) to do the acceptance of/inspect the technical documentation at the time of the equipment acquisition</td>
<td>subject matter:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- drawing up terms of reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- checking documentation sent in connection with equipment supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- setting up machine–files</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- updating documentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- filing documentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- providing user service</td>
</tr>
<tr>
<td></td>
<td>3.3 start training programmes on technical documentation</td>
<td>- make ABC analysis of most important works in relation to safety, production, quality and environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- launch requests to machine manufacturers or colleagues</td>
</tr>
<tr>
<td></td>
<td>3.4 make an assessment of existing technical documentation at the factory – gather all documentation in one central place – make copies for the users</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.5 complete technical documentation</td>
<td></td>
</tr>
</tbody>
</table>
Module 21
Unit 3

Table 21.1 (cont’d.)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTIONS</th>
<th>METHODOLOGY/OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>SPARE PARTS</td>
<td></td>
</tr>
</tbody>
</table>
| 4.1  | make analysis of stocks currently held in the plant | - classify and valuate on spare parts in three categories  
|      |         | - consumable  
|      |         | - standard parts  
|      |         | - specific parts  
|      |         | - identify dead stock |
| 4.2  | make a study of spare parts needs/ make sure that designations are accurate | - study of technical documentation and investigation among users according to priority machines  
|      |         | - bring stock up to required levels |
| 4.3  | set up a stock management department | - code all spare parts  
|      |         | - define stock management parameters  
|      |         | - set up a data collection system  
|      |         | - institute a computerized stock management system based on a preceding feasibility study |
| 4.4  | study the parts with a view to local manufacturing of repairs | - classify parts as  
|      |         | - to be imported  
|      |         | - available on the market  
|      |         | - can be manufactured  
|      |         | - can be repaired |
| 4.5  | design warehouses of ample size, with adequate facilities for the storage, handling and protection of the spare parts |
| 4.6  | speed up the enterprise’s in-house procedures for parts reordering |
| 4.7  | develop parts reclamation/repair techniques |

The order of priority of restructuring activities will be as follows:

- formulating a corporate maintenance management plan, including the maintenance concept and relevant training;
- informing the workforce about the organization of maintenance;
- centralizing maintenance activities;
- introducing an organization chart for the maintenance department;
- introducing some basic forms (job request, job order) permitting efficient data collection and follow up of work;
- organizing the maintenance teams;
- upgrading the technical documentation;
- upgrading stores of spare parts;
- organizing job preparation, work scheduling and programming;
- introducing a maintenance management information system (MMIS);
- launching a permanent promotion campaign on maintenance;
- introducing a periodic evaluation system.
Figure 21.7 illustrates the relations between the activities listed above, using a programme evaluation and review technique (PERT).

### 3.2 Maintenance awareness and promotion

The importance of a sound maintenance system is not sufficiently understood by many of the people concerned. A permanent effort must be made to promote maintenance and make all staff aware of how vital this is to operational performance, productivity, safety and quality. In addition to the maintenance teams themselves, staff at the following levels should be involved: general managers, departmental heads, supervisors and machine operators.

Maintenance concerns all employees and cannot be effective without cooperation. As an analogy to quality circles, maintenance circles can be imagined, with the objective of improving maintenance through a positive contribution from the entire company staff. For bigger companies with different maintenance centres (e.g. railways), the award of quality labels for good maintenance results and the title of “Centre of Excellence for Maintenance” both contribute to the same objectives.

On a management and departmental level, awareness raising will mainly concern the microeconomic aspects of maintenance. One convincing method is to use figures from the company and compare them with statistics from other companies in the same sector. This means that the maintenance manager must be well-documented and able to think like an economist rather than a technician when speaking to the board of directors.

Where production staff are concerned training in the correct operation of equipment is important. Statistics show that more than 50 per cent of breakdowns or failures originate in poor operating methods. Failures result in short or medium-term breakdowns. Moreover, operators must be taught to report anything unusual immediately (noises, smells, vibrations or leaks). Then there is a good chance that failure can be avoided before breakdown occurs.

For maintenance personnel, the importance of each aspect of the job must be emphasized, as well as the necessity of prevention. In addition, managers must insist on high quality maintenance work.

All actions must be coordinated and guided by a task force. A maintenance committee should be set up with members from various departments and employers’ and workers’ representatives. The committee can act as an intermediary between the maintenance department and other departments in the factory.

### 3.3 How to carry out a maintenance audit

**The survey**

The aim of a maintenance audit is to assess the existing problems in maintenance, both from the organizational and the strategic point of view, and to propose solutions, determine priorities for the recommended measures and set up a plan of action.
Figure 21.7: Restructuring a maintenance department
During an audit-survey, it is necessary to form an idea of the prevailing situation as objectively as possible. To this effect, enquiries should be made in the production department as well as in the maintenance department. Service heads, supervisors and workers on the shop floor should all be interviewed.

Guidelines for a maintenance audit are presented in table 21.2.

The guidelines for a maintenance audit include the following topics:

**General data concerning the plant**
The location of the plant, products manufactured, process profile, age of the equipment, ownership and construction contract, management, the labour force and the general and industrial infrastructure of the region.

**Production equipment**
These data will give an idea of the maintenance requirements and workload and indicate any technical problems which may exist. Information about the complexity of the equipment, the degree of standardization, accessibility for maintenance work and suppliers is set out so that an indication can be given of the skills and number of maintenance personnel required and the volume of spare parts.

**Organization of the maintenance department**
The company organization chart shows the hierarchical levels of the maintenance department. It provides data on the centralization of maintenance, its place in the organization chart, the existence and interdependence of its different services.

Questions concerning the central maintenance planning office (CMPO) are related to its organization, its role and efficiency.

In addition, questions will be raised regarding the existence and efficiency of:

- preventive maintenance and lubrication;
- technical documentation;
- job preparation;
- information systems;
- computerized maintenance management systems (CMMS).

The result of these enquiries will reflect the degree to which maintenance is scheduled or improvised.

Information regarding the mechanical, electrical and instrumentation services covers:

- the central workshop and/or decentralized workshops and their location;
- the planning section;
- capacity of the workshop (mechanical and electrical division) or of the laboratory (instrumentation division);
- intervention teams and special teams, machinery and equipment;
- quality of work.
Table 21.2: Guidelines for a maintenance audit

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>SUBJECT OF SUR</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERAL DATA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>manufactured products</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>year of start up</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>type of construction contract</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>management</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>total workforce of the plant</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>process profile</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>location (+ nearest industrial centre)</td>
<td></td>
</tr>
<tr>
<td><strong>PRODUCTION EQUIPMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-  <em>Mechanical equipment</em></td>
<td>- variety of suppliers</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- standardization of equipment</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- complexity</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- maintainability</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- state of machinery of main production equipment</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- state of utilities</td>
<td></td>
</tr>
<tr>
<td>-  <em>Electrical equipment</em></td>
<td>- variety of suppliers</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- standardization of equipment</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- complexity</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- maintainability</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- state of machinery and equipment</td>
<td></td>
</tr>
<tr>
<td>-  <em>Instrumentation equipment</em></td>
<td>- variety of suppliers</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- standardization of equipment</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- complexity</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- maintainability</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- state of equipment</td>
<td></td>
</tr>
<tr>
<td><strong>ORGANIZATION AND SERVICE OF THE MAINTENANCE DEPARTMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Organization chart of the plant</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Organization chart of the maintenance department</td>
<td></td>
</tr>
<tr>
<td>-  <em>Central Maintenance Planning Office</em></td>
<td>- organization chart</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>- existence of sections: methods</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>engineering/drawing office</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>inspection</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>programming</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>job-preparation</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>scheduling</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>central documentation</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>photocopying facilities</td>
<td></td>
</tr>
<tr>
<td>TOPICS SUBJECT OF SURVEY</td>
<td>RESULT</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>- location of the various sections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- manning tables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- efficiency of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>programming/scheduling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- technical documentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>drawings, manuals, instructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lubrication programmes, preventative programmes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>uniform codification of drawings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>itemization of machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% completed (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- updating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- forms/design/efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>work execution (JR, JO, work specification sheet)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>machine-file</td>
<td></td>
<td></td>
</tr>
<tr>
<td>machine history record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>machine record card</td>
<td></td>
<td></td>
</tr>
<tr>
<td>preventive maintenance card</td>
<td></td>
<td></td>
</tr>
<tr>
<td>consignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Information flows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- lubricating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>scheduling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>executing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>standardization of lubricants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- preventive maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>scheduling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>execution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- maintenance management system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>manual/computerized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>if computerized, which soft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>which ratios are gathered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>management monitoring chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Mechanical Services (MS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Organization chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Planning section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Interventions:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quality of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>specialized teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOPICS</td>
<td>SUBJECT OF SURVEY</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>- mechanical workshop (MWS)</td>
<td>- hierarchical dependence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- workshop centralized or not</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- machine–tools section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- sheet metal working section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- repair section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- other sections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- organization/information flows</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- job preparation/efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- orderliness and cleanliness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- quality of work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- cleaning and maintenance of machine–tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- manning tables</td>
<td></td>
</tr>
<tr>
<td>- Electrical Service (ES)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Organization chart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planning section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Interventions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- organization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- quality of work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- specialized teams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- tools</td>
<td></td>
</tr>
<tr>
<td>- Electrical workshop (EWS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- hierarchical dependence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- workshop centralized or not</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- rewinding section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- organization/information flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- job preparation/efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- orderliness and cleanliness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- quality of work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Manning tables</td>
<td></td>
</tr>
<tr>
<td>- Instrumentation Service (INS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Organization chart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planning section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Interventions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- organization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- quality of work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- specialized teams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- equipment/tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- manning tables</td>
<td></td>
</tr>
<tr>
<td>TOPICS SUBJECT OF SURVEY</td>
<td>RESULT</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>- workshop for instrumentation (LAB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>Spare parts Management and stores Services (SPMS)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- hierarchical dependence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- organization chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- study and selection of spare parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- codification and designation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- codification grid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- uniform codification (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- % of codified stock (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- stock management:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- data collection + flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- stores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- central stores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- storage capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- store catalogue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- orderliness and cleanliness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- conservation of parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- storage facilities/systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- information flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- number of stock items (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- stock value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- standardization of parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- sufficient quantity of stocks (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- specific parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- standard parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- consumable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- % of stock-outs (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- number of movements per month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- satisfaction of requested items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- reordering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- in-plant delays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- % of imported parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- manning table</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>General Maintenance Service</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Organization chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Production and distribution of energy and fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Transport and handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maintenance of Rolling Stock (MRS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- hierarchical dependence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- garage/equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- quality of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOPICS SUBJECT OF SURVEY</td>
<td>RESULT</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>- manning tables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- orderliness and cleanliness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- technical documentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- data collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- spare-parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Building Maintenance (BM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- various trades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- manning tables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- quality of work</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

COMPLEXITY OF MAINTENANCE WORK
- % of routine work (estimation)
- % of specialized work (estimation)
- % of very specialized work (estimation)

MAINTENANCE PERSONNEL
- Manning tables for whole maintenance department
- Detailed account of qualifications
- Total for each qualification group:
  - cadres
  - foremen level
  - qualified workers
  - unqualified workers
- Vocational training
  - manning tables training section
  - training equipment, buildings, etc.
  - training on-the-job
  - training outside the plant
  - forecast
  - in progress
  - complementary training
  - results of training actions
  - discipline
  - turn-over of personnel
  - respect of internal procedures and rules

MAINTENANCE COST AND BUDGET
Adequacy of cost-accounting system
- systematic collection of maintenance costs
- systematic processing of maintenance costs

Assessment of maintenance investments

Management ratios in relation to cost

MAINTENANCE MANAGEMENT
- Corporate Maintenance Management
  Master Plan - YES/NO
<table>
<thead>
<tr>
<th>TOPICS SUBJECT OF SURVEY</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>If yes, does it include/explain:</td>
<td></td>
</tr>
<tr>
<td>- HRD</td>
<td></td>
</tr>
<tr>
<td>- general strategy</td>
<td></td>
</tr>
<tr>
<td>- method for implementation</td>
<td></td>
</tr>
<tr>
<td>- problems</td>
<td></td>
</tr>
<tr>
<td>- acquisition renewal of equipment</td>
<td></td>
</tr>
<tr>
<td>- corporate policy</td>
<td></td>
</tr>
<tr>
<td>- implementation</td>
<td></td>
</tr>
<tr>
<td>- problems</td>
<td></td>
</tr>
<tr>
<td>- computer aided maintenance</td>
<td></td>
</tr>
<tr>
<td>- corporate policy</td>
<td></td>
</tr>
<tr>
<td>- links with other computerized systems</td>
<td></td>
</tr>
<tr>
<td>- subcontracting</td>
<td></td>
</tr>
<tr>
<td>- corporate policy</td>
<td></td>
</tr>
<tr>
<td>- which fields</td>
<td></td>
</tr>
<tr>
<td>- how it is managed</td>
<td></td>
</tr>
<tr>
<td>- maintenance concept</td>
<td></td>
</tr>
<tr>
<td>- definition</td>
<td></td>
</tr>
<tr>
<td>- based on which principles</td>
<td></td>
</tr>
<tr>
<td>- implementation</td>
<td></td>
</tr>
<tr>
<td>- problems</td>
<td></td>
</tr>
<tr>
<td>- describe relations with or concerning</td>
<td></td>
</tr>
<tr>
<td>- production</td>
<td></td>
</tr>
<tr>
<td>- QC</td>
<td></td>
</tr>
<tr>
<td>- safety department</td>
<td></td>
</tr>
<tr>
<td>- protection of environment</td>
<td></td>
</tr>
<tr>
<td>- Reliability-centered maintenance</td>
<td></td>
</tr>
<tr>
<td>- does the principle exist?</td>
<td></td>
</tr>
<tr>
<td>- list all technical analysis</td>
<td></td>
</tr>
<tr>
<td>- FMECA</td>
<td></td>
</tr>
<tr>
<td>- system reliability</td>
<td></td>
</tr>
<tr>
<td>- FTA</td>
<td></td>
</tr>
<tr>
<td>- HAZOP</td>
<td></td>
</tr>
<tr>
<td>- ABC (Pareto)</td>
<td></td>
</tr>
<tr>
<td>- MTFB</td>
<td></td>
</tr>
<tr>
<td>- MTTR</td>
<td></td>
</tr>
<tr>
<td>- others</td>
<td></td>
</tr>
<tr>
<td>- condition monitoring techniques</td>
<td></td>
</tr>
<tr>
<td>- computer assistance for condition monitoring</td>
<td></td>
</tr>
<tr>
<td>- implementation</td>
<td></td>
</tr>
<tr>
<td>- results</td>
<td></td>
</tr>
<tr>
<td>- problems</td>
<td></td>
</tr>
<tr>
<td>- Ratios and other management topics (complementary to questions asked under CMPO/Personnel and Cost Control)</td>
<td></td>
</tr>
<tr>
<td>- list other ratios (technical/economical)</td>
<td></td>
</tr>
<tr>
<td>- use of steering chart in relation to strategic decisions</td>
<td></td>
</tr>
<tr>
<td>- give correct figures of last 6 months</td>
<td></td>
</tr>
<tr>
<td>- relation to CMMS</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation of the quality of work is based on the state of equipment and on an investigation of work in the maintenance workshops.

Within the field of spare parts management and stores the following issues are analysed:
- existence, nature and codification/classification of spare parts;
- organization and efficiency of stock management;
- selection and quantity of spare parts;
- forms and information systems;
- problems of reordering;
- storage facilities.

In the field of utilities, the enquiry should cover the maintenance of rolling-stock, buildings, tracks, roads, sewerage and equipment for production and distribution of energy and fluids. Both the quality of the work and the means to carry it out (equipment, spare parts) are examined.

**Personnel**

The maintenance workforce includes all personnel belonging to sections which have a maintenance task and which are included in the maintenance organization chart as it exists in the plant. Questions regarding training of maintenance personnel will essentially relate to the actions which have been undertaken in this field. Attention should also be given to discipline (follow up of orders, filling in of paperwork, attendance at work) and to the safety of work (respect for regulations, fire-prevention measures).

**Maintenance cost and budget**

Accounting as it relates to maintenance is reviewed by analysing the company cost-accounting systems. Special attention will be given to the degree of analytic accounting and the independent treatment of maintenance costs. The survey should examine whether investments in maintenance are treated independently from other investments, and should also study the value of stocks and the amount of subcontracted maintenance work. Further, it will be determined whether breakdown costs are known and evaluated and whether detailed maintenance budgets exist.

**Maintenance management**

Does a corporate maintenance management plan exist? If so, what are the headings? What about reliability-centred maintenance? As a complement to the maintenance cost and budget section and to the questions under the CMPO and personnel chapters, are there other management ratios (technical and economic) which are followed up? How is the maintenance monitoring (steering) chart used for strategic decisions? What is the relation to the CMMS?

All the data collected could be summarized in the table which was used in the guidelines.

**Analysis of the survey**

Data analysis aims at assessing maintenance problems in a company in order to recommend improvements. The following topics should be studied in depth and their impact on production, quality, safety and the environment should be described. When possible, figures or quantifiable outputs should be given:
- average distance from the plant to the industrial centre of the region. Analysis of the possibilities for subcontracting;
- process profile;
- complexity of machinery and equipment;
- standardization of mechanical and electrical equipment;
- accessibility of the equipment for maintenance work;
- state of machinery and equipment - give figures concerning availability and reliability;
- corporate maintenance management plan, including the maintenance concept;
- the position of maintenance in the company organization chart;
- amount and quality of technical documentation and its accessibility;
- forms and data processing;
- workshops: organization and equipment;
- spare-parts needs, efficiency of spare-parts management and reordering, level of stocks, suitability of storage facilities, degree of satisfaction of requests for parts;
- the qualifications of the maintenance workforce and training carried out;
- maintenance management systems, figures concerning performance ratios (technical and economic).

Conclusions and recommendations - plan of action

The conclusions of the study should be presented under the following headings:

- equipment, including action to be taken when acquiring new equipment;
- human resources;
- material resources (spare parts, technical documentation, tools, measuring and monitoring instruments);
- organization and management, including computerization;
- infrastructure;
- social and cultural environment.

Recommendations should reflect the established priorities. This will result in a plan of action for the short-, mid- and long term. In order to highlight the interdependence of the various actions proposed, these can be presented in a PERT planning chart (see figure 21.7). The plan of action should address both corporate and maintenance management. Finally, a cost-benefit analysis should also be included, as this will facilitate decision making.

3.4 Management tools for maintenance

What are they and how can they be used?

Maintenance managers have long been aware of the need for benchmarks which give a measure of the performance of their department. Performance indicators are generally presented in the form of coefficients or as a relation between two absolute values; these are called 'ratios'. Ratios are the tools for monitoring a maintenance system.
Performance indicators

There are two categories of ratio under which performance indicators can be presented:

- economic ratios which show the evolution of internal results and allow certain comparisons between the maintenance services of similar plants;
- technical ratios which provide a means of checking the technical performance of installations.

a) Economic ratios

(i) Ratios linked to maintenance costs

The most representative economic ratios have been used in this unit. For practical use, this list must be completed by ‘customizing’ it for the company concerned.

Direct cost of maintenance
Added value of products

The added value of the product constitutes the total cost of production less the cost of raw materials. This ratio situates the importance of maintenance in a plant.

Cumulative costs of maintenance of a unit since start-up
Number of running hours since start-up

This ratio links the total direct costs of maintenance to a time unit. Two precautions are necessary: the cost must be calculated in constant monetary values and the interest on money spent must not be added to the costs of previous years.

(ii) Ratios in relation to spare parts

Average stock value
Replacement value of production equipment

This ratio takes into account the components of maintenance costs in relation to exterior costs. The ratio is significant for indicating ageing of the equipment.

Cumulative value of spares issued over 12 months
Average stock value over 12 months

This ratio measures the stock level of spares or stock rotation, i.e. the number of times the value of the stock is issued per year.

Cumulative value of issues over 12 m. - cum. value of issues of spare parts over 12 m.
Average stock value without buffer parts

This ratio eliminates the buffer parts issues on the ratio of stock rotation. These parts are generally supplied with the production equipment. From the accounting point of view, they are often considered together with the fixed assets.

A substantial reduction in the stock value then arises without decreasing the value of the issues. Here stock rotation would not reflect the real situation.
(iii) Ratios in relation to manpower

\[
\frac{\text{Cost of subcontracting}}{\text{Direct cost of maintenance}}
\]

This ratio follows the evolution of the policy on subcontracting. Subcontracting refers to the maintenance operations which are given to outside companies.

\[
\frac{\text{Cost of maintenance personnel}}{\text{Direct cost of maintenance}}
\]

This ratio gives an idea of the impact on fixed or temporary personnel.

b) Technical ratios

The technical ratios, far more numerous than the economic ratios, are also much more varied. In contrast to economic ratios, which often relate to the whole plant, technical ratios mainly concern apparatus, gauges or installations. They can be placed under two categories:

- those which interest the users of equipment and measure the efficiency of maintenance;
- those which interest the maintenance manager and measure the efficiency of maintenance policy.

\[
\frac{\text{Hours theoretically available} - \text{Hours of maintenance}}{\text{Hours theoretically available}}
\]

This ratio indicates the time during which the equipment would have been in production. It is one of the principal performance ratios for maintenance. It also permits a calculation of the degree of use of equipment

\[
\frac{\text{Number of running hours}}{\text{Number of running hours} + \text{down time for maintenance}}
\]

This is the ratio of operational availability.

Down time for maintenance includes: repairs, preventive and corrective maintenance, overhauls, micro-failures.

\[
\frac{\text{Number of hours of down time for unscheduled maintenance}}{\text{Number of running hours}}
\]

The numerator is calculated as total down time for maintenance, less the hours for scheduled inspection and maintenance. This ratio represents production hours lost because of breakdown, during which the production staff were idle.

\[
\frac{\text{Number of stoppages}}{\text{Number of running hours}}
\]

This ratio characterizes the number of failures in the system per unit of time and is a measure of the failure or breakdown rate. The ratio shows the reliability of equipment during its life cycle.

\[
\frac{\text{Number of work hours for troubleshooting}}{\text{Number of work hours for scheduled maintenance}}
\]
This ratio measures the efficiency of the applied maintenance policy.

\[
\text{Sum total of time allocated} \\
\text{Sum total of time actually spent on these jobs}
\]

This ratio gives an indication of the effectiveness of interventions.

From the reflections developed above two aspects are apparent and must be considered.

1. The interdependence of the ratios in general. A ratio on its own rarely signifies anything specific. It must always be backed up or confirmed by examining others which relate to the same topic.

2. The need for precise terminology in the numerators and denominators.

It is obvious that one must be extremely careful when examining ratios published in the international literature without further explanation. Care should also be taken when comparing the ratios of maintenance departments from different enterprises.

A study for the Arab Industrial Development Organization (September 1987) analysed ten ratios in three sectors of European industry (mechanical construction, cement and petrochemicals) and complemented this with a literature survey. The study aimed at giving benchmarks for these ratios in order to orient managers of the same industrial sectors. The results are found in table 21.3.

**Management monitoring chart (steering chart)**

Ratios permit the maintenance manager to follow the performance of maintenance. They are gathered on a ‘monitoring chart’, also called a ‘steering chart’ whose principal objectives are:

- to serve as a warning if something goes wrong in maintenance practice;
- to allow systematic comparison with previous results and so establish the evolution of parameters and trends;
- to judge the performance of different maintenance services, as far as this is possible within the limits of the ratios.

The monitoring chart will allow the maintenance manager to establish company standards for each ratio after a certain implementation period. Moreover, it will be possible to set objectives for each ratio. By following up the evolution on a weekly basis, the manager will be able to take any measures necessary. The objectives can then be split up for each production sector or even for each installation. Each section head or maintenance supervisor will have targets and the results obtained can then easily be checked and the necessary measures discussed. A principal element in this management system is the reporting procedure between the different sections and the maintenance manager. Experience proves that good maintenance management is only possible if the manager is correctly informed.
Table 21.3: Results of study of performance ratios

<table>
<thead>
<tr>
<th>RATIOS</th>
<th>MEC</th>
<th>CIM</th>
<th>PETROCHEM.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Direct cost of maintenance</td>
<td>10.44</td>
<td>12.9</td>
<td>11.87</td>
</tr>
<tr>
<td>Added value of production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Direct maintenance cost</td>
<td>12.7</td>
<td>16.4</td>
<td>7.98</td>
</tr>
<tr>
<td>Replacement value of assets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cost of maintenance personnel</td>
<td>58.35</td>
<td>41.75</td>
<td>52.90</td>
</tr>
<tr>
<td>Direct cost of maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of spare parts and current maintenance items</td>
<td>22.79</td>
<td>44.64</td>
<td>17.02</td>
</tr>
<tr>
<td>Direct maintenance cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average stock value</td>
<td>13.06</td>
<td>9.8</td>
<td>3.49</td>
</tr>
<tr>
<td>Replacement value of production equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulated value of issued spares over 12 months</td>
<td>120.8</td>
<td>71.15</td>
<td>n.a.</td>
</tr>
<tr>
<td>Average stock value over 12 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance workforce</td>
<td>5.6</td>
<td>28.4</td>
<td>65.70</td>
</tr>
<tr>
<td>Total plant workforce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtime due to breakdown</td>
<td>10.42</td>
<td>5.94</td>
<td>n.a.</td>
</tr>
<tr>
<td>Hours theoretically available for production on year basis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of stock items satisfied on IS</td>
<td>95.83</td>
<td>98.07</td>
<td>100</td>
</tr>
<tr>
<td>Total number of requested items on IS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of stock-outs</td>
<td>3</td>
<td>6.99</td>
<td>0</td>
</tr>
<tr>
<td>Total items in stock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ Guide for the application of management ratios for maintenance
In Industry - by DGS INTERNATIONAL for AODI and INMA/Algeria
(Institut National d’Etudes et Recherches en Maintenance)

MEC: mechanical construction
CIM: cement
PETROCHEM: petrochemicals
n.a.: data not available
3.5 The maintenance department: Activities and organization

Activities of a maintenance department

Methods The methods of the department consist of planning and making the best possible preparation for maintenance work through the use of suitable techniques and appropriate resources. This function can be applied either to a single well-defined job, in which case it involves 'work preparation', or to a whole maintenance programme on a machine or installation.

The way to proceed is to use the maximum number of methods which enable maintenance work to be carried out properly. These methods include:
- establishing record cards and history cards for each machine;
- establishing machine files and keeping them up to date;
- designing preventive maintenance programmes;
- analysing and evaluating on a continuous basis all the information gathered, with a view to improving methods for all important jobs and updating and adapting existing programmes and procedures;
- cooperating with the stock management department in selecting the spare parts, tools and materials to be kept in stock;
- developing forms and documents for use by the various services of the maintenance department and determining their flow (management information system).

Engineering This function concerns the study and design of modifications or minor extensions to existing equipment and machinery, with a view to improving capacity or output, quality of production, operational safety, maintainability or accessibility, and environmental impact. The engineering section, as designer, will monitor the work executed by the relevant maintenance services or by the subcontractor. In this capacity, the section will be responsible for the studies and also for the erection, installation, start-up and fine-tuning of machinery.

Job preparation This activity determines work studies (operating procedures), job specifications, material resources, requirements, time allocation, and workload. Job preparation results directly from the methods function, but centres on a given individual job. Good job preparation involves describing the job and breaking it down into separate operations. The job description is also a guide for the person responsible for monitoring safety, quality, and cost.

Work programming - Work scheduling - Follow up of work-in-progress Work programming is responsible for assembling the required material and human resources, drawing up a programme and setting time limits. The job includes planning the overall programme for the department (long-term planning). Activities include assessing work request priorities, making sure that orders for subcontracting and supplies are followed through and ensuring respect for instructions and timeliness.

Work scheduling is the function closest to job execution (short-term planning) and deals with workloads. Follow up of work-in-progress is usually the responsibility of the work-scheduling team, which continually monitors the workload of those executing the work and of the machine tools. The team corrects both under- and over-utilization.

Job execution Job execution is facilitated by good preparation and efficient planning,
provided that those responsible for job execution keep up quality standards while respecting deadlines, thus avoiding wasted time. Wasted time will result in:

- poor synchronization of the work done by the various teams;
- a large number of unsolved problems emerging during job execution;
- the use of tools that are unsuitable for the job;
- poor deployment of skilled personnel.

Quality control of maintenance work. The quality control function for maintenance work is very important in that it guarantees first-class execution. The essential nature of its role fully justifies the necessary investments in personnel, tools and measuring instruments. For manufacturing workshops, and in particular for machine tooling, it is worth training some of the staff to specialize in quality control. On the shop floor, supervisors will often be made responsible for checking the work of their crews.

Spare parts management and stores. The prime task of stock management is to anticipate, at all times, the factory’s need for consumables and current maintenance items, standard parts and spare parts for specific equipment. These requirements must be managed, and the quantities to be reordered must be determined in terms of stock levels and other parameters such as consumption, delivery delays, buffer stocks, and the requirements of certain markets.

Management of maintenance personnel. Personnel management is an essential aspect of running a maintenance department; it defines the rational selection, motivation and deployment of staff. The quality of these activities has a direct impact on the effectiveness of the department.

Cost control. By reducing its own costs, a maintenance department enhances the profitability of an enterprise. To be able to control costs, it is necessary to know what they are and how to interpret them. A maintenance-oriented accountancy system should be set up in close cooperation with the factory accounting department, with the objectives of:

- supplying the maintenance department on a continuous basis with all the data relating to its own expenditure, and thus enabling it to react promptly to any discrepancy or error;
- ensuring better monitoring of allocations (to cost centres) and thus limiting the number of errors;
- facilitating the drawing up of estimates;
- enabling the expenditure relative to a single job to be calculated more easily;
- defining and keeping a close watch on the allocation of overheads.

Exploitation of utilities. The utilities, or facilities for the production and distribution of energy and fluids, include:

- electricity production and distribution;
- water treatment, distribution and sewerage;
- compressed air production and distribution;
- the vacuum network;
- heating and steam production and distribution;
- storage and distribution of various gases;
- storage and distribution of fuels;
- refrigeration and cold network.

Exploitation of utilities includes not only the maintenance but also the operation of these facilities. Maintenance is the most appropriate department to carry out this task, since it requires qualified personnel who can act as service technicians as well as operators.

**Maintenance management** All the above functions should be managed in a proper way. Apart from its technical aspect, maintenance is considered more and more as a top-management function at company level. Maintenance managers need to adapt their (often technical) language so that it will be understood by executives and decision makers (in terms of costs; return on investment and added value).

Maintenance management covers the following levels:

- shop floor: technical management of maintenance work including methods, planning, quality control and analysis of operational statistics;
- maintenance department: strategic and economic management through the definition of maintenance policies, including a maintenance concept, the follow up of economic performance indicators, personnel management and subcontracting policy;
- company executive level: participation in drawing up corporate master plans concerning renewal policy, acquisition of new equipment and development of human resources.

**Some considerations on maintenance strategies**

A maintenance management plan should be drawn up as part of a corporate strategy. Several important elements in this plan are discussed below.

a) In the company hierarchy maintenance must be at the same level as manufacturing/production, marketing, administration and finance. In other words the maintenance manager must be a member of the board of directors.

b) There are various possible structures for a maintenance department: centralized, decentralized or mixed. The choice between centralization and decentralization depends on a multitude of factors such as geographic considerations, size of the plant, differences in process technology between the production areas, degree of availability requested, non-efficiency costs, etc. The structure that has given the best results in small and medium-size enterprises is that of centralized maintenance. Even for bigger companies a centralized structure can produce excellent results.

c) In the development of human resources, there are two urgent priorities: motivation and training. One of the problems is to attract highly qualified personnel to a field which traditionally offers rather poor career prospects. The company should provide better career opportunities for maintenance personnel.

d) Computerization of maintenance should be integrated with the total company information system.

e) Maintenance specialists should take part in all negotiations during the acquisition of new equipment.
A subcontracting policy contributes greatly to the performance of the maintenance service. The inevitable question is whether the work should be done by the company workforce or by outsiders. In the latter case, which jobs should be subcontracted and which should be kept within the maintenance department to avoid a loss of know-how, even if this means investing in specialist personnel?

An important part of the maintenance management plan is the definition of a maintenance concept, which in fact means selecting a maintenance form for each machine, depending on company priorities in terms of safety, production, quality, cost and environmental protection. There are various techniques for defining the maintenance concept. They include the: failure mode effects and criticality analysis (FMECA), system reliability analysis (SRA), fault tree analysis (FTA), hazard and operability study (HAZOP). Once the maintenance forms to be applied to each component or system are defined, periodicities can be fixed for components or sub-systems which must be grouped into packages at system level. This will lead to related maintenance programmes. The maintenance tasks can then be defined and an assessment made of the human and material resources needed.

Organizational structure of the maintenance department

Principles of maintenance organization The main principles of good maintenance organization are summarized below.

- Decide on the structure of the maintenance department. If possible, centralize all maintenance activities in one department.
- Place the maintenance department high on the organization chart.
- Make sure that maintenance is not headed by the production manager. Ensure that production and maintenance managers are on the same level.
- Assign fully qualified personnel to the maintenance department.
- Allocate sufficient financial resources.
- Devise an organization which suits the particular needs of the factory and allow it to evolve accordingly.
- Avoid trying to set up a perfect organization from the start. Find flexible structures and ensure that staff understand the system thoroughly before final implementation.
- Avoid useless paperwork but keep any forms necessary to ensure an efficient exchange of information.

It is important to establish a direct link between the head of maintenance and the factory or company manager. The hierarchical position which should be assigned to the maintenance department is illustrated in the general organization chart shown in figure 21.8 below.

As the objective for the production and maintenance departments is the same, i.e., production at minimum cost under good conditions of quality and safety, it is necessary to place the two departments on the same hierarchical level so that relations can be based on equivalent decision-making power.

Maintenance organization chart A maintenance organization chart (organigram) which can be used as a guideline for different types and size of factory signifies an approach in terms of the functions which must be assured. It should be understood that a function on the chart (see figure...
21.9) can be carried out by one or several people or conversely one person can assure several functions. It all depends on the size of the company.

**Figure 21.8: The place of the maintenance department in an organization structure**

![Organization Chart](attachment:organization_chart.png)

**Figure 21.9: The simplest organization chart for a maintenance department**

![Simplest Organization Chart](attachment:simplest_organization_chart.png)

A maintenance department should include five functions in order to cover all tasks. These functions are:

- reflection on methods, job preparation and planning
- execution
- control
- logistics: workshops, laboratories, garage, stores
- evaluation and management

Organization charts can be completed in successive stages. The functions are explained step by step so that the reader can find all the elements needed to adapt the suggestions to a particular situation. The simplest organization chart (first stage) for a maintenance department in a small factory shows the basic functions for an efficient maintenance operation. This organization chart contains the following functions:

- **MM**: Maintenance management. Responsible for technical and administrative management. This particularly concerns supervisory work, establishing a budget, following up expenditure, interpreting technical failures, giving instructions for maintenance programmes, recruiting personnel, taking part in board meetings and advising on equipment.

- **PL**: Planning. Responsible for methods (preventive programmes, work preparation),
work planning (programming - scheduling) as well as for technical documentation. The planning function is also responsible for selecting parts to be stored and administering the stores.

- INT: Shop floor interventions. Responsible for all mechanical, electrical and other interventions, for preventive as well as corrective maintenance.
- ST: Spare parts storage. This function is responsible for stock keeping (registration, conservation, storage) and issuing of spare parts.
- WS: Mechanical and electrical repair. Responsible for minor welding jobs, metalwork and small electrical repairs.

For very small factories these functions could actually be carried out by a single person (a plant with a total workforce of ten) or by four or five people for larger plants (total workforce 20 to 30). For still larger factories (workforce 50 to 100) maintenance departments will need a staff of ten to 20 people.

This organization chart could progress (for small factories) towards the chart shown in figure 21.10.

**Figure 21.10: Complex organization chart for small firms**

The same functions as those in the first organization chart above are found here but with some developments:

- INT has been split into two sub-functions: one mechanics (MEC), the other electricity and instrumentation (ELEC/INSTR). Moreover, the mechanical function is split into two: one for preventive work (PREV), the other for breakdowns and minor repairs (CORR);
- the WORKSHOP (WS) has been reinforced by the following sub-functions: MT (machine tools), REP (mechanical and electrical repairs) and a small store for raw materials and tools (TST).

In this case, we are speaking of a factory workforce of 80 to 130 and a maintenance department of 20 to 25 people.

A second stage in the design of organization charts concerns a larger factory with one production area working 8 hours a day. The preceding organization charts could evolve as shown
in figure 21.11.

**Figure 21.11: Maintenance organization chart for a large factory**

The maintenance department is composed of the previous functions, resulting in four line services (MS - ES - SPMS - GM) and one staff section (CMPO). The functions in the preceding organization charts appear again, but the implementing services have been adapted slightly for some of them. This is the case with the mechanical and electrical functions which have now grouped together not only the interventions but their respective workshops (MWS: mechanical workshop/EWS: electrical workshop). In other words, the mechanical and electrical functions are big enough to run their own workshops. In fact, a central workshop would probably be too small to exist as a separate service. A new service has been added: GM (general maintenance). This service is responsible for utilities (production and distribution of energy and fluids), maintenance of rolling-stock (GAR: garage) and civil works (CW). An organization chart of this size is appropriate for a factory workforce approaching 200 and a maintenance workforce of 40 to 50 people.

If a plant has a lot of control, regulation or automation equipment it is wise to create a separate service for instrumentation (INS). In the case of a plant with mechanical and electrical equipment which needs continuous monitoring (for instance plants with high breakdown costs such as a power plant), creating a heavy workload on the MS and ES, then it would be wise to group the workshops MWS and EWS into a CWS (central workshop).

A third stage in the design of maintenance organization charts applies to a factory with several production areas working 24 hours a day. This is the most complete organization chart for a maintenance department (see figure 21.12). In considering the various services, we find exactly the same functions as described above. Thus, even though this organization chart can be considered more or less standard, it has to be adapted to each factory. Therefore, it can only be used as a guide, not as a master plan.

This organization chart is composed of seven centralized services, each reporting to a service head. They are the central maintenance planning office, the mechanical service, the electrical service, the instrumentation service, the central workshops, spare-parts management and stores, and general maintenance services. Each head of service reports to the maintenance manager. In large plants, some of the services may be decentralized in each production area (assigned maintenance), under the authority of the maintenance manager. This is especially the case for the CMPO, MS and ES.
Many alternative forms of the standard organization chart are possible: the chart represents a general organization whose principles may be applied in any plant. The various sections of each service are detailed below.

1. Central maintenance planning office (CMPO)
   The following sections are part of this service: methods, engineering, tribology, maintenance management and documentation.

   The maintenance methods section (MET) is composed of a central office with desks in the various production areas of the plant. The maintenance engineering and construction section (ENG) has a drawing office at its disposal and (apart from modifications and small extensions) will deal with updating drawings, standardizing parts and machines in the plant and studying plant improvements. The tribology section (TRIB) will be mainly responsible for planning, organizing and inspecting lubrication work, and with the selection of lubricants. The maintenance management section (MMA) analyses maintenance costs and statistical data on frequency and origin of breakdown. The central documentation section (DOC) will collect and administer all documents, drawings, instruction manuals and catalogues regarding the plant and its equipment. To assure the necessary flow of documents, a fully equipped copying section (REPRO) is a necessity.

2. Mechanical and electrical services (MS-ES)
   Mechanical and electrical services deal principally with troubleshooting, on-the-spot repair, monitoring equipment and carrying out routine and preventive maintenance. To facilitate internal communication and to encourage personnel to specialize in one or more production areas, the mechanical and electrical services can be decentralized by assigning maintenance teams to the different production areas of the plant. Each maintenance team would be composed of two parts: the planning section (PL) (maintenance programming - job preparation scheduling) and the intervention teams (INT) which are split into a day team (N) for preventive work and three teams for corrective work organized in three shifts a day to give 24-hour cover.

3. The instrumentation service (INS)
   The instrumentation service deals with equipment for monitoring and regulating the production process. This service also deals with all pneumatically and electronically controlled equipment, including automation. The principles of decentralization and organization, as described for the electrical and mechanical services are equally applicable here. Frequently the telecom-service, which deals with all telecommunications equipment in the plant, is part of the instrumentation service. INS also has a specialized workshop (LAB).
4. The central maintenance workshops (CMWS)

The central workshop is composed of a mechanical workshop and an electrical workshop. Heavy and light machine tools (HMT and LMT) are part of the metalworking section (MW) of the mechanical workshop (MWS). In some cases, there may be a large number of these machines. All work concerned with metallic construction is part of the sheet metalworking (SMW), piping (PIP), welding (WEL) and cutting (CUT) section. The foundry and the forge are essential for manufacturing spare parts. Often subcontracting may be used to avoid the need for such equipment. This may also be the case in other specialized shops such as gear cutting, tool-making, heat treatment, chrome-plating, metalization, diesel engines, pumps, vulcanizing, hydraulic equipment, overhead traversing bridges, refractories and machine tools. The repair shops (REP) deal with important overhauling, as well as with repairs in the shop and on the spot. The electrical workshop (EWS) contains a rewinding section (REW). In some cases a factory lighting (FL) section may be justified. A PL section in each shop will deal with job planning and preparation. A store for tools, raw materials and small spare parts is included in each workshop.

5. Spare-parts management and stores service (SPMS)

A selection of spare-parts and codification of specific parts’ section will deal with the selection of all spare parts which should be kept in stock. The codification of standard parts’ section will deal with the codification/classification and the designation of standard parts and of all maintenance materials. The ‘standardization’ section (STAND) deals with the standardization and interchangeability of parts with a high turnover. The ‘stock management’ section (MAN) deals with the proper administration of stock. Common parts and articles are stored in a central store (CST), which may have some decentralized buffer stores in different areas of the plant. The central store will receive the parts, distribute them and keep stocks.

6. General maintenance (GM)

General maintenance normally has its own teams for operating and maintaining factory utilities (equipment for the production and distribution of energy and fluids such as electricity, air, water, gas, steam, etc.). In some large plants, utilities (UTIL) can be separated from the maintenance department. The ‘maintenance of rolling-stock’ section (MRS) will have its own maintenance infrastructure (garage, store, etc.). The maintenance of the buildings and infrastructure (BM) is done by a special section, which has masons, electricians, plumbers, carpenters and painters. The ‘materials handling’ section (MHAN) has crane drivers, drivers for light and heavy vehicles, drivers for lifting equipment, etc. Maintenance of tracks, roads and drains is done by a specialized section (TRS).

Remark

The above organization charts concern a centralized maintenance department. The reasons for a centralized structure have been listed previously. Nevertheless we have attached in figures 21.13 and 21.14 the organization charts of a decentralized structure, and of a mixed structure. In addition, and for reasons of comparison, two alternative ways of organizing a centralized structure for the same type of plant are shown in figures 21.15 and 21.16.
Figure 21.13: Decentralized maintenance structure

PLANT MANAGEMENT

PROD

OPER  MAINT
PRODUCTION AREA 1

OPER  MAINT
PRODUCTION AREA 2

OPER  MAINT
PRODUCTION AREA 3

PROD  : Production
OPER  : Operation
MAINT : Maintenance
Figure 21.15: Centralized maintenance structure (Alternative 1)
Figure 21.16: Centralized maintenance structure (Alternative 2)
Maintenance management information system (MMIS)

Setting up an efficient MMIS requires the identification of all data to be collected and the clear fixing of information routings from shop floor up to management and vice versa.

The data which the maintenance department will require in order to carry out its job efficiently are of various types:

- basic data regarding written procedures on the internal relations and organization of the maintenance department;
- detailed inventory of machines, apparatus and installations, including their technical characteristics;
- data contained in the technical documentation;
- instructions and information regarding work execution;
- historical data on machines;
- information regarding spare parts;
- necessary data for cost control and maintenance management.

In order to avoid incoherence and discontinuity of work due to staff turnover, it is necessary to record all instructions regarding organization, work methods, information systems and so on. By keeping written records, the misinterpretation of verbal instructions can be avoided.

The starting point for maintenance strategy and planning is a complete inventory of all items to be maintained with an indication of their location and main characteristics.

Technical documentation contains all the drawings and documents relating to the design and construction of the plant and the correct operation of the equipment. It also contains information on the operation, maintenance and possible future extension of the plant.

The information on work execution covers:

- the job request;
- the background data for job preparation, including work specifications (work study);
- the job order;
- work planning (maintenance programming and scheduling);
- feedback of information to the various sections (methods, stock management, accountancy, machine files).

Information on the history of the machines is recorded on a history record card after each maintenance intervention on the machine, and also during the operation of the machine. This information is used for cost and productivity analyses on the machines, as well as for preventive maintenance programmes and the preparation of capital overhauls.

Together with the technical documentation, the documents regarding spare parts constitute the main information support between the purchasing department, the spare-parts store and the user. These documents concern the codification of parts, spare-parts management, procurement/reordering and stock movements.
The data for cost control and maintenance management should make it possible to calculate the cost of each maintenance job. This cost should include labour, materials, subcontracting services (internal and external) and overheads. The labour cost covers actual wages paid, incentives and social benefits. The material cost covers spare parts, raw materials and other maintenance materials. External subcontracting costs may cover the carrying out of an actual maintenance job, or payment for technical assistance or part-time personnel. Internal subcontracting occurs when the maintenance department receives services from other departments of the plant. Maintenance overheads include rent (i.e., surface occupied, energy), as well as the depreciation of machines used by the maintenance department, insurance and other operating costs.
UNIT 4: PREPARING FOR IMPLEMENTATION

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand and apply maintenance planning methods.

2. Set up a documentation system for equipment, spare parts and stores.

3. Formulate maintenance policies, design a maintenance system and train a maintenance specialist.

UNIT 4: CONTENTS

4.1 Maintenance planning

4.2 Equipment documentation

4.3 Spare parts and stores

4.4 Corporate policy for maintenance training

4.5 Exercise on maintenance organization and information flow

Bibliography
UNIT 4: PREPARING FOR IMPLEMENTATION

4.1 Maintenance planning

The planning of maintenance work concerns daily maintenance, the repair schedule, preventive and design-out maintenance, periodic overhauls, planned replacements and the activities of the central workshops. In this section we will detail the planning of preventive maintenance and lubrication and also the planning of overhauls and major repairs.

Planning of preventive maintenance

The preventive maintenance file contains all the information necessary for preventive maintenance work. This information includes the work study (work specifications), details of the machine to be inspected, job planning, inspection schedules and checklists. A distinction is made between the following types of information:

- job instructions - the preventive maintenance card;
- programming of preventive maintenance - work programming;
- scheduling of preventive maintenance jobs - workload planning;
- inspection of the work.

The preventive maintenance card separates the work into mechanical, electrical and instrumentation work. A card is made for each machine, assembly or sub-assembly. Instructions are given for each periodicity, starting with the highest one. These instructions should be clear, precise and simple.

Based on the preventive maintenance programme for each machine, detailed planning will be undertaken for all the machines. Preventive maintenance planning will take into consideration the time necessary to carry out all the jobs for each sub-assembly indicated in the programme. It will also consider the periodicity of the inspections.

Planning of lubrication

The lubrication file contains all the information necessary for carrying out lubrication, including work specifications and lubricating points, planning and inspection. A distinction should be made between the following elements:

- work instructions - the lubrication card;
- lubrication planning - work programming;
- the lubrication workload schedule - workload planning.

Planning is carried out for lubrication which exceeds two weeks. It is based on the lubrication programme and is in line with preventive maintenance planning, because most lubrication activities which exceed two weeks coincide with periodic maintenance.
Planning of overhauls and major repairs

The various operations in maintenance work can consist of a number of complex tasks. This is especially the case for overhauls and major repairs. Planning must respect a particular sequence and interdependency. This means that certain tasks are consecutive, while others can be done simultaneously. Several methods exist for the planning of overhauls and repairs, including the PERT method (programme evaluation and review technique). The methods are based on calculating the critical path of all tasks to be executed; this can be done very easily today by using existing microcomputer programmes.

4.2 Equipment documentation

The objectives of technical documentation

The lack of equipment documentation is a major problem faced by maintenance services in production plants. Equipment documentation is necessary to ensure maintenance management, repair work, manufacture of spare parts, rapid troubleshooting, work safety, the correct selection and management of spare parts and efficient staff training. Unfortunately, when purchasing production equipment, technical documentation is frequently neglected by both supplier and customer.

Complete documentation is expensive. For a new factory it can vary between 8 and 22 per cent of the value of the equipment. In order to lighten expenses for existing plants, full documentation should only be prepared for priority equipment. In any case, investment in setting up or improving technical documentation will only be justified if the documentation is used efficiently. For this, the documents must be updated regularly and dispatched judiciously.

Content of equipment documentation

Technical documentation can be divided into three types:
- study and engineering;
- construction and start-up;
- exploitation.

We have paid most attention to the third type, which is vital for the efficient running of the factory, because most of the documents concerning engineering, construction and start-up are little used once the factory is in production.

Equipment documentation is classified in four different types of file, established by zone, department or production line: these are the general file, the machine files, the utilities file, and the standard files. All the documents should be presented in hard-cover A4 binders. The different headings are separated by numbered insertions so that each heading is easily accessible.

a) General file

This file consists of:
- technical specifications for the installation;
- flow sheets showing the machines and apparatus, and information concerning raw materials, consumption of fluids, etc.; the plant layout and section drawings of installations showing clearly the connections between the different machines;
- operation and service instructions.

In order to obtain an overall view of the equipment belonging to the installation, an 'inventory of machines' will be set up including the machines, apparatus and important accessories.

b) Machine files

In the machine files a distinction is made between the important/complex machines and the simple ones. The file of an important or complex machine is composed of eight headings under which the equipment documentation is classified. The same sort of classification is used for simpler machines and equipment but the content will be reduced.

The different headings comprise the following documents, separated by numbered insertions:

1. Technical documentation: machine record card / layout drawings / description of functioning
2. Installation and start-up: foundations and installation / transport and handling / instructions for assembling / commissioning
3. Instructions for operation: safety instructions / operation / instructions for tuning / troubleshooting
4. Service instructions: maintenance / lubrication
5. Drawings and nomenclature: mechanical / electrical and automation / instrumentation / hydraulic / pneumatic and other fluids
6. Recommended spare parts
7. Prospecti and catalogues
8. Control certificates and commissioning reports

c) Utilities file

The utilities file deals with the distribution network of energy and fluids, such as electricity, compressed air, water, steam, and gas. The drawings and documents dealing with machines which produce energy and fluids can be found in the appropriate machine files. The utilities file also contains eight headings, which are:

1. Technical characteristics
2. Description of the installation
3. Exploitation manual for the installation
4. Maintenance
5. Prospectus and service manuals for apparatus and devices
6. List of recommended spare parts
7. Drawings and diagrams
8. Control certificates and commissioning reports
d) Standard files

Documentation for standard apparatus and accessories (valves, motors, pumps, measuring devices, etc.) for machines or installations, is classified in the standard files. There are three types of standard file: mechanical, electric/automation and instrumentation. These files also contain the same eight headings as above, but the content is simpler.

Management of equipment documentation

The coding structure of equipment documentation corresponds to different sections of the factory; a code is given to each machine, assembly, sub-assembly and apparatus. This permits the allocation of maintenance expenditure to each machine and makes it possible to follow up interventions which have been carried out. It is an invaluable tool in maintenance management. This coding is also used in filing and administering the technical documentation.

The room in which technical documentation is stored should be dust-free and dark so that the documents do not deteriorate. Drawings should be stored in drawers, according to codification number and size (AO to A4). The machine files, standard files and utilities files should be stored in metal cabinets, according to the file number. Catalogues of standard and commercial parts and products will also be stored in metal cabinets. Filing will be carried out alphabetically.

Each modification, however small, must be recorded immediately on the original documents and made known to the users. This updating is important because it mainly concerns the drawings (electrical, mechanical, etc.). It must be carried out by the methods section together with the drawing section of the CMPO. Each modified drawing will carry a new index. The updates are also noted on a sheet in each machine file. In this way it is possible to see at any time if the plan or document in one’s possession is the latest and most up-to-date version.

Basic terms of reference for equipment documentation

The terms of reference for documentation to be supplied by the manufacturer should be available. These are added to the terms of reference that deal with general and detailed conditions of purchase.

The objectives of the terms of reference are:

- to determine which documents, drawings and diagrams are to be delivered by the supplier;
- to define the standard format and other requirements which the above documents should satisfy;
- to define the form of presentation in order to obtain uniform documentation which is easy to classify and consult;
- to define the delivery conditions for documentation (where, when, how, number of examples, originals, etc.);
- to determine the responsibilities of the supplier and to fix penalties if the contract is not fulfilled.
Improvement actions in the plant

At plant level, the following short-term improvement actions are recommended:

- centralize all technical documentation in one area of the plant;
- code and classify the documentation, create a system for updating and dispatching;
- specify priority machines with a high risk of production bottlenecks and make up detailed machine files for them;
- establish standard terms of reference for technical documentation which must be imposed on equipment suppliers.

4.3 Spare parts and stores

The following common problems are typical of spare-parts management:

- a wide variety of equipment manufacturers and little effort made to standardize machinery and components, resulting in a large investment in spare-parts stock;
- poor selection of spares to be stored;
- incorrect designation of spare parts;
- lack of a uniform in-plant codification of parts;
- inefficient or non-existent stock management, due to a lack of systems or a lack of information;
- lengthy reordering delays due to internal delays in the company, delivery delays, delays in payment, customs delays;
- lack of hard currency in some countries for imported spare parts, which obliges plant management to reduce its stock;
- random allocation of import quotas in certain countries;
- poor storage due to inadequate facilities;
- poor knowledge of stock.

In addition to the above problems, detailed contractual clauses concerning spare parts are often missing or unclear when purchasing equipment. Specific tender documents for spare parts rarely exist.

Techniques for reconditioning spare parts (protective coating through welding, metalization, application of antifriction metal, adhesives, Metalloc system, etc.) are little known and in many countries almost no effort has been made to develop them. Nevertheless, they represent a cheap way to make up for the lack of spare parts. Finally, very little action has been taken in the field of specialist training for the selection, coding and designation of parts and for stock management.

Selection of spare parts to be kept in stock

The stock in a maintenance store can be divided into three types of article:

- specific parts of an installation, machine or device. These are manufactured specially for the equipment and are not interchangeable with parts from another make (for instance
machine frames, valve-lovers, spiral gears, switch-contacts, piston-rings, connecting-rods);
- standard parts which correspond to international standards and/or which are interchangeable with parts from another make. The manufacturer of the parts is not necessarily the manufacturer of the equipment on which they are installed. Examples of standard parts are bearings, O-rings, lip-seals, fuses, cocks and fittings, roller-chains, V-belts, etc.;
- maintenance consumables and current store items which are generally found on the market. These include sheetmetal, iron castings, nuts and bolts, pipes, building materials, sealing compounds, cleaning products, rags, glues, lubricants, grinding paste, etc.

The selection of parts to be stored is based on a study of the equipment components and related factors, including:

- parts subject to wear;
- parts which rarely wear out but which must be in good condition for the machine to function;
- stress on the equipment and its components in relation to the degree of utilization;
- the lifetime of the equipment;
- the technical level of operators and maintenance personnel;
- the motivation of personnel;
- the management and care of production equipment;
- the general organization of the company and of maintenance in particular.

Stock levels depend on the availability of a rational stock management system, thus allowing a strict follow up of consumption. If this system does not exist from the very beginning, initial supplies should be increased.

Parts designation and codification

Without a uniform and common language, it is impossible to centralize spare-parts management and stores for different production areas. Therefore it is vital to set up a single designation and codification system for spare parts and current store items. Correct designation is indispensable in order to:

- avoid stocking identical parts under a different name, in different places in the store and consequently to avoid ‘false’ stock-outs (an item is thought to be out of stock but the same part is available under a different label);
- ensure easy filing in the purchasing department and the stock management section;
- develop a common language between users, purchasers and suppliers;
- allow the supply of standard parts from the world market and not only from one supplier according to a standard (international, national, company or in-house) for parts.

A coding system has to meet the following requirements:

- a code number must correspond to one item only;
- an item must correspond to one code number only;
- a code number must be final. A change of code number is a constant source of confusion and should be avoided;
- the code number must be logical, i.e., given according to a system reflecting the main
characteristics of the item which has to be coded.

A system which generally provides good results in industry is based on codification according to the nature of the spare parts. It starts with a broad classification of products into ten classes (from 0 to 9). The classes are then divided into families, sub-families, groups and sub-groups. A code number of eight figures is enough even for very large stores.

In order to proceed with codification, a grid should be set up, adapted to the equipment in the company. This must be done by the spare-parts management and stores service, assisted by a methods section and/or the technicians in charge of job preparation.

Spare-parts management

The function of stock management (or stock administration) is to ensure the availability of spare parts according to demand. The basic parameters of stock management are monthly consumption, unit price, delivery time, reordering level, minimum stock level and maximum stock level. When considering reordering quantity and frequency rational stock management means that the total of purchase price, acquisition cost and owner costs is kept to a minimum, with:

- acquisition cost: all administration costs in connection with purchasing
- owner costs: all costs resulting from stock composition and conservation (interest loss on invested capital, storage costs, personnel costs, distribution and conservation costs, etc.)

The system chosen will depend on the nature of the item, and its average consumption. In general two main categories can be established:

- consumables and non-durable items, current store items, standard parts, certain specific parts. These items are used often, their lifetime is limited and they are subject to wear. They are called fast movers;
- items which are rarely used, but which must be kept in stock, in case of unexpected breakdown, incident or wear. A prolonged stoppage of the machine can occur if they are not in stock. They are called 'buffer parts' or 'slow movers'.

It is evident that stock in the first category will have a fast turnover, whereas stock in the second category will be 'resting'. The criterion for classifying an item is its monthly consumption. If consumption exceeds 25 per cent of stock, then an item will be listed as a fast mover; if less than or equal to 25 per cent it will be listed as a slow mover.

In order to avoid stock-outs due to a longer delivery delay than expected or due to accelerated consumption, a 'safety stock' or 'minimum stock' is determined. This stock is expensive because it is permanent, it takes up precious storage space, it uses capital and it causes owner costs (conservation, personnel, etc.).

Management of fast movers is mainly based on the quantity to be ordered, which takes into account the utilitarian price (Pu) of the item (unit price increased by transport and handling costs, etc.), the interest on invested capital (i) and sundry costs (d) (storing, personnel, etc. expressed as a percentage of average stock).
The economic quantity is calculated according to Wilson's formula

\[ Q = \sqrt{\frac{24 \times CA}{i + d}} \cdot \sqrt{\frac{Ma}{Pu}} \]

where \( Ma \) = average monthly consumption
\( Q \) = quantity per order
\( Pu \) = and \( CA \) = the acquisition cost per item

This quantity should be tentatively considered as the correct quantity to store. It is rounded up to the next packing quantity or adjusted in relation to projected maintenance events such as big repairs or important overhauls.

It must be emphasized that the use of formulae for reordering should only serve as a guideline. They help the decision maker to take all the parameters into consideration but a considerable number cannot be translated into formulae. This is why permanent follow up and updating of the files are required.

Slow movers are not supposed to be subject to much wear. Therefore, it is the safety stock which is at stake if unforeseen breakdowns occur. In order to determine the quantity of slow movers to store, answers must be provided to two questions:

- what is the impact of a broken part on production?
- what are the possibilities of local repair or reconditioning of the part?

The quantity to be kept in stock can be decided on the basis of this information and taking into account the price of the items, as well as the type of reordering. In some cases zero stock may be acceptable (e.g. a repaired part can be used if the frequency of incidents permits it).

Different types of reordering are possible, both for slow movers and for fast movers:

- reordering based on a reordering level: each time stock reaches the level which equals the sum of consumption during the internal reordering period + consumption during the delivery period + the minimum stock, a quantity calculated by Wilson’s formula is reordered;
- periodical reordering: a consequence of reordering based on the reordering level is that orders are placed at variable dates. The disadvantage of this is that each item must be considered separately. Grouping would reduce the number of orders. The two main criteria for this grouping are the supplier and the geographical location;
- reordering in the case of low consumption: when consumption becomes very low, i.e., less than one unit per delivery period, the quantity to be stocked is calculated according to consumption during the time between two deliveries;
- reordering by contract: this is more a purchasing technique than a method of stock management. It consists of a contract with a supplier which specifies the quantity to be supplied over a certain period of time. The contract details all the purchasing conditions, particularly price and delivery period.

Regular stock analysis permits the tuning of spare parts management and should be an element of general policy. It determines the parts which need particular attention and which directly influence the efficiency of spare-parts management.

The process of stock analysis consists of putting the items in decreasing order of value (unit price). Subsequently a graph is drawn up: in abscissa, the cumulated items in the same order as
above, and in ordinate the corresponding cumulated values (this method is called ABC-analysis).

The conclusion reached is that a major part of the capital invested is tied up in a small number of items. Studies aimed at reducing stocks of these items will make a considerable financial impact. This in turn will optimize stock management.

Storage systems

The following factors are essential to ensure optimal storage:

- spacious premises with well-designed storage systems, allowing easy access;
- suitable handling equipment in sufficient quantity;
- suitable shelves, bins, racks and other storage facilities;
- order and cleanliness;
- methods for conservation of parts (protection against dust, rust and humidity, suitable conditions for storing perishables.

From the organizational point of view, a centralized spare-parts management and stores service produces the best results. Auxiliary (buffer) stores in production areas are possible, but the stored items are then considered as being consumed.

4.4 Corporate policy for maintenance training

Objectives and prerequisites for maintenance training

The principal objectives of maintenance training are as follows:

- remedying as quickly as possible the lack of qualified personnel;
- adapting employees to their work;
- mastering imported technology;
- adapting the workforce to technological change;
- increasing productivity;
- bridging the gap between industry needs and academic training;
- keeping up with rapid changes in industrial society.

The following measures have to be taken before a training programme is launched:

- organization of maintenance in the company (organization chart, job descriptions);
- assessment of training needs;
- formulation of a training policy;
- planning of recruitment and training, with regard to the need for skilled workers;
- appointment of a head of training for follow up, checking and evaluation of results;
- administration of training and recruitment.
Assessment of training needs

Training needs are assessed on the basis of an in-depth analysis of maintenance practice in the company. In relation to the present inventory of production equipment, actual and future training needs are defined taking into account production programmes (load on the machines), reserves (margin to cover unexpected breakdown) and shut-downs for maintenance reasons. A maintenance policy for this production equipment, in relation to safety, price, and availability, will make it possible to estimate the amount of scheduled and unscheduled work. The time required can then be calculated from the maintenance programmes and periodicities for scheduled work and on estimates for unscheduled work. In this way the workload of the maintenance department can be predicted. The organization of work can then be defined including the organization chart, the information flow, management and quality control aspects. This will indicate the need for direct and indirect personnel, installations and spare parts. Detailed staffing tables can then be set up.

A comparison should be made between existing staff capacity and projected personnel needs. This will show the detailed training needs for workers (direct personnel) and for supervisors and engineers (indirect personnel). Training programmes should be drawn up on the basis of job descriptions and a vocational training analysis, including retraining and upgrading.

Development of appropriate training methods

a) Management training

Training of engineers and maintenance managers covers two fields: maintenance techniques and management. For technical training, the best method is to organize short study tours to machine manufacturers, complemented by on-the-job training during plant construction or by a specialized technical assistance programme. Training in maintenance management should be carried out through specialized upgrading seminars complemented by short-term practical training in selected plants.

b) Supervisory training

Team leaders Part of the training of team leaders can be carried out in a training centre or institute; here they receive theoretical training which brings them up to the technical level needed. Team leaders are often recruited amongst young qualified workers and are selected for their intelligence, their ability to explain and control a group. They are chosen not only for their professional qualities but for their human qualities as well. After an appropriate period of job experience and having obtained the necessary qualifications, they will become team leaders, responsible for four or five workers.

Technicians and foremen The best qualification for foremen is the accumulation of years of professional experience. The foreman is the keystone of a maintenance department. If foremen are needed urgently, then intensive training can be given to thoroughly experienced workers. On-the-job training has produced excellent results in the past.
c) Training of workers

Training programmes for skilled workers should ensure that the trainee learns not only techniques but also work habits. To achieve this, workers should be given more responsibilities and skills. On-the-job training is most appropriate for workers on the shop floor. They acquire practical skills by trial and error and accumulate a certain amount of theoretical knowledge.

As previously mentioned, on-the-job training for maintenance workers during the construction of a plant is indispensable. One efficient solution is to integrate maintenance workers into the construction teams. The builder is responsible for their work but their activities are monitored by the head of training in the company.

Apprenticeship programmes should be promoted for young workers. Experience has proved that apprenticeship is one of the most efficient methods for training new maintenance workers. Small groups composed of a foreman, a qualified worker and an apprentice have produced excellent results.

4.5 Exercise on maintenance organization and information flow

The exercise takes as an example a brewery producing 100,000 hl/year. The brewery has the following main sections:

- storage tanks for raw materials (a lot of stainless steel, piping, pumps, valves, some instrumentation)
- brewery
- bottling and storage of final products
- utilities (steam generation - refrigerating network - compressed air - carbonic acid - gas - water and related treatment - fuel)

The brewery and utilities sections work on a round-the-clock basis. The bottling section works two shifts five days a week. The total workforce is 100.

The following elements should be considered in the organization of maintenance:

- maintenance of rolling-stock (lorries, vehicles) is not done by the plant;
- the workshop is equipped with 1 lathe, 1 milling machine, a table-grinder, some work benches and welding equipment;
- all painting, heavy metallic construction and piping, woodworking and heavy jobs are subcontracted;
- the spare parts store is open 8 hours per day, 5 days per week. Access to the store outside these periods is assured by the shift boss;
- maintenance staff are on duty during the night and at weekends.

It should be pointed out that many small problems arise in the bottling section. This section needs the permanent presence of maintenance personnel, especially mechanics.

The exercise consists of carrying out a restructuring study on the maintenance department.
It has been decided that a central maintenance structure should be installed at the same level as the production department. The following workers will be kept: one electro-mechanical foreman, two electro-mechanical qualified workers level 3, two mechanical qualified workers level 2, one electrical qualified worker level 2, one storekeeper and one specialized welder.

Questions

1. Design a simple but efficient maintenance organization chart for the plant.

2. Set up a manning table for the maintenance department; the eight workers listed above should be kept and additional staff should bring the maintenance workforce up to a maximum of 25.

3. Devise a data-flow circuit for preventive maintenance work and for planned corrective work. The data flow should include a list of forms and the number of copies to ensure correct data transmission.

   Please compare your solutions to those given in Annex I to this unit.
ANNEX I

The brewery

a) Organization chart and staffing table

Various organization charts are possible but the one presented below has produced very good results.

```
MSI

CMPO

INT

PM CM BOTT WS

ST UTL
```

MSI: Maintenance Superintendent
CMPO: Control Maintenance Planning Office
ST: Store
UTL: Utilities
INT: Interventions

WS: Workshop
BOTT: Bottling section
PM: Preventive M
CM: Corrective M

Several staffing tables could be set up. The point is to ensure that all maintenance tasks are carried out with a minimum of personnel.

The following table has produced excellent results.
## Module 21
### Unit 4

<table>
<thead>
<tr>
<th>ENG</th>
<th>P</th>
<th>F</th>
<th>M</th>
<th>E</th>
<th>EM</th>
<th>SK</th>
<th>LMO</th>
<th>W</th>
<th>TOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSI</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CMPO</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>INT</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CM</td>
<td></td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>PM</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOTT</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>WS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>ST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>UTL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

ENG : Engineer  
EM : Electro-mechanic  
P : Preparator  
SK : Store keeper  
F : Foreman  
LMO : Lathe and milling machine operator  
M : Mechanic  
W : Welder  
B : Electric  

The above functions/personnel will deal with following tasks:

**MSI:**  
maintenance superintendent - engineer (BSc) or higher technician  
- maintenance management  
- supervision of stores  
- supervision of UTL-crews  
- stock management

**CMPO:**  
central maintenance planning office - job preparation  
- maintenance methods  
- job preparation  
- selection of spare parts to be kept in stock  
- work programming

**INT:**  
interventions headed by a foreman  
- supervision of crews  
- work-scheduling/follow up of work-in-progress  
- quality control of finished work

**CM:**  
corrective maintenance crew - working in shifts (3 x 8 hrs + 1 in rest) - composed of four qualified mechanics level 2 (one per shift) and four qualified electricians level 2 (one per shift) - in charge of repairs and troubleshooting - also in charge of cleaning and some greasing work during the night shift. The crews deal with the whole plant
except the bottling section (mechanics) and utilities section (mechanics and electricians).

**PM:** preventive maintenance crew - day-crew (8 hrs/day) composed of two qualified mechanics level 2 and one qualified electrician level 2. In charge of execution of all preventive work, inspection rounds and lubrication. This crew deals with the whole plant including the bottling section, but with the exception of utilities.

**BOTT:** permanent presence of one mechanic in two shifts for corrective maintenance, lubrication and cleaning.

**WS:** the workshop has one lathe and milling-machine operator and one specialized welder (for stainless steel welding).

**ST:** The store has one store-keeper in two shifts - during the night and at weekends the store can be opened by one of the qualified workers on shift - store-keepers are in charge of supplying spare parts, cleaning, and keeping records (inventory).

**UTL:** Utilities are operated and maintained (preventive and corrective) by one qualified electro-mechanic level 3 in three shifts.

**b) Information flow**

A job request is issued for every job except work foreseen in the preventive maintenance and lubrication programme or emergency work. The job request is sent to the CMPO, which registers it. A short analysis is done: if the work is complex, a work-file is opened which contains the job request, drawings, schemes and any other instructions. This information will allow for job preparation. For a simple job or after preparation of a complex job, a job order is issued showing when the work can be carried out (all resources available).

The CMPO enters the work into the long-term plan (programming). On the basis of this, the CMPO transmits the work-file (complex work) or job order alone (simple work) at the right moment to the supervisor of interventions who plans the workload and distributes the work to the teams. Emergencies are communicated by phone to the supervisor who will issue a job order after the work has been done.

If the job cannot be done there are two possibilities: if the problem is temporary a job order is issued which then waits until all resources are available; if it is definitely not possible to do the work then everyone concerned must be informed.

A data-processing circuit for this exercise is shown below (job execution, figure A1). In this circuit the number of copies of each form is indicated. In order to guarantee good information flow to the maintenance manager, the foreman or workers complete a job report at the end of each shift.

A similar information flow is applicable to the scheduling of preventive maintenance. In this case, work originates in the preventive programme, which differentiates between work with a high frequency (periodicity less than 2 weeks) and work with a low frequency (periodicity
For high frequency work, the foreman will automatically include the high frequency jobs in the workload planning of the teams. The list of jobs and their periodicity is compiled only once by the CMPO (central maintenance planning office). Copies of the preventive maintenance cards which contain the work instructions and specifications are lodged with the foreman of the intervention section. For scheduling the jobs, the CMPO sends a job order to the foreman with a cumulative list of all relevant preventive maintenance cards/tasks. After the job has been done and inspected, the completed job order will follow the normal circuit described above.

Regarding low frequency work, the CMPO will make a job order in conformity with the preventive maintenance programme. The corresponding preventive maintenance cards will be added and a work-file containing all relevant information will be opened. The work is entered in the long-term programme. The file is transmitted to the foreman, who enters it in the workload planning. Execution and further data processing is carried out according to the circuit. After preventive maintenance has been carried out, the maintenance worker will make a job report. A data-processing circuit for preventive maintenance is presented below in figures A3 and A4.

Inspections are included in the foreman’s workload planning or are done by the preparator from the CMPO. An inspection report is made after each inspection. This report is a form which should already contain all the predetermined points in a checklist where the items have to be ticked.
Figure A1: Job execution
Figure A2: Preventive maintenance

Diagram showing the flow of information between different modules and sections:
- **PROGRAMME HIGH FREQ.**
- **PROGRAMME LOW FREQ.**
- **PROGRAMMING**
- **CMPO**
- **DISPATCH**
- **REGISTER**
- **ACCOUNT.**
- **WORKLOAD**
- **FOREMAN**
- **EXECUTION**
- **CONTROL**

The diagram illustrates the main circuit and feedback information paths between these modules.
Figure A3: Simplified circuit of job requests and job orders

- Origin of JR
- Programming Work Study Scheduling
- Dispatching of File
- Account
- Waiting File
- Foreman
- Breakdown/Phone
- Intervention Team
- End of Work

Circuit of JR, work file, programming, and JO before execution
Circuit of JR, work file, programming and JO after execution
Informations
Figure A4: Simplified data-processing circuit for spare parts
Module 21
Unit 4

ANNEX II

Answers to questions

1. A maintenance management plan should cover the following topics:
   - the hierarchical position of maintenance in the company organization chart;
   - the development of human resources in maintenance;
   - the introduction of an accounting system which details maintenance expenditure per cost centre and per machine;
   - the setting up of a separate maintenance budget;
   - the acquisition and renewal of equipment (choice of technology, definition of reliability and maintainability specifications in the design, terms of reference, participation of maintenance specialists during negotiations, introduction of the life-cycle cost approach, taking into account the indirect costs);
   - the structure of maintenance: centralized, decentralized or mixed;
   - computer-assisted maintenance (technical) and computerized maintenance management systems;
   - subcontracting of maintenance work;
   - the definition of a maintenance concept;
   - the relation with the QC department;
   - the safety of personnel and safety in general;
   - the protection of the environment.

2. An important part of the maintenance management plan is the definition of a maintenance concept, which in fact means choosing a maintenance form for each machine depending on company priorities in terms of safety, production, quality, cost and protection of the environment. The use of the following techniques can be considered:
   - Failure mode effects and criticality analysis (FMECA) which deals with the study of failure mechanisms of components. The effects of possible failures are analysed in relation to the function and performance of each component. They are divided into various categories: catastrophic, complete or partial loss of function, no effect. A criticality index for each failure mode is obtained by calculating the product of the following ratings:
     - probability of each failure mode occurring;
     - seriousness of the failure;
     - difficulty of detecting the failure in advance.
   - System-reliability analysis. This analysis is based on the FMECA for components and their influence on the system, and on maintainability considerations;
   - Fault tree analysis (FTA) is a risk analysis based on the study of failures or malfunctions which can lead to catastrophic failure. A risk of occurrence is given for each of these events which, through a fault tree, finally gives the catastrophic failure risk;
   - Hazard and operability study (HAZOP) is the study of possible failures and their effect on the operability of an item (component or system). This study is carried out during the design stage as well as continuously during operation;
   - ABC analysis (Pareto’s law): production machines and utilities are grouped in three classes depending on the importance of the effect of failures or malfunctions. The degree of importance is given by an enterprise-specific priority rate in relation to safety, production, quality and protection of the environment. Failures on 20 per cent of the machines will be responsible for about 80 per cent of critical effects.
A maintenance concept (policy) can be defined in terms of the proportions between the various maintenance forms (periodic, condition-based, corrective or design-out maintenance), which must be applied to each component or system.

Periodicities for components or sub-systems must then be grouped into packages. This will lead to maintenance programmes which should be linked to maintenance levels. For each level, the maintenance tasks can then be defined in order to assess the necessary human and material resources.

Regular evaluation must be carried out of implementation of the maintenance concept and the effect on equipment. This will allow a tuning of the maintenance programme and feedback of information.

3. At plant level, the following actions for improvement are recommended:

a) Short term
- centralize all technical documentation in one area of the plant;
- codify and classify the documentation, create a system for updating and dispatching;
- specify priority machines with a high risk of production bottlenecks and make up detailed machine files for them;
- establish standard terms of reference for technical documentation which must be imposed on equipment suppliers.

b) Medium and long term
- train personnel in the preparation of machine files and in the administration of technical documentation;
- gradually complete the technical documentation for machines other than priority ones, according to their importance for safety, reliability and production;
- assemble workshop drawings for the manufacture of spare parts, in particular, from manufacturers that are no longer making the parts.
BIBLIOGRAPHY


ILO: *Upgrading of maintenance and repair personnel* (Geneva, 1970)


Sakakibara, S.: *Application of modern production management technique to maintenance from the developing countries' point of view* (UNIDO, 1973).

Takahashi, Y.: *Practical aspects of application of modern production management techniques to maintenance* (UNIDO, 1973).


MODULE 22
INFORMATION MANAGEMENT
MODULE 22:  LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Understand the role of information in the total business system and recognize the importance of well-managed information technology (IT) for the survival and prosperity of your organization.

2. Appreciate the structure, controls and organizational relationships of modern management information systems (MIS); and understand how IT systems can help to improve information timeliness, quality and accessibility.

3. Grasp the importance of management responsibility for the successful application of IT in the improvement of your organization’s performance.

4. Use a series of IT tools and checklists to improve the productivity of yourself, your department and your organization.

MODULE 22:  CONTENTS

UNIT 1:   Information and business

UNIT 2:   Information in management

UNIT 3:   Making management information systems (MIS) effective

UNIT 4:   MIS installation and maintenance

UNIT 5:   The human factor

UNIT 6:   Summary and review

Bibliography
UNIT 1: INFORMATION AND BUSINESS

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and explain the difference between effectiveness and efficiency as applied to IT in running a business.

2. Know the potential and importance of IT in an organization's strategy.

3. Define the meaning of information and MIS.

4. Define the elements of an organization's information cycle and explain how information is transformed into corporate intelligence and memory.

UNIT 1: CONTENTS

1.1 The strategic role of information technology (IT)

1.2 Information: The lifeblood of business
UNIT 1: INFORMATION AND BUSINESS

1.1 The strategic role of information technology (IT)

1.1.1 Effectiveness versus efficiency

There is a fundamental need for all managers to recognize that efficiency - "doing things right" - can be very different from effectiveness - "doing the right things". The trend towards decentralization of authority and, at the same time, the proliferation of personal computers and software packages has resulted in islands of productivity where each department or individual manager has improved productivity in isolation from others in the organization. All are doing things right; but in the absence of an overall IT strategy, who knows whether they are doing the right things?

Let us look at an example from the area of financial services related by Peter Keen in Shaping the future (Keen, 1991).

Company A

The head of one of America’s top ten insurance companies stated in 1989 that his business strategy was to “make sure the basics are not neglected - underwriting, investment, pricing, costs”. He saw IT as part of the responsibilities of the heads of individual lines of business and saw no need to articulate a statement of direction.

Business units in that company varied widely in their use of IT systems, none of which could share information with other units. They used different hardware and software and, at one time, had 30 separate telecommunications networks in use.

The company ran into serious trouble when it failed to match its competitors in cross-selling products, reducing transaction costs and providing an efficient and timely service. The company hired a top-class IT specialist who immediately declared a state of emergency and announced that unless the firm developed a corporate strategy and architecture it should forget about competitive advantage for at least the next five years.

Company B

At the same time the chief executive officer of one of the company’s competitors visualized his organization as “the easiest in the industry to do business with”. He has become a leader, using IT to reduce costs, speed up transactions and improve quality and responsiveness to customer needs. Proposals in this company for any IT investment must be made in terms of business logic and its contribution to the vision (doing the right things!).

The case of the first company is not unusual. Unfortunately such stories can be told in all industries - no doubt within your own experience or that of your fellow participants in this
module.

So let us establish from the start that we are not only looking at how IT can enhance your personal or departmental productivity.

We are also looking at the tremendous strategic impact it can make on your whole organization - on its survival and its competitive strength.

So improving productivity through MIS starts at the top. Your chief executive’s vision should recognize the impact that IT could have on the long-term shape of the organization. The critical success factors (CSFs) for achieving that vision could well include major investments in IT systems.

The competencies needed to give the organization competitive advantage in the future will certainly, in some way, involve changes in the management of information, and improve its quality, timeliness and effectiveness.

---

**Checklist 1 - Strategy**

When you return to work, use this checklist to reinforce your learning and to start applying it to your own work.

1. Vision
   - What is your organization’s vision statement?
   - What critical success factors will enable that vision to be achieved?

2. Competitive strategy
   - With the above in mind, what organizational capabilities are essential:
     - for survival?
     - for competitive advantage?

3. MIS implications
   - How has your corporate strategy been interpreted into an information systems strategy?
   - What are the strategic implications for your department?

---

1.2 Information: The lifeblood of business

1.2.1 The person from Del Monte

In May 1990 Del Monte Foods, through a £290 million management buy-out, acquired from its previous parent, Reynolds/Nabisco, total responsibility for business operations and financial success. One of the new management’s first decisions was to sharpen focus on management information, i.e. sales forecasts, cash flow projections, inventory, productivity and treasury management.
As a result, the next two years saw a complete transformation of the company’s information systems. “We had outgrown the hardware and needed to bring our software up to date,” said Del Monte’s MIS Director. “Our information systems need to be the best to help maintain our market leadership.”

### 1.2.2 Anatomy of an organization

Information is the lifeblood of your organization. Without information the board (the corporate brain) cannot make key decisions. Without information, purchasing, personnel and finance (mouth, heart, lungs?) cannot get the resources needed to sustain the life of the organization. (Without information the corporate body is a blundering, mindless, directionless zombie.) So let us look at the structure and (increasingly) the dynamics of information in the organization.

**Definitions**

An important distinction needs to be made between data and information. Data may be looked upon as a raw, random collection of individual facts. Nowadays, data are recorded on a variety of media, including paper and film as well as magnetic and optical disks. The data recorded may take any audiovisual forms, including text, pictures (both still and moving) and sound.

It is only when relevant data have been selected, organized and suitably summarized that information is obtained. Management information is a collection of facts that can be useful in the management of an enterprise. The term management information systems (MIS) is commonly used to refer to a procedure for data gathering, storage, manipulation and production of management information.

Information technology (IT) is a catch-all phrase signifying the application of technology (computers and telecommunications) to MIS problems. In a modern enterprise, timely and accurate information is vital for effective decision-making and management of resources. Management involvement is then essential for the effective exploitation of information potential, converting information into “know-how”.

**The information cycle**

The vast majority of information flows are the result of the ongoing planning and reporting system of an enterprise. Management establishes periodic (typically annual, broken down by month) plans for the coming period. Such plans are often highly industry-specific (number of refrigerators to be manufactured, life insurance policies to be sold, fee amounts to be generated, etc.), and key aspects can generally be expressed in financial terms in the form of budgets. Budgets may be aggregated into financial statements (balance sheet, profit and loss, cash flow) to provide a composite financial plan.

The results of operations are then fed back, summarized as required, and measured against the plan. Industry-specific manufacturing, sales, etc., reports are generated, together with the corresponding financial statements. Based on actual as against planned performance,
management is in a position to take whatever corrective action is deemed necessary to meet organizational objectives.

In addition to the routine information which should be available to management, provision should also be made for exception reporting to address such events as customer enquiries, inventory out-of-stock conditions, tracing of individual account balances, etc. In fact, a number of routine management decisions can be relegated to the computer. Examples include the automatic issue of purchase orders for inventory (based on a comparison between quantity on hand and a pre-set reorder point) and follow-up letters to delinquent debtors (based on a comparison between account balance and credit limit).

In situations where management lacks access to accurate and timely information, inventory shortages/overages, lack of follow-up on overdue customer invoices, poor sales performance, increasing number of debtors etc., may occur.

Although we have emphasized, so far, the strategic aspects of MIS, we must acknowledge here that many organizational failures - especially in small and medium-sized enterprises - are the result of failures of the information system at operation level: failure to recognize falling sales; failure to spot escalating costs; and/or failure to anticipate the haemorrhage of cash from the business.

Every manager should be aware of the CSFs of the enterprise (e.g. cash flow) and ensure that high-quality, timely information is generated for the management of those CSFs.

*Corporate intelligence*

Nevertheless, this information cycle, whilst keeping the business alive, contributes little to its competitiveness and growth.

Overlaying the routine reporting systems must be the management information needed by key people - both inside and outside the enterprise - to assist them in making effective business decisions. A review of corporate information starts therefore with a definition of the company's network of communication, the key "nodes" (departments and people), the flows of information between them and the methods used to convey the information.

These networks are rarely planned or maintained in an organized way. They usually just grow in a haphazard manner. One dramatic technique used by consultants to demonstrate such inefficiencies is to clear the wall of an office and display all documents and their tracks across the business. Resistance to their recommendations tends to melt away as soon as the "tangled knitting" is revealed.
The Executive Information System

Frustration with traditional reporting methods in the late 1980s set leading business executives on the quest for an effective method of getting at the essential facts of business life.

The Chairman of Rhone Poulenc UK was particularly keen on getting to the bottom of exceptions and variances in results. When management reports indicated an anomaly, it often proved impossible to unearth the explanation when it was urgently wanted.

The emergence of packaged Executive Information Systems (EIS) has now made it possible for top managers to discover the answers to many of their key questions for themselves, on the spot, through their own desktop computers.

Electronic reporting has replaced the conventional briefing book. With the exception of a single-sheet summary, directors review performance on a large-screen projection of tables and graphs covering the company's performance.

As an individual user, Rhone Poulenc's Chairman finds that EIS has provided a useful means to explore monthly results before meetings. He also generates his own charts and information for meetings with different groups, including union representatives.


Corporate memory

Del Monte needed, in the words of its MIS Director, a means to "remove data from individual applications and give us the flexibility to manage complex, multicompany, multicurrency information as a corporate resource". Information is a corporate resource. But all too often it is locked away in one department or, worse, in one individual. The organization must learn from its day-to-day transactions, from decisions that work (or don't), and from signals received from customers, suppliers and the business environment.

Every organization needs to store information on customers, suppliers, products, processes, etc., that is readily accessible to decision-makers. In most cases this is still primarily in the form of filing cabinets and record cards. Increasingly, but too slowly, it is being converted to electronic databases.
Module 22
Unit 1

Checklist 2 - Information

1. Information cycle
   - What information, from or to your department, is essential for the management of the organization’s CSFs?
   - What steps must you take to improve the quality (accuracy, timeliness and distribution) of that information?

2. Corporate intelligence
   - Draw up a network of information flows between your department and those with whom you exchange information.
   - Discuss with the key people at the “nodes” of the network how you can improve the quality of those information flows.

3. Corporate Memory
   - How satisfied are you that all key information generated in your department is available, in quality form, to others who need it?
   - How readily can you obtain information generated by other departments?
   - What must you do to improve your contribution to the organization’s database?

Questions for discussion

1. What is the difference between effectiveness and efficiency, between data and information? Provide linkages between these terms.
2. What is the relationship between information, IT and organizational strategy?
3. What are the results of ineffective information flows?
4. What is the difference between corporate intelligence and information?
UNIT 2: INFORMATION IN MANAGEMENT

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Describe the role and typical structure of an MIS department.
2. Explain the range of MIS applications and packages in common use in organizations.
3. Define the components of a modern computer system.
4. Understand the choices open to management in automating information systems.

UNIT 2: CONTENTS

2.1 Management information systems (MIS)
2.2 The MIS system in an enterprise
2.3 Automated information systems
UNIT 2: INFORMATION IN MANAGEMENT

2.1 Management information systems (MIS)

2.1.1 Definition

Management information systems (MIS) provide for the planning, control and feedback on the operations of an enterprise. In order to address the issue of complexity, MIS applications are typically split up into manageable logical modules whereby each module can be developed semi-autonomously before being integrated into a whole. Information timeliness, quality and availability aspects are addressed through computerization.

An apt analogy for an MIS is a production line for information which parallels, and acts in symbiosis with, the operations of the enterprise. Such a production line may be purely manual, as in clerical procedures, or automated through computerization. Today, the majority of MIS in technologically advanced countries depend on a blend of manual and mechanized procedures. Developing countries are now rapidly catching up with the use of computers, often leapfrogging to the latest and most effective technology without recourse to the costly intermediate steps already taken in more advanced regions of the world.

2.1.1 Role of the Management Information Systems Department

The MIS Department has three prime functions:

1. It supports the work of line and functional management with the relevant, timely and accurate information needed for the smooth operation of the enterprise and for quality decision-making.
2. It stimulates management’s awareness of the potential benefits of new technologies.
3. It guards the enterprise against unwise investments.

These are the pressing demands of keeping the system running against those of developing new systems. And there is often conflict between those who believe that MIS is a necessary (and costly) evil and those who believe it is the cure for all the organization’s problems.

One thing is certain: it is essential that the head of MIS is involved at the strategic level, translating the vision into a viable and cost-effective information systems platform and, at the same time, ensuring that top management is aware of the potential competitive advantage of new developments.

2.1.3 Staffing and operations

Today’s systems are designed to be operated by regular office staff having some typing skills. Such personnel utilize computer terminals as a natural extension of their jobs. Specialist support is, however, required for development and customizing tasks as well as to provide the
necessary training to help to ensure the optimal use of technology. This role can be contracted out or managed entirely in-house.

In enterprises where specialist support is contracted out, in-house MIS staffing can be restricted to a coordinating function with a minimum complement of two people, for back-up purposes. The coordinator would provide routine training to users, carry out regular housekeeping chores, including daily and periodic file back-up, and liaise with outside suppliers of hardware, software, applications and maintenance. Depending on the workload, this function might be carried out on a part-time basis.

At the other extreme, a major enterprise such as a bank with an extensive branch network and heavily dependent on computerization would tend to have a large MIS department which could run to hundreds of people.

Overseeing IT

American Express uses a small core group to follow IT activities at its subordinate companies. The aim of this group is to achieve synergy and economies of scale while allowing operating companies to remain decentralized. Advanced competitive develops include the use of image processing and voice systems for the company's travel business, laser printing and consolidated statements for financial services subsidiaries, and expert systems for credit and charge authorization.


The scope of work of MIS departments falls under the distinct headings of Development, a creative activity, and Operations, a routine production-oriented exercise. A fairly typical organizational structure for an in-house MIS department might have the following functions reporting to the head of MIS:

- **Development**, for MIS strategic planning, systems analysis, design and programming (including prototyping);
- **Database administration** (may also be included under Development), to specify which data are to be captured, how they are to be stored and how access privileges are to be organized;
- **Technology research** (may also be included under Development), for evaluating hardware, software and applications available in the market place and helping to ensure that the most appropriate technology (from a cost/benefit viewpoint) is selected for implementation;
- **Training and implementation** (may also be included under Development), to conduct user training in systems operation and to provide users with implementation assistance for new applications;
- **Operations** for routine operation of the computer facility;
- **Software engineering** (may also be included under Operations), for software selection, implementation and trouble-shooting with the objective of helping to ensure the efficiency and reliability of computer operations;
- **Telecommunications** (may also be included under Operations), to help to ensure the adequacy and cost effectiveness of data communications; and
- **Input/output control** (may also be included under Operations), to conduct quality control...
over the completeness and accuracy of input data, computer processing and reporting as well as to distribute and archive computer reports.

Other functions which may be found in a given MIS organization include Change control (to help to ensure that only authorized changes are made to production systems), an Information centre (to provide training and service to help users to exploit the information resource better), etc.

Checklist 3 - The MIS Department

1. Strategy
   - Arrange a meeting with the head of your MIS Department and explore how the organization's vision and strategic plan have been translated into an appropriate information systems platform (is MIS a cost or a strategic investment?).

2. Functions
   - Spend some time in the department - with the approval of the department head - observing how it:
     - supports the information needs of the business;
     - brings new technological opportunities to the attention of top management; and
     - guards against unwise investments.

3. Roles
   - Get to know the key people in the MIS Department and discuss with them how your department can benefit from closer liaison.

2.2 The MIS system in an enterprise

An MIS system in an enterprise is typically composed of a combination of manual and mechanized applications. Computerized applications may be derived from packages as well as from custom development. MIS implementation tends to be an ongoing endeavor to catch up with the evolving needs of the enterprise.

(a) Manual procedures
   Even in highly automated systems such as banking, with its Automated Teller Machines (ATMs), manual procedures are still required to complement mechanized applications. In this instance, manual cash replenishment procedures are needed to maintain adequate financial controls. Manual procedures should be closely coordinated with the organization structure and job descriptions. The overall controls over system integrity, covering input - processing - output, should be manual.

(b) Packaged applications
   Packaged computer applications are developed for sale to many users. Since the development costs of a sound application with wide appeal tend to be high, ranging from tens of
thousands to millions of US dollars, it makes sense to spread those costs over numerous users. Users benefit by avoiding the delays, risks and costs associated with re-inventing the wheel. Some of the pitfalls experienced are that the package is not fully proven, that it does not satisfy requirements or that it is too complex to be successfully operated by user personnel.

Package developers have come a long way since their first primitive offerings. Today's packages are professionally documented and come with interactive tutorials and exercises. They are flexible and have tailoring options allowing them to be readily customized for a good fit to individual user requirements. In cases where the fit is just not good enough, a custom application should be developed. In many cases, an enterprise will use a selection of packages from the classifications discussed below.

**Horizontal - Multipurpose.** This class of application package is designed to satisfy users irrespective of the industry or the type of work performed. Examples include word processing, spreadsheets, project planning and personal/group aids.

**Horizontal - Accounting.** By its nature, whereby the results of operations are expressed in purely financial terms, general accounting tends to be independent of the enterprise type. Because the applications satisfy many different classes of enterprise, they are termed horizontal. Applications under this heading include accounts receivable, accounts payable, fixed assets, general ledger and financial statements.

**Vertical - Business.** Vertical business packages are designed to appeal to specific classes of enterprise. There is some overlap here with horizontal applications as well, although there is an ongoing effort to refine enterprise classes, through further subdivision, in order to obtain a better fit to user requirements. The more successful user of such a package would be a small business with no preconceived ideas as to operating procedures or MIS requirements. Typical applications in this category include sales order-entry/invoicing, purchasing, inventory control and management reporting. Vertical markets such as distributors of motor vehicle parts, clothing suppliers, videotape rental shops, etc., would have an appropriate version of the required applications, suitable for their business, available to them.

**Vertical - Manufacturing.** Manufacturing enterprises have MIS needs over and above those pertaining to trading and service organizations. Their requirements will run to parts/raw materials inventory control, bill of materials processing, materials requirements planning, production loading/scheduling and production costing.

**Vertical - Other.** A vertical business package will sometimes provide a complete and fully integrated solution for an enterprise type. Many such packages already exist and new ones are becoming available all the time. Examples of vertical market services in this manner include banks, department stores, hotels, hospitals and law firms.
Improved management information

When Woolworths in the United Kingdom appointed a new Store Operation Director, he needed improved information on retail performance across 1,000 stores and information to keep the management team able to address exceptions and issues emerging in the weekly performance of stores while something could still be done about them. Exploiting the availability of retail Executive Information System (EIS) tools, he directed the rapid implementation of a computerized management information system for himself and his senior managers. The rapid availability of trend and exceptional information to the entire retail management helped the fast and open identification and resolution of management issues. The EIS was supportive in cementing the working relationships of the senior management group, providing open and relevant information and leading the group through the priority issues.

Source: PA Consulting Group (London), promotional material.

(c) Custom applications

In cases where a package application is not appropriate, a custom applications approach should be developed. Users should be aware of the inherent cost, risk and elapsed time implications, which are often badly underestimated. These aspects are aggravated by a shortage of skilled personnel who are competent in the development of quality applications. Costs are mainly those associated with the skilled manpower required for the development effort. A substantial cost contribution can also come from the computer resources necessary for programming and testing. Such costs would be dependent on the class of machine (mainframe, mini or micro) called for in the development process.

The risks lie in the probability of exceeding time and cost budgets and the possibility that the project will end in failure. Failure in this instance implies a less than satisfactory system or, in the worst case, a system that cannot be implemented and must be scrapped. Elapsed time for development can be measured in months or years before the new system can be satisfactorily implemented. This timeframe may be unacceptably long in view of business needs. Application development may be carried out in-house or contracted out to a reputable software house. Cost, risk and elapsed time can often be better controlled by contracting out, particularly where the enterprise does not already have the necessary skills available in-house.

2.3 Automated information systems

From the invention of the hammer and chisel (information-recording instruments) and jungle drums (telecommunications equipment), the human race has had IT tools at its disposal. However, it was only some 150 years after the start of the Industrial Revolution that the "Information Revolution" was truly launched with the first commercial computer installation (Univac 1 at General Electric's Appliance Park, in Louisville, Kentucky, United States) in 1954.
2.3.1 Definitions

Since that time, the world has seen rapid and enormous strides in the development of computer hardware (the physical machine and associated peripherals), system software (computer housekeeping programmes which provide the hardware with unique operating characteristics and man/machine interface) and applications software (suites of computer programmes designed to address specific end-user requirements) as well as the link-up with telecommunications technology for the rapid dissemination and networking (sharing) of data and information.

Function

The function of IT can be summed up in the phrase

\[ \text{INPUT} - \text{PROCESSING} - \text{OUTPUT}. \]

Input of data is effected primarily through a keyboard connected to a visual display unit (VDU) for ready person/machine interaction. In future, as the technology is perfected, a major movement towards voice and handwriting recognition can be anticipated as well.

Processing of data is carried out to verify, sequence, summarize and carry out logical and mathematical operations on the data according to predefined instructions. This tends to be the most complex and time-consuming area in applications development.

Output is the information produced from the data, typically in the form of a printed report or on a visual display.

2.3.2 Components of a modern computer system

A computer system is composed of hardware, software and utilities.

Hardware

The hardware is physically tangible and includes processors, visual display devices, disks, printers, etc. There are significant overlaps between the various categories of computer which may best be defined as follows:

- **Mainframe.** A computer big enough to fill a sizeable room, used for processing high volumes of data (e.g. payroll) or supporting the total information system of an enterprise.
- **Minicomputer.** A computer the size of an office desk, used for significant departmental processing (e.g. a booking system) or supporting a local network of workstations.
- **Microcomputer.** A computer that sits on top of an office desk, also known as a personal computer or workstation, used for individual tasks or as an extension of the above networks.

To the above could be added the category of Supercomputer, a very fast machine used in scientific applications requiring extensive number-crunching support.

A typical single-user computer hardware configuration (personal computer) might consist...
of the following interconnected components:

- a box containing the central processing unit (CPU), memory and disk drives;
- a printer; and
- a user terminal composed of a visual display device similar to a TV screen with a typewriter-like keyboard.

Such a system is now available in various versions including desktop, laptop and notebook. The latter configurations tend to sacrifice screen legibility and keyboard size for portability.

A multi-user system would involve a number of user terminals sharing the same logical computer system. Such a system may be configured through the simultaneous sharing of a single computer by multiple terminals, a network of single-user computers, or a blend of the two. Following on the popularity of low-cost personal computers, as well as for compelling technological reasons, there is an increasing trend towards the network approach.

Computer operating and applications processes are registered on hardware memory devices rather like the sound and images on a videocassette tape. A fine line can sometimes be drawn between hardware and software because, when the software is permanently registered on a hardware component, such as a ROM (Read-Only Memory) chip, the combination is considered to be a hardware device.

Software

Software is composed of the operating system and utilities with a user interface which give the computer a specific identity or personality vis-à-vis the user and the applications which are tools necessary to satisfy user requirements and might include word processing, spreadsheet, sales and accounting packages.

Utilities

Utilities are additional programmes which support the main programme. These utilities fall into a number of different categories, as follows:

- system utilities: programmes which support the computer itself, for example the Diskpark utility, which parks the hard disk head for transportation purposes; the Viruscheck utility which checks the computer for viruses: it ensures that the computer is “clean” but has no other purposes; and the Powerman power management programmes for laptop computers which manage the power supplies to conserve energy.

Utilities are not part of the main programme but add facility. Most programmes today have built-in utilities;

- word processing packages have spelling checkers, grammar checkers, thesaurus programmes, etc.;
- spreadsheet packages such as LOTUS offer data import utilities, i.e. programmes which convert data in one format to the LOTUS format and vice versa;
- data management programmes such as MPRO offer notebook utilities which allow users to make notes in the database. And so on...
All programmes which add facility to mainstream programmes are referred to as utilities.

2.3.3 Current trends

Current trends are towards increasing sophistication and complexity in IT with a bewildering array of choices. There is a significant emphasis by developers on cosmetics and the machine interface in order to make interaction as simple and natural as possible. Graphic user interface (GUI) software, pictures and sound are rapidly encroaching on traditional character-based computing.

Users are no longer satisfied with running one application at a time but insist on multitasking, with a rapid switching capability between applications in progress. These evolutionary trends lead to increased overheads as regards processing speed, memory and disk storage requirements (in many cases unnecessary and underutilized). In many cases it is vital that current information can be shared, leading to the need for multi-user capabilities which can be implemented on single or networked computers.

Computer systems versus systems of computers. An ongoing technical debate pits computer systems against systems of computers, with a steady trend towards the latter. A single physical computer has limits as to its power and the number of users it can satisfy. Stand-alone personal computers are not the answer because information often needs to be shared. Imagine the confusion if airline reservations were to be made without regard to a common seat inventory! The answer is to spread the work among many interconnected machines in the same way as an organization structure serves to coordinate the work of numerous employees.

The development of special-purpose languages such as SQL (Structured Query Language) have opened the door to splitting applications along client/server lines, whereby the client machine supports the users and their applications and the server satisfies database storage and retrieval requests.

Vested interests, technical complexity and a veritable “Tower of Babel” as regards user options are retarding progress in the area of distributed systems. Large multi-user computers (“mainframes”) cast in the traditional mould of “one company - one computer” are high-profit boutique items. Personal computers (“microcomputers”), the building blocks of many networks, are low-profit commodity articles. Microcomputers lie somewhere between the two as regards computing power and profitability. Guess which way your average computer salesman, with his vested interest in maximizing sales and profit, will try to steer your organization! His dream will come true when you place the biggest order possible to satisfy your needs - a selection from each of his de facto categories, including mainframes, minis and micros. The low-cost approach, when this is feasible, may well be a configuration made up solely of personal computers.

Current trends favour the “systems of computers” over the “computer systems” paradigm. So far, this discussion has looked on a physical computer as electronics contained in a box. In fact, the box includes multiple computer processors assigned to different tasks. One computer processor (with or without an optical arithmetic co-processor to speed up mathematical computations) is assigned to the operating system and user applications while others carry out more
mundane activities such as disk input/output, visual display screen processing, etc. The overall effect is to enhance performance.

Transputers, or parallel computers, are a new development whose objective is to increase performance by splitting up applications processing among many processors. This has resulted in dramatic throughput increases for those applications, principally in the scientific area, which lend themselves to this approach.

**Standardization and open systems.** Standardization issues are becoming increasingly important as a means of focusing ongoing development efforts and reducing the learning curves inherent in moving between different hardware, software and applications products.

Open systems are based on software products which are transportable between the processing hardware of different computer manufacturers. Offerings in this category include operating systems, programming languages, database servers and telecommunications protocols. This encourages price competition among vendors, since their product’s performance with open systems offerings may be readily compared, and helps users to avoid being trapped with any given supplier.

Perhaps the best example of an open system is “C”, which was originally developed at Bell Labs to write the Unix operating system. Both C and Unix have since evolved from a research-oriented academic environment to widespread acceptance by the business and scientific communities. They have been introduced to numerous hardware platforms, ranging from the personal computer to the largest mainframe.

**RISC versus CISC.** By the early 1980s, computer scientists had discovered that the bulk of instructions executed amounted to some 30 per cent of those available in general purpose CISC (Complex Instruction Set Computer) hardware. By reducing the number of hardware instructions, speed of execution may be increased, thereby leading to the development of RISC (Reduced Instruction Set Computer) technology.

Personal computers, which fall into the CISC camp, are being increasingly challenged by the most powerful RISC technology. Personal RISC computers are now known as workstations to differentiate them from IBM-compatible personal computers. RISC technology is also beginning to make itself felt in the minicomputer mainframe categories.

**Pitfalls of computerization.** There are complex issues to be addressed in the development and implementation of effective and reliable MIS systems on computers, and there are numerous pitfalls to trap the unwary. Some of the more common pitfalls are listed below:

- management abdication whereby technical people are left to their own devices to address information needs;
- computerization of unproductive manual operations without first reviewing and improving these operations;
- inadequate planning;
- lack of necessary development/implementation skills to carry out the work satisfactorily;
- poor choice of hardware, software or applications in relation to requirements;
- use of unproven technology, leading to reliability problems;
- inadequate human or material resources to address MIS objectives;
- underestimation of resources required to meet MIS objectives;
- attempt to address too many MIS requirements simultaneously rather than in a logical priority sequence;
- MIS systems as implemented provide a poor fit to requirements;
- lack of integration and excessive manual intervention, leading to delays and the introduction of human error;
- unreliable operations, owing to inadequate testing;
- inadequate controls, leading to unreliable reporting and information;
- lack of adequate user training;
- excessive processing/response time from the MIS system;
- inadequate documentation for ongoing maintenance and operation; and
- excessive maintenance time/cost to correct flaws or to satisfy new requirements.

**Checklist 4 - MIS Systems**

1. **Systems**
   - What are the MIS applications which directly affect you and your department?
   
   - Looking at each one:
     - is it manual, packaged or custom built?
     - what are its strengths and weaknesses?
     - what would be the cost/benefit of improving it?

2. **Automation**
   - How “computer-aware” are you?

   - To what degree do limitations in your awareness affect your ability to:
     - maximize your use of current systems?
     - make a case for upgrading IT support for your department?
     - avoid the pitfalls?

   - What plans have you for bridging the knowledge gap?

**Questions for discussion**

1. What are the most important roles of an MIS department?
2. What are the common pitfalls which must be avoided in automating information systems?
3. What are the major conflicts between new MIS developers and those who prefer to run the old one?
4. What are the typical elements of an MIS department and their major tasks?
UNIT 3: MAKING MANAGEMENT INFORMATION SYSTEMS (MIS) EFFECTIVE

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Describe the main elements in the MIS productivity improvement process.
2. Understand the strategic way to improve IT effectiveness.
3. Explain the IT platform, the elements of reach and range.
4. Understand how IT policy can be developed.

UNIT 3: CONTENTS

3.1 Managing MIS productivity
3.2 Starting at the top: IT strategy
UNIT 3: MAKING MANAGEMENT INFORMATION SYSTEMS (MIS) EFFECTIVE

3.1 Managing MIS productivity

3.1.1 Investing is not enough

So information is the lifeblood of business, and investment in IT will ensure maximum productivity from your management information systems - right?

Wrong! A comprehensive analysis of American companies in 1988 by Paul Strassman showed that there is no correlation between IT investment and improvement in sales, profit or return on assets (see box). Other commentators claim that the only justification for IT spending is defensive - to keep up with your competitors.

The truth of the matter is that spending money on technology does not, in itself, create benefits. All investment must be wisely managed - and the history of IT is, unfortunately, littered with unwise management:

- in the 1970s, massive investments in number crunching but little decision support for line management; and
- in the 1980s, a proliferation of "islands of automation" and systems that do not communicate with each other.

Even today, the polarization of decision-making between technologists who do not understand business and business people who do not understand technology continues to jeopardize the effectiveness of IT investments.

So, unlike most modules in this programme, this is not a presentation of proven best practice: it is more a statement of unrealized potential and a plea that you, the manager of the future, will contribute to the fulfillment of what IT promises.
Technology and economic payback

Strassmann (1988) has provided the most comprehensive analysis of studies of the economic results of IT investments. Here is a summary of his findings:

- Industries that invested most heavily in IT have shown relatively poor productivity growth;
- There is no correlation between a firm’s return on assets or return on investment and its spending on IT;
- If anything, heavy computer users show a poorer, not stronger return on assets (ROA) than average;
- Study after study indicates firms’ lack of ability to measure the business value of IT and continued frustration in trying to do so;
- There are no proven cost/benefit techniques to assess IT;
- Comparisons of spending levels as a percentage of revenues or cost base are meaningless; firms within the same industry vary too widely in such areas as sales per employee, ROI, asset base, etc.;
- High or low IT expenditures give no indication of the effectiveness of spending; Methods available at present are inadequate to satisfy management needs; senior executives remain frustrated with the problem of assessing IT; and
- The most profitable consequences of IT investment appear to come from long-term restructuring and simplification of internal and external communications.

3.1.2 Productivity of information systems

Productivity, as you know, is a measure of output over input. It can be defined, for IT systems, in two ways:

- the degree to which IT assists you and your organization to increase the quality, volume and timeliness of your work; and
- the degree to which IT assists you and your organization to reduce the resources used in achieving your objectives.

Assessing the potential for improvement. This is a two-way process, business-driven and technology-driven.

Every manager has the responsibility of constantly seeking improvements to the way he or she works and of monitoring changes in the business environment that demand changes in work practices.

The MIS Department has the responsibility of bringing to the attention of the appropriate
managers any new opportunities to improve productivity that are afforded by technological advances.

**Enhancing Exec to IT Communication**

At General Motors in New York in the late 1980s, this was the job of the supervisor of computer graphics. When GM’s Treasurer at the time began to push for an Executive Information System that would give him quicker access to stock reports, currency exchange rates and other information, the supervisor responded.

The GM system that he helped to develop has grown to support 15 users, including two in Detroit, GM’s financial vice-president and its chief financial officer.

“The most important thing is to go to the man and ask him what he wants,” advises the supervisor. “Don’t keep giving him information you think he might want, just keep asking questions. That way he feels that it’s his system and he has some input.”

Source: Moad, 1988, p. 46.

This dialogue is crucial to the successful application of IT and we shall return to it again.

*Short/medium/long term?* Many expensive mistakes have been made by managers, under pressure to achieve short-term results, introducing hardware that is incompatible with that of other departments and systems that do not communicate.

As we discovered earlier, the biggest pay-off from IT is its long-term impact on the total business, through the planning and disciplined implementation of an integrated organizational system.

How can you do this? You can do it at three levels - by exerting whatever influence you have on top management to ensure that MIS systems match your strategy, by ensuring that you get maximum support from your MIS Department in improving the productivity of your department, and by making IT a way of life, maximizing the contribution that modern systems can make to your personal productivity.
Checklist 5 - Managing MIS productivity

1. **Matching systems to strategy**
   - Have you a clear picture of your organization’s overall strategy?
   - If not, how will you get it?
   - What is your IT strategy and policy for system development and enhancement?
   - Are you sure that your IT investments and projects match those strategies?

2. **Getting support from your MIS Department**
   - Do you know the people in your MIS Department, their roles and their capabilities?
   - Do you set prime time aside to develop good relationships with them?
   - When seeking their support, do you present well-prepared business cases in line with their strategies and policies?

3. **Making IT a way of life**
   - How good is your knowledge and confidence in using IT?
   - How proficient are you in using the keyboard?
   - What do you need to do to upgrade your knowledge and skills?

### 3.2 Starting at the top: IT strategy

#### 3.2.1 The management process

The management process for IT planning has three distinct levels:

- *awareness* of the business importance of IT;
- *a business* vision to drive its deployment; and
- a comprehensive integrated *IT platform*.

We have dealt with awareness and vision elsewhere. It is through the IT platform that the organization translates that vision into action.

*The IT platform.* The firm’s IT platform is a major determinant of its “business degrees of freedom” for the future, enabling or disabling future options on IT-related products or services. It is a shared information services delivery base, defined in two dimensions: “reach” (the locations linked by the platform, internally and externally); and “range” (the information shared across systems and services). Figure 22.1 illustrates how these dimensions enable strategic decisions to be made.
Standards - open or proprietary? Standards are the key to integration. The question of open versus proprietary standards is central to the evolution of the IT industry and its services to management. The goal of Open Systems Interconnection (OSI) is to provide an architecture which is to maximize “reach” and “range”. The world is moving slowly towards open systems, and the practical path to open systems is via IBM architecture - not necessarily IBM products but certainly those which are compatible with IBM.

IT policy. The role of senior management is not to make day-to-day decisions on IT investment. Having defined the platform, “reach” and “range” and standards, the Board should establish policies which make it possible to take day-to-day decisions that will fit the firm’s IT strategy. Here are examples of a set of policy criteria:

1. Business practicality. Our IT base must never block a practical and important business initiative;
2. Competitive lockout. If our competitors use IT as the base for a successful initiative, we must not be automatically locked out of countering or imitating it;
3. Electronic alliances. We will match the competition in being able to make alliances, value-added partnerships or enter consortia; and
4. Reorganization and acquisitions. If we reorganize, or make acquisitions or divestments, our IT systems will adapt quickly and routinely.

Having established these and other criteria, we have now put the ball firmly in the court of the MIS Department for effective implementation - always ensuring, of course, that line management is involved and informed.
Questions for discussion

1. Why is investing money in IT not sufficient to improve business effectiveness?
2. How can the productivity of MIS be assessed, and what are the most important “outputs” and “outcomes” of MIS?
3. How can IT policy be developed and why is the involvement of top management of critical importance?
UNIT 4: MIS INSTALLATION AND MAINTENANCE

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand and explain the MIS project management process and elements.
2. Describe stages of the system development life cycle (SDLC).
3. Know about MIS maintenance to maximize its utilization.

UNIT 4: CONTENTS

4.1 MIS project management
4.2 Systems development life cycle
4.3 System maintenance: day-to-day productivity
UNIT 4: MIS INSTALLATION AND MAINTENANCE

4.1 MIS project management

A typical functional organization structure for MIS projects, comprising of a steering committee and project team, is discussed below.

4.1.1 Steering committee for control and distribution

A management steering committee should be established to oversee the control and direction of MIS activities and projects. The committee should be chaired by a senior manager, preferably the chief executive officer, and be composed of a representative selection of management. The internal auditor should be a member to help to ensure that adequate controls on information are provided for, as well as to ensure that audit requirements are fully addressed. The composition of such a committee can vary. For instance, when the topic to be discussed is MIS priorities for the enterprise as a whole, there should be broad management representation. On the other hand, when the issue in question is sales reporting, the key participants should be from the sales and marketing departments.

The MIS manager/project manager should report to this committee on a functional basis and bring along such members of staff as are appropriate for a given meeting. The steering committee should agree on priorities, plans and related budgets for the information resource. Regular meetings should be held to review progress against plans, tackle problems and progressively examine, discuss and approve systems at their various stages of development in order to ensure that requirements are satisfied.

In addition to regular review meetings, special meetings may be held to review and approve, as appropriate, the satisfactory completion of milestones identified in the plan.

4.1.2 Project management and staffing

Although the enterprise may have a formal organizational structure in place for the MIS function, MIS development is best carried out on a project basis. At any given time, a number of MIS development projects may be under way, each with its own limited objectives and scope as well as the corresponding budget and schedule.

The project manager should be selected not only for his or her technical skills but for management ability as well. The project team should be composed of both MIS technical experts and user personnel who are familiar with their information requirements and can contribute their knowledge and efforts to the successful outcome of a given project.
Using a project management team

At the United States Printing Office in Washington, DC, an interdisciplinary team was set up to plan an information system when the public printer first said he wanted a system that would track the rapidly growing printing programme.

The Director of Information Resources formed a project team consisting of IS, finance and other professionals to draw up what it called a requirements document. According to the Director, there was “constant communication between IS and the project management team. We needed a group like the project management team because the systems analysts themselves don't have the experience to understand the many disciplines involved, such as financial management and materials management.”


4.1.3 Systems development life cycle (SDLC)

A systems development life cycle (SDLC) is one term used for an organized approach to systems development, implementation, operation and maintenance. Once the system becomes obsolescent and/or ongoing, maintenance/operating costs over a few years exceed the estimated capital cost of a new system, and the cycle starts again. The SDLC methodology will be described in more detail in the following section.

4.1.4 Project milestones

As with any project type, management attention in the SDLC should focus principally on project milestones. At each milestone, management needs to be assured that the underlying tasks have been satisfactorily completed before giving approval to proceed to the next phase.

4.1.5 Documentation and reporting

The evidence of accomplishment in the SDLC should be in written form. The documentation and reporting produced during the life of a project constitutes the principal foundation on which management judgements, conclusions and decisions should be based. At certain milestones, such evidence should be supplemented by demonstrations and user tests on computer. The purpose of good documentation is not only to afford a basis for quality assurance but also to provide for continuity in development and maintenance. Further, it can help to avoid the situation whereby the enterprise can become totally dependent on a given individual or group and lay itself open to blackmail.

Traditionally, documentation has been the weakest element in systems development projects, which is why management must be particularly alert to any shortcomings in this area. The reason for documentation deficiencies is that talented developers want to spend their time on creative endeavor and not on the drudgery (they believe) of putting the results of their
thought processes on paper. Actually, even a relatively small systems assignment tends to be of sufficient technical complexity to confound the human memory. Efforts are being made to automate the documentation process, notably through the development and application of CASE (computer-assisted systems engineering) tools. Current efforts focus on making it possible for CASE to generate application systems as well, a highly desirable progression!

4.2. Systems development life cycle (SDLC)

The importance of following a sound SDLC methodology should not be underrated. As an analogy, imagine constructing a tall building without using architectural drawings or following a construction plan. The results would be a disaster! Yet this is precisely the way in which many enterprises have approached the relatively new discipline of developing, implementing and operating MIS systems. The unsatisfactory results might not be so obvious with the MIS systems, which are intellectual products, as they would be with a physical building. Nevertheless, the negative impact of unsatisfactory MIS systems is substantial and can cripple the management potential of the enterprise.

An SDLC methodology is a guideline for systematically developing MIS systems. The guidelines described in this module have been refined through practical experience in numerous MIS development projects and can be broken down into the major phases of: strategic planning; feasibility study; vendor selection; development; system testing; user training; implementation; operation; and periodic review. The SDLC may be further modified and adapted to suit management preferences, project characteristics and the MIS personnel in the individual enterprise.

4.2.1 Strategic planning

The MIS strategic plan should dovetail with, and be a component of, the business plan of the enterprise, and all elements in the SDLC should be planned and implemented in line with MIS strategy.

The process of producing the plan is similar to that described below in the next subsection; but the “study” is of the total organization’s requirements, and the outcomes and action plan become part of the organization’s strategy.

4.2.2 Feasibility study

The major activities in the feasibility study are discussed below.

Terms of reference. Terms of reference (TOR) need to be developed, discussed and agreed with management prior to launching the study proper. They should address: project objectives and scope; the background and series of events leading to the request for the study; the study approach, communications and reporting relationships; a description of the workplan to be followed together with the related schedule; project staffing, including participation by a steering committee and user counterpart personnel; and an estimate of associated costs and out-of-pocket expenses.
Orientation. Following management approval to proceed, the study team members should be phased out of their commitments so that they are available for their scheduled participation. The project steering committee, composed of senior individuals with a direct interest in the area under study, should be established and a chairman appointed. The members of the committee should be briefed on their roles and functional responsibilities.

The TOR study should be reviewed and refined, as appropriate, by the team. Interview guidelines, fact-gathering checklists and questionnaires should be prepared as appropriate. Review meetings should be scheduled with the steering committee at fortnightly or monthly intervals and aligned with project milestones. Suitable support arrangements should be made for office space, computer facilities, typing, photocopying, etc. Personnel affected should be made aware of the study and the overall mandate. Brief site visits and introductory meetings should be held with user management and counterpart personnel to complete the team’s initial orientation to the project.

Survey system. The survey system is carried out through interviews and fact gathering. Topics covered should examine the present situation, from a systems viewpoint, together with the perceived problems and the interviewees’ suggestions for improvement. Copies of pertinent forms and reports should be gathered during the interview itself or arrangements made for subsequent pick-up/delivery. Interviews should be supplemented by physically following the existing systems and paper trails, where appropriate. A first-hand view can best be obtained by talking to the people involved at their workplaces and having them explain the existing manual/mechanized procedures using current examples from work in progress. In addition to taking notes, the interviewer should again gather representative samples of any pertinent forms and reports. Depending on study objectives and scope, the type of documentation to be gathered or reviewed includes historical financial statements; business plans and strategies; policy and procedure manuals; documentation on existing computer systems; organizational structure, job descriptions and staffing levels; original blank sets of forms handled and photocopies of selected completed specimens illustrating their usage; sample copies of reports produced; and pertinent correspondence and other files.

The TOR study should determine the focus of the fact-gathering process.

Analysis. The analytical process should be carried out in parallel with the review and completed during this activity. The information gathered should be classified by selection component, summarized, and key information flows documented. Estimated transaction volumes, file sizes and report printing requirements should be assessed. An analysis of strengths, weaknesses and opportunities for improvement should be carried out in each of the various MIS components. Existing manual processes should be critically reviewed. Possibilities for abolishing certain process steps need to be evaluated. MIS components should be based on best practice and not necessarily on the existing operating practices. The analysis should be the subject of a workshop presentation to members of the steering committee and other interested parties. The workshop should provide an opportunity for a full discussion with the objective of gaining a general group consensus on the present situation as it pertains to the MIS area under study. The results of the workshop review should be documented in memo form and circulated to the participants.

Definition of requirements. The opportunities for improvement identified in the previous activity should be developed into a set of MIS requirements that need to be satisfied. The
requirements should be placed in order of priority according to business needs and with due regard to a logical development sequence. The definition of requirements should be reviewed and agreed with the steering committee.

*Conceptual design.* A conceptual systems design should be developed to satisfy the definition of requirements. However, this activity may be bypassed if a package solution is anticipated. The design should include the following components: application relationships; database file structure showing the principal input transactions; data dictionary of fields to be recorded in the database and including name, description and other attributes; a cross-reference chart of files versus data elements; and a system flowchart and narrative for mechanized applications (this component may optionally be deferred to the detailed design step).

Various design methodologies may be used instead of, or in addition to, those illustrated here. The designer should feel free to use the tools with which he or she feels most comfortable, although a minimum set of standards should be adhered to in a given enterprise.

Increasingly sophisticated CASE (computer-assisted systems engineering) tools are becoming available to automate MIS design tasks. The more advanced methods are claimed to convert CASE design specifications to operational computer systems.

*Alternatives.* Numerous alternatives may be available to implement the systems concept, particularly as regards computerization. Typical alternatives to be considered, either alone or in combination, include centralized versus decentralized computing; class(es) of computer(s) to be used (mainframes, minis, micros); package or custom solution; operating system and language(s) to be used; in-house versus contract development; and data communications protocol(s) to be used.

The most promising alternatives should be identified and reviewed here in terms of advantages and disadvantages. The best combination, from a cost/benefit viewpoint, should be identified and justified in some detail.

*Cost/benefit considerations.* The costs of implementation and operation of a selected alternative should be estimated. The estimates should include a provision for cost overruns, typically 15-30 per cent. The corresponding tangible and intangible benefits of the new or revised MIS should be assessed. Where practicable, the benefits should be quantified in financial terms by user management. In some cases the requirements are of a "must have" nature and the quantified benefits tend to be immaterial.

*Conclusions and recommendations.* Based on the study findings, the study team’s conclusions and recommendations should be developed as to feasibility, scope and approach to the desired MIS. Where appropriate, a list of up to a dozen qualified vendors should be identified who could be approached for the supply of necessary hardware, software and services to support the recommendations.

*Action plan.* Assuming that the recommendations are to proceed with implementation, an action plan should be developed to carry out subsequent steps and activities. This plan should be based on subsequent SDLC guidelines covered in this module. The action plan should be refined and updated on a continuous basis throughout the life of the SDLC to reflect actual progress as
against current plans.

*Reporting.* The study findings, conclusions and recommendations should be outlined and presented verbally to the steering committee. Following a full discussion, the study results should be refined and summarized in a written report.

### 4.2.3 Vendor selection

Following management approval, this step in the SDLC is aimed at achieving maximum benefits from optimum investment in the selection of suppliers of hardware, software and other services as appropriate.

The benefits of a turnkey approach should not be overlooked. The guidelines that follow apply to both single and multiple purchases.

*Request for proposal.* A written request for proposal (RFP), based on the feasibility study document, should be prepared for major expenditures, covering the following points: scope and purpose; guidelines for submission; evaluation criteria; requirements; conceptual design; and the action plan.

Cost should be examined separately.

*Vendor briefings.* A conference should take place within a week of issuing the RFP to provide a verbal overview and respond to questions for clarification.

*Evaluation.* Proposals should be scored against evaluation criteria and the results charted by score against cost. Care should be taken to ensure that “apples are compared with apples”.

On the basis of these results, up to three vendors should be shortlisted for final evaluation and selection through detailed discussion of their proposals and negotiation of their offers and costs. An agreement is then concluded with the selected vendor.

### 4.2.4 Development

MIS development implies the production of written specifications covering all aspects of the MIS. Detailed systems specifications (systems definition) should include:

1. Computer applications
   - application relationships;
   - database file structure;
   - system flowchart;
   - menu content and structure;
   - video screen formats; and
   - printer layouts.
2. Operating instructions
   - schedules;
   - control procedures;
   - back-up and archiving.

3. Clerical procedures
   - flowcharts; and
   - layouts of forms and documents.

4.2.5 System testing

   The programme testing carried out during development is unlikely to lead to reliable application. System testing should therefore be carried out by users, assisted by the development team.

   Any problems should be corrected by the development team and the test run again until runs of both high-volume and low-volume test data yield flawless results.

4.2.6 User training

   Users should be trained on the operation and utilization of MIS applications through classroom instruction, supplemented by on-the-job pilot operation using small samples of regular transactions.

4.2.7 Implementation

   Pre-implementation activities may call for site preparation and equipment installation. Once the above steps have been satisfactorily completed, a parallel run should be undertaken with both sets of procedures - existing and new.

   This needs to be carefully planned to cope with a worst case scenario of 100 per cent increasing workload for a period of two or three months.

4.2.8 Ongoing operation and maintenance

   A well-conceived MIS should settle down to a smooth and reliable operation. Ongoing maintenance should then be required to correct any problems uncovered during operations, to introduce enhancements and develop updates in line with changing business needs.

   A formal request procedure should be put in place for scheduling and control of the maintenance function.
4.2.9 Periodic review

An independent review of the MIS should be carried out on an annual basis and, as requested, to determine the degree to which the system is satisfying its objectives.

The review should determine whether any corrective action is a maintenance matter and one requiring a fresh SDLC cycle; for capital budgeting purposes, MIS investments should be deemed to have a life of three to five years.

Checklist 6: Systems development

1. Defining the need
   - What is your organization’s approach to the assessment and upgrading of its existing systems?
   - How often is there a full-scale appraisal of your MIS systems?

2. An organized approach
   - When a major review is undertaken, what is the process of analysis, selection and implementation?
   - How does this compare with the SDLC model described in section 4.2?

3. In retrospect
   - What are the strengths and weaknesses of recent MIS system changes in your organization?
   - What has been learned by senior management, implementers and users?

4.3 System maintenance: Day-to-day productivity

Another reason why the size of investment in IT fails to correlate with higher productivity is that big spenders often become excited about the latest technology but neglect to maximize the effectiveness of existing systems.

Such investments are often technology-driven rather than business-driven and, of course, we need both. This is probably where you, personally, can make your greatest contribution. You are probably not a technical person, nor are you, yet, the chief executive.

4.3.1 You - The internal client

We hope that this module will enable you, more effectively, to behave as an “internal client” of your MIS department, ensuring that you have the best and most appropriate hardware available in the company; the software packages are the latest versions; and you and your staff are fully briefed on how to maximize the benefits of the system.
4.3.2 Maximizing utilization

Today's computers and telecommunications equipment are tremendously powerful machines with extensive ranges of capability and prodigious memories. But that capability is rarely used. For example, are you using the potential of your word processing system to reduce filing of documents? Did you even realize you could do so? What percentage of the facilities on your digital telephone do you use? Have you set up so-called “macros” which allow you to display the most important forms, letters, etc., on your screen without having to generate this information over and over again? Have managers changed their working styles or do they still, for example, provide handwritten draft text to be typed by secretaries and changed over and over again (because it seems so much easier with word processing!)? Learn everything you can about the capability of your systems and ask yourself and your staff whether an operation could be more quickly, easily and reliably done on the system. If so, what has to be done to automate it?

4.3.3 Good housekeeping

This is a major responsibility of computer users and, if neglected, can cut productivity to shreds or worse, lose precious information vital to the survival of the firm. Most productivity improvements are the result of incremental, day-by-day actions. Good housekeeping means saving files, creating back-up records, getting rid of files no longer used, logging information for speedy retrieval, and so on. Ensure that you and your staff have regular coaching sessions on good housekeeping - little things mean a lot!
Module 22
Unit 4

Checklist 7: Day-to-day productivity

1. System assessment
   - Discuss, with other managers, the hardware and software they use:
     - Is it faster, more user friendly, more flexible than yours?
     - How do they get the best from it?

2. System capability
   - Are you aware of the full capability of your computers, telephones and networks? Calculate what percentage of their capability is used/not used.

3. Housekeeping
   - How satisfied are you that you and your staff use the system efficiently:
     - Filing and storing in a disciplined way?
     - Maximizing speed of retrieval?
     - Deleting out-of-date files?

4. Your role as internal client
   - Meet the staff of your MIS department and agree on a plan for:
     - Upgrading your department's system;
     - Regular briefings for your staff on maximizing the system's benefits and on good housekeeping.

Questions for discussion

1. What does MIS installation mean?
2. What are the main MIS project management elements?
3. What is the role of the SDLC?
4. What are the main components of MIS maintenance?
UNIT 5: THE HUMAN FACTOR

UNIT 5: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Understand the meaning of “human factors” applied to MIS.
2. Know how to deal with resistance to change.
3. Understand the role of education and training in MIS effectiveness.

UNIT 5: CONTENTS

5.1 The role of the human factor
5.2 Resistance to change
5.3 Invest in the culture change
5.4 Education and training
5.5 Build an MIS management partnership
UNIT 5: THE HUMAN FACTOR

5.1 The role of the human factor

"For you, management is the art of smoothly transferring the executives' ideas into the workers' hands" (Konosuke Matsushita). The human factor is regarded as the most serious obstacle to the full application of IT for the improvement of organizational performance. Both senior management decision-makers and systems suppliers have colluded in creating this situation.

Company decision-makers have put most of their energies into technical appraisal and selection, arranging for initial training and leaving line managers to handle the transition. Suppliers have played down the human elements involved in the change for fear of frightening the customer, recommended a modicum of training and quickly moved on to another hi-tech sale. As a result, companies have succeeded only in automating the status quo. They have failed to take full advantage of the new systems in creating new approaches to work and in developing a corporate culture that maximizes the commercial benefits.

Ask managers, in all but the smartest companies, if they make full use of a new digital telephone or a new office utilities system. You will certainly find that most of them use less than half of the facilities available.

5.2 Resistance to change

The inertia of people, when facing a change from comfortable and safe methods of working, is normal and understandable. But, when faced with change involving IT, organizations often behave like rabbits transfixed by snakes.

A case study by McCalman and Paton describes a high technology change programme at Digital's factory in Ayr, United Kingdom. Even here, in the heartland of IT, the project team encountered strong resistance: "Some people ... feel threatened, unsure and anxious about how they will be affected."

Some of the problems were personal: some people preferred traditional ways; it took time and effort to change established habits; and the change process exposed personal feelings and emotions.

Some of the problems were managerial: concepts had to be adapted to existing circumstances; the boundaries of the change were not clear; supervisory roles became ambiguous; and timing became a major issue.

A manager explained: "Things were a battle. You had this battle mentality. Whoever you worked with, you were in a battle with on some issues ... The reason is, the objective and the goal are not the same for individual groups. Really, the goals should be common, and the ownership should be common: the only way to do it is by teamwork."
5.3 Invest in the culture change

And there lies the problem - the reason that, so often, high investment in IT fails to bring a corresponding pay-off in productivity. Top management must take responsibility for that common ownership. The culture change necessary to maximize the benefits of IT needs as much investment in management time as the decisions on hardware and software. People are part of the system!

Aligning technical and social change

The critical importance of aligning technical and social systems with new technology is clearly in evidence in the automobile industry. Your US assembly plants were studied by Drafick and Womack of MIT Sloan School of Management in the late 1980s.

Our General Motors plant in Massachusetts typified plants in which neither new work practices nor new technologies were introduced. Another GM plant in Michigan was infused with US$650 million of advanced manufacturing technologies but did not undertake organizational change.

Two plants - the Californian plant of NUMMI (a GM/Toyota venture) and the Honda plant in Ohio - effected technology upgrades with very ambitious work reforms.

Analysis of productivity and quality in these plants led to startling conclusions. First, the performance of the GM plant with high technology but no work reform was not significantly better than that of the low tech plant. Advanced technology by itself clearly made little difference. Second, the NUMMI and Honda plants, with their moderate investments in technology but fundamentally reformed work organizations, dramatically outperformed GM’s high technology plant. Both required 45 per cent less time to assemble a car and produced 45 per cent fewer quality defects.


5.4 Education and training

A key enabler for this culture change is creating organizational know-how: not just training people to use machines but developing true awareness of the impact of IT on current activities - and also of the changes it will bring to those activities.

One of the greatest resistances to change is the fear of looking a fool, as can so often happen when we lack knowledge of new things. The speed of change is such that everyone in an organization will need to be constantly re-educated or face intellectual redundancy.

The experiences of leading American firms suggest that people need to spend 10 per cent of their time on education - half a day a week. In this respect organizations should select people for their “connectivity” (ability to understand computer terminology), “compatibility” (fitting into existing approaches) and “networking” (relationship-building capability); and maintain people with briefings on MIS issues and a continuous programme of IT education.
Against this background of education there will be times when new systems are introduced and specific training is organized. You should ensure that your own people:

- devote prime time to training on the system;
- take maximum advantage of the vendor’s need to ensure customer satisfaction with the installation by bombarding them with questions;
- are not satisfied with understanding “how to” but have hands-on experience until they “can do”;
- make sure that people will need and consequently use IT in their daily work; and
- repeat, refresh and reinforce until the new technologies become habitual.

5.5 Build an MIS/management partnership

“If only people who understand business and (those who understand) information technology thought alike, shared a common language and talked and worked together!” (Peter Keen).

We have talked a great deal about making MIS part of the organization’s strategy: but it is more important (because strategies change) to make it part of the organization’s culture. Like it or not, we have moved from the industrial age into the information age. MIS and IT can no longer be peripheral to the activities of a business: they must be at its heart!

This module is really about relationships and dialogue. Your organization has specialists who are experienced in handling the technical issues we have described. Your job is to be aware of the potential of MIS and to know enough about the technology to brief them and liaise with them. The checklists will, we hope, have stimulated the dialogue and enriched your relationships. We hope you will keep the dialogue going and build a relationship that will result in your organization and yourself developing maximum productivity from Management Information Systems.
Checklist 8 - The human factor

1. Resistance to change
   - How comfortable are you and your people with the use of IT?
   - What are the personal barriers to change?
   - What are the managerial barriers?

2. Education and training
   - What plans have you, and each member of your staff, to upgrade their IT awareness?
   - When you recruit staff, how careful are you to select people who will welcome IT change?
   - How thoroughly do you train your people when introducing new systems?

3. MIS/management partnership
   - How well do you play your part in the dialogue with the MIS department and other technical support people, such as suppliers?

4. Action
   - What are your plans for overcoming resistance to change in your department and for improving communication with the MIS department?

Questions for discussion

1. What kind of role do people play in MIS operations?
2. Why do people resist change in MIS? What are the best ways to overcome such resistance?
3. What are the relationships between cultural factors and MIS questions?
4. What kind of training is the most appropriate, and for whom, when using MIS?
UNIT 6: SUMMARY AND REVIEW

UNIT 6: LEARNING OBJECTIVES

Once you have learnt this unit, you will be able to:

1. Describe the module’s content and essence and the role of management training in MIS operations.

UNIT 6: CONTENTS

6.1 Summary and review
6.1 Summary and review

The term "management information systems" (MIS) refers to the overall manual procedures and computerized systems within an enterprise. There is an increasing trend towards the application of computers to MIS with the objective of improving information timeliness, quality and completeness.

Information Technology (IT) is evolving at an increasingly rapid rate and presents a bewildering array of choices in computer hardware, software, application packages and telecommunications products. Few enterprises have been successful in harnessing anything approaching the full potential of IT to satisfy evolving MIS needs because of complexity issues, shortage of skills and relationships between technologists and line managers. In addition, there are many pitfalls to trap the unwary when addressing their MIS goals.

The principal ingredients to the effective development of the information resource are a corporate vision, a team approach, sound project and maintenance methodology and careful attention to the human factor.

An MIS development team should possess appropriate skills and experience to address a given project phase. Management control should be exercised through a steering committee and there should be extensive user interaction to ensure a close fit to requirements.

The development methodology should recognize the need for continuous adaptation to changing enterprise directions as well as the necessity of periodic renewal. Just as an ageing car cannot be kept on the road for ever, so an MIS must be replaced periodically because of escalating maintenance costs, as well as to take advantage of new technology.

The most critical factor in improving the productivity of MIS is the establishment of a continuing dialogue and the building of close working relationships between line management and its technical advisers.

We hope that this module will play an important part in creating that dialogue and those relationships for you.
MODULE 23: LEARNING OBJECTIVES

Once you have learnt this module, you will be able to:

1. Apply the basic principles of productive office management (efficiency, effectiveness, mission orientation, span of control, skill levels, costs of quality).

2. Understand the link between productivity and quality in office work.

3. Carry out work distribution analysis to analyse productivity and quality improvements for both managerial and clerical tasks.

4. Use measures of effectiveness such as timeliness, quality and competitiveness.

5. Improve job allocations between office personnel.

MODULE 23: CONTENTS

UNIT 1: Introduction to office productivity
UNIT 2: Improving office productivity and quality
UNIT 3: Improving professional and managerial productivity
UNIT 4: Improving the productivity of clerical staff
Bibliography
UNIT 1: INTRODUCTION TO OFFICE PRODUCTIVITY

UNIT 1: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Understand the role of the office and the nature of its activities.
2. Distinguish between different types of office work.
3. Assess the main performance criteria for office work.
4. Understand the meaning of effectiveness and efficiency in the office context.

UNIT 1: CONTENTS

1.1 Some definitions: Office and office management
1.2 The principal roles and functions of a company office
1.3 Office workers and their activities
1.4 Performance criteria and assessment
UNIT 1: INTRODUCTION TO OFFICE PRODUCTIVITY

1.1 Some definitions: Office and office management

It is very important to begin by stressing that the office is not just a place; it is an activity with service and control functions. As a place, an office may be nothing more than a briefcase, or it may be in a multi-storey building. And the total number of office workers in the firm could range from 0 (in small firms where the owner combines office and production functions) up to 15,000 and more in large firms. With today’s office tools such as portable personal computers, facsimile machines, long-distance pagers, voice mail, electronic mail and telephones in cars and airplanes, “the office” can move with the individual to home, hotel or recreation sites.

Companies that view the desk as the primary workstation and the place to optimize work will probably lose out competitively to companies that encourage collaborative development of products or services by work groups in a conference room. The company more likely to succeed is the one which encourages its personnel to spend most of their time at the customer’s site rather than in their own office.

In a very broad sense office management could be defined as the direction of all phases of the business operation which rely upon data processing, communications, and organizational memory. It also includes office automation, mechanization, flow of work, design, layout, office equipment and facilities, personnel development and compensation. However, the primary mission of the office is to process information, that is to gather, analyse, decide upon, act upon and disseminate information.

The office provides managers with correctly interpreted information as a basis for their decisions, rather than guesses or opinions, and helps to communicate management decisions to employees, customers and suppliers.

Therefore the most important “products” of an office take the form of organized and often interpreted information presented in documents and reports generated by the office or received from outside sources such as customers, suppliers or banks.

1.2 The principal roles and functions of a company office

An office can play two different roles. They are:

An animating (contributory) role, as when its function is to:

- assist sub-units to regulate their activities in the light of external situation changes;
- receive information from internal sub-units as well as external units, and transmit decisions, views and comments;
- maintain records and other important historical information;
- provide professional services in ancillary activities - selecting and hiring, maintaining personnel records, providing legal advice, accounting, corresponding with external units, training, designing systems, and making facilities and resources available in time (materials,
transport, contractor services);
- follow up sub-units to see that they keep to schedule, and provide information on their ef-
fectiveness and productivity.

A vigilant (depressing role), as when its function is to:

- assist in maintaining discipline;
- see that employees adhere to rules and regulations;
- be responsible for budgetary control.

Thus, the main office functions are to assist in:

- decision making and such managerial functions as planning, organizing, coordinating, di-
recting, controlling, motivating, innovating and integrating;
- providing information and other services to company departments and units, customers, sup-
pliers, investors, employers and regulating authorities.

1.3 Office workers and their activities

The most common classification of office workers are as follows:

- managers
- professionals
- technicians/paraprofessionals
- sales staff
- secretaries
- clerks

Some organizations distinguish only between professional and general service staff. “Pro-
fessional” here refers to senior white-collar staff who may or may not have qualifications which provide them with a formal title such as engineer, accountant, or systems analyst.

An expression which has emerged recently is the term “knowledge workers”, which refers to senior office workers who are not clerical employees performing highly repetitive tasks. However, in today’s quality oriented firms, the lowest level employees (frequently clerks) are being “empowered” to make judgements in order to provide high quality services to customers and suppliers. Therefore, most office workers today are thought of as knowledge workers, even if they spend a high proportion of their time doing clerical work. However, we need to make some distinctions for the purpose of analysis and to recognize that not all workers in an office can perform all tasks efficiently or effectively.

Most clerical work is highly routine, quite discrete and perhaps subject to automation just as repetitive factory work was subject to routinization and mechanization. It is usually easy for tradi-
tional clerks or even supervisors of large numbers of clerks to divide their time between sepa-
rate activities, because up to 80 per cent of their job consists of performing the same discrete functions repeatedly.
At the other extreme, many managers perform only 20 per cent of their activities on a regular basis. The remainder have no pattern, are not necessarily predictable and approach an art rather than a science. Very little of this work is discrete.

The transition from routine, clerical activities to more creative, non-discrete roles is illustrated in figure 23.1.

**Figure 23.1: White-collar work activities**

The closer the office position moves to management, the more creativity is involved in the job, and the more interaction takes place with other functions, activities and positions.

As already mentioned, clerical workers spend about 80 per cent or more of their time performing routine tasks, while managers spend only about 20 per cent of time on routine activities and about 80 per cent on non-discrete, creative functions. At the same time, any manager has to spend some time on administrative activities. Incidentally, these could be delegated to lower paid personnel.
If senior knowledge workers and managers (who are also knowledge workers) are fully productive, they should produce savings on value added worth three to five times their cost. Therefore, any attempt to improve office productivity will require a clear definition of what is to be improved as well as simple ways of measuring the result if changes are made.

1.4 Performance criteria and assessment

Performance criteria for white-collar workers are very different from those used in manufacturing, because the most important output of office work is information. That is why the approach to evaluating office work should not be to measure the volume of documents prepared and/or processed: there is no direct correlation between the quantity of documentation and its usefulness. Often the more documents there are the more difficult it is to extract useful information from them. For this reason it is essential to start with the criteria of efficiency and effectiveness.

Efficiency (doing things right) means doing work at the lowest cost compatible with acceptable quality, measuring the ratio of the quantity of service provided to the cost. However, in services or white-collar work this concept does not determine the degree of satisfaction derived by users or clients or the extent to which the desired impact or goal is achieved.

Effectiveness measures show how well office workers are meeting their objectives and indicates whether the office is making optimum use of the resources available to achieve its goals. Thus, effectiveness (doing the right things) does not relate to minimum cost but to doing the work which will best serve the long-term interests of the organization.

For example, managers may work effectively without being efficient (they get the strategy right but waste paper and secretarial time) or they may be efficient without being effective (cutting clerical staff costs to the point where more valuable and expensive workers have to carry out routine clerical tasks). Effectiveness then encompasses both quantity and quality aspects of office services.

The principal differences between indicators of efficiency and effectiveness lie in measuring direct output (efficiency) and evaluating its consequences (effectiveness). It is useful to contrast them as being “inward” (efficiency) and “outward” (effectiveness) forms of measurement. Thus, productivity in office work could be defined as the efficiency with which resources are consumed in the effective delivery of office services. This definition is focused on inputs, outputs, outcomes and impacts.

This particularly concerns knowledge workers, who are not usually hired at the lowest market rate as machine operators. Some knowledge workers are expected to contribute three to five times their costs in savings or increased revenues. Knowledge workers can also improve product or service design, reduce risk and build positive relationships with customers or suppliers, thereby increasing the health of the enterprise. Knowledge workers are expected to add value to the enterprise and their value is considered in terms of a multiplier of their cost. In this regard, it is essential to have a good understanding of what constitutes knowledge worker effectiveness. Most measurement systems address efficiency (how many, how fast, how cheap) but ignore effectiveness (quality, usefulness, impact).
To design good measures for office work it is important to start with two basic questions:

- Are we providing the correct services to our client?
- Are we providing these services in the best possible way?

The measures used should provide answers to these questions. The examples below illustrate this principle.

<table>
<thead>
<tr>
<th>Traditional approach</th>
<th>Effectiveness approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Measures reflect activities</td>
<td>• Measures reflect services</td>
</tr>
<tr>
<td>• One or two measures used to assess a function</td>
<td>• A comprehensive group of measures used to describe all the work</td>
</tr>
<tr>
<td>• Measures established by management or outside consultants</td>
<td>• Measures established by employees jointly with specialists</td>
</tr>
<tr>
<td>• Measures established for individuals</td>
<td>• Measures established for work groups</td>
</tr>
<tr>
<td>• Measures used for controlling, monitoring</td>
<td>• Measures used for planning, coaching</td>
</tr>
</tbody>
</table>

Figure 23.2: Measurement systems
The manufacturing division of a large aeronautical firm decided that too many staff hours were wasted because of incomplete and late engineering drawings. This led to problems in other divisions: wrong parts were ordered, products failed during testing, and so on. The engineering design division examined its services and concluded that to improve effectiveness, it had to focus on the quality of drawings and responsiveness to requests from its customers (manufacturing group).

To track improvement efforts, the engineering division established the following ratios:

1. **Total specifications met per drawing**
   **Total specifications submitted per drawing**

2. **Number of drawing errors**
   **Total drawings completed**

3. **Number of drawings released on time**
   **Total number of drawings**

These ratios measure not only the output, but also the results.

Another example of the use of ratios is for the accounting group in a large financial service company. The group provides operating budget forecasts to management for planning and control activities with the objective of improving the timeliness and accuracy of their reports:

**Measures:**

1. **Measure user satisfaction with a questionnaire.**

2. **Forecast information actually used**
   **Total information in forecast**

3. **Critical tasks completed within agreed time frame**
   **Total of critical tasks completed**

4. **Total employee days in forecasting process**
   **Total employee days available**

5. **Total rewrites - avoidable rewrites**
   **Total rewrites**

Source: Salemme, 1987, p. 34.
These examples show that there could be many different ways to assess office work productivity; the design of the measures depends on the nature of the service and its impact. However, some common principles and ratios could be recommended to develop specific measures. The following formulae are simple and very practical.

**Impact achievement in non-financial terms**

\[
\text{Impact} = \frac{\text{Total cost of policy}}{\text{Economy}} \times \frac{\text{Efficiency}}{\text{Processing capability}} \times \frac{\text{Effectiveness}}{\text{Achieved impact}}
\]

**NB** Ratio 2 = Ration 3 x Ration 4 x Ration 5

Success in improving ratio 2 may come in the areas of "economy" (ratio 3), "efficiency" (ratio 4) or "effectiveness" (ratio 5). "Economy" in turn can be subdivided into "price" and "quantity" as in the diagram below.


There could be other approaches to assessing how effectively office workers are using their time. Two of them are worth mentioning here: Professional Productivity Analysis (PPA) developed by Epstein and Fass, and Structural Productivity Analysis System (SPANS) developed by KPMG Peat Marwick Consultancy (USA).

The PPA is especially useful in offices or departments with a concentrations of professional knowledge workers of largely the same type, or serving the same purposes (e.g. sales, engineering, social work, design, marketing, systems analysis, financial analysis and policy analysis). Managers can use a "self-analysis" version of this methodology to identify ways to improve their own value to the organization. The analysis focuses explicitly on improving the use of staff time to contribute to organizational goals, and by performing more high-skill, high-value work and less routine work.

SPANS allows the examination of work distribution across all departments. More detailed analysis of work distribution is unlikely to be necessary for clerical or technical staff. For
managers and supervisors the system includes an analysis of spans of control.

Both systems use an analytical technique known as work distribution analysis (WDA) to show how office workers use their time and assess whether their time allocation is optimal. Work distribution analysis involves defining the various types of work performed by people in a department and determining what percentage of their time is spent on each type of work. It is a simple and valuable quantitative tool for analysing office productivity and some aspects of quality, notably the cost of quality, which some estimate may be 40 per cent or more of total office costs.

WDA is purely a diagnostic tool. It does not solve productivity problems by itself. If you apply WDA to 100 per cent of an office’s activity, the analysis merely indicates which areas should be examined in more depth. As the primary diagnostic tool, WDA shows how other information should be introduced into the analysis, and which specific improvement approaches should be examined in greater detail. The other information to be used with WDA data will vary with each situation. It could include information on staffing, physical conditions, workload, technology, supervision or organization culture.

Unlike productivity assessment approaches used elsewhere, both these systems focus on the relative allocation of the time of managers and support staff, not on the output from their work. This has its advantages. It is relatively easy to measure time and draw sensible conclusions about whether it has been used on the “right” type of work. That does not, however, provide any information on how much work has actually been done, either during that time or overall. Nor does either system by itself provide information on the quality of the work done. Thus there is neither a measure of output quantity nor of output quality. If such information is required, further analyses need to be made.

Measurement of output can provide such data, but this may be unpopular with employees. It will also be more costly to do, is likely to vary more from one day to the next, and will provide little information on whether employees (particularly managers) are working effectively. By itself it may also provide less information on whether employees are allocating their time optimally, unless considerably more data processing is undertaken.

Managers and consultants aiming to introduce office productivity or quality analyses should therefore begin by asking themselves whether volume of output or the employees’ use of time is more relevant. However, neither the amount of output nor the relative time spent on it provide a very accurate indication of the value of the manager’s work, only of its cost. The cost of the time spent on making managerial and professional decisions is not difficult to calculate. The value of the decisions may not become apparent in many cases until long after the study has been concluded.

The complexity of the concept of productivity in office work reflects many accountability requirements: the demand for efficiency means measuring output and inputs: the demand for service quality means measuring office responsiveness to client needs; the demand for service effectiveness means measuring goals and achievements. This degree of complexity means that office productivity has to be measured by multiple (family) measures.
Module 23
Unit 1

Questions for discussion

1. What are the main roles and functions of the office?
2. As you consider different types of office worker, from clerk to manager, how does the nature of the work change?
3. What is the most common “product” in an office?
4. What is the difference between efficiency and effectiveness?
5. What are the consequences of professional knowledge workers spending time on work not requiring their professional judgement or skill?
UNIT 2: IMPROVING OFFICE PRODUCTIVITY AND QUALITY

UNIT 2: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Appreciate the role of a clear mission and objectives in better focusing office workers’ activities.

2. Estimate the potential of improving organization structures and processes for increasing productivity and quality.

3. Understand how office workers are motivated and recognize their role in productivity improvement.

4. Use the potential of office organization for productivity improvement.

UNIT 2: CONTENTS

2.1 Focus: Mission and goals related to office productivity and quality

2.2 Organization

2.3 Process and quality

2.4 Motivation
UNIT 2: IMPROVING OFFICE PRODUCTIVITY AND QUALITY

Analysis of office productivity provides important information on the effectiveness and efficiency of the administration of an organization. However, this information is important only as far as management uses it to make decisions about improvement. Efforts to improve office productivity and work quality depend on being clear about the aims and objectives of the office itself and of the larger organization of which it forms a part.

The best potential for impact on productivity improvement is found in the areas of focus, organization, process and motivation.

This means we have to provide answers to the following questions:

Focus: Are we doing the right things?
Organization: Do we have the best possible structure and integration?
Process and quality: Are we doing things right?
Motivation: Do we want to do our best?

Finally, it is very important to ask questions about management as well:

Are our perceptions clear?
Are our interventions effective?

An attempt to answer the above questions (and to improve if the answers are negative) will provide a good framework for office productivity and quality improvement. Let us discuss these elements in more detail.

2.1 Focus: Mission and goals related to office productivity and quality

The first step in any improvement programme must be to establish - for all who will be involved in the programme - a clear definition of the mission and goals of the organization of which the office forms a part. They are the reference points against which any improvement will be measured.

Some organizations have formal mission statements, or written lists of goals and objectives. Where these exist, they should form the starting point. Where they do not exist, or where they have not been disseminated to the employees, (or where employees cannot remember them), the implied goals of the organization and of the office should be considered. It is a good idea to write them down separately for the organization and for the office.

The statements should be as brief, as simple and as clear as you can make them. Two words, a verb and a noun (e.g. pay bills, collect receivables, design cars) will often suffice to describe the essential goals of an office. If the organization or office tries to achieve special functions (e.g. assure quality of products and services, protect the environment) you should try to capture these. If there are important constraints under which the office must operate (e.g. staying within budget, complying with government legislation) they should usually be included.
Focus also deals with links between the overall company strategy and the activities of professional staff. It is important to identify those white-collar activities that are redundant or have low net value. The next step will be to reallocate employees' time and efforts to more productive areas. It is also desirable to eliminate the duplication of work by different units and officials.

One way to free up the time of office and knowledge workers is by automation. Assume that three financial analysts spend four hours each day gathering data, punching keys on a calculator to tally the data, cross-checking and balancing the data and performing various other calculations in order to forecast trends. After that, they spend four hours interpreting the data and writing up their recommendations for action.

Now consider the impact of providing the three knowledge workers with computers. With personal computers, it takes two hours to gather and input the data. The computer then does all the calculations, cross-checking and forecasting of trends. Now only two analysts can provide the same 12 hours of analytical power (interpretation and judgement) as the three analysts did before. The third analyst could, in addition, provide 1.5 times the professional/analytical power of one analyst previously (6 hours versus 4 hours). In this example, management has used the principles of efficiency to increase the effectiveness of the financial analysts. It would then be necessary to decide whether to retain the services of the third analyst. If this employee were a machine operator or a clerk, management would normally decide against this but because of the "leverage" or "cost multiplier" factor of the average knowledge worker, management may elect to retain the expertise either for additional analysis on that job or for redeployment to a similar job in another area.

Another way to reallocate an office job is to delegate or transfer tasks. For knowledge workers it is particularly important to delegate the administrative content of their jobs to employees who are paid less and who are better suited for administrative duties.

Some knowledge workers, such as engineers or architects, may perform tasks that require special skills but do not involve a great deal of professional judgement. Some of these tasks could be computerized or assigned to paraprofessionals or technicians trained to do such work but paid less than full professionals. It will normally require training and/or office equipment to transfer perhaps 20 per cent or more of a knowledge worker's tasks to an administrative assistant, technician or paraprofessional.

To achieve a proper focus on white-collar job allocation and goal setting the following areas should be considered:

- Strategy congruence
- Job responsibilities
- Operational objectives
- Net value of services
- Activity contribution
2.2 Organization

Improving office organization involves studying the system which governs the efforts of office workers. Improving organization structure could result in more transparency, better communications and coordination, horizontal integration, more staff autonomy in organizing the work, better quality and higher productivity. Too many layers of management cause delays and sometimes confusion in communicating between the top and the bottom of the organization, in either direction. Additionally, it has been found that many managers could manage more resources and increase their span of control (the number of people directed by one manager). One way to improve office productivity by eliminating management levels and reducing the number of managers is to examine the span of control exercised by each manager.

A statistical work distribution analysis helps us to adjust the height or width of an organization structure by allowing us to examine the content of each management/supervisory job and to determine the appropriate span of control. The aim should be to reduce the number of levels in the hierarchy. The dangers of too many levels of management include:

- delay from the point at which senior level decisions are made to the time they are implemented;
- possibility of a failure of communication and misinterpretation at each level;
- a tendency towards empire building or even organizational blocking at each level.

As far as the optimum number of subordinates is concerned, there is no single answer. Some feel that corporate presidents should not manage more than five vice-presidents. Some say that supervisors in a clerical department can be responsible for more than 20 subordinates, but this does not mean that “average” is appropriate to every situation.

It is useful to prepare a diagram of the organization as well as a survey to determine how much time managers spend managing the personnel reporting to them. Examples of three types of diagram are provided below so that you can note their strengths and weaknesses for examining spans of control.

The reporting structure in the organization

The organizational structure shown in figure 23.3 tells us that four managerial personnel are managing 18 other employees (22 - 4 = 18), which means an average span of control of 4.75 (19 ÷ 4 = 4.75). Managers can usually manage more employees than that. Two main inferences could be drawn from such a report:

- Johnson is apparently managing four people: Kennedy and Crosby, who are junior managers, and two others who do not manage other people, perhaps a secretary and another assistant. We assume that Johnson could manage more than two junior managers and two non-managers.
- Kennedy is only spending 10 per cent of his time on supervision or four hours a week managing nine people, possibly a secretary/administrator and eight sales personnel. This amounts to half an hour a week per sales person, which is not enough time to manage resources as valuable as sales personnel.
Chapter 23
Unit 2

The horizontal organization chart

Figure 23.4 represents an organization chart rather than a table to highlight issues of organization width, depth and span of control. This organization has five managers/supervisors (A, B, C, D and E). C, D and E also manage seven, six and seven employees respectively, i.e., a total of 20 employees for five managers. The ratio of one manager for four employees is very top heavy.

It is unusual that A manages only three employees — managing five or more junior managers is common unless there is a great deal of travel involved or the manager spends a lot of time as a knowledge worker performing an important functional specialty.

In this case A claims that 90 per cent of work time is spent in supervising three people, which seems inordinately high. Managers usually require 10 to 20 per cent of their time for upwards communication and perhaps 20-30 per cent for lateral communication, i.e. around 40 per cent for those two aspects of their job.

Employee B has only one person reporting directly to him. This person, in turn, supervises six people. B does not supervise anyone else. Unless B is absent from the workstation a great deal of the time, he should be able to take on all D’s supervisory/managerial duties. Either B or D should be categorized as a “special contributor” not as a manager or supervisor. Many companies promote individual contributors into management positions because that is the only way to reward them with more money or more prestige. This is generally not good practice if the organization is to be efficient and effective.

Employee C and E seem to spend a great deal of time managing. Perhaps their subordinates would not need so much supervision if their work tasks were more rationalized or computerized. Other approaches to reducing employee dependence on the supervisor would be to increase employee training and/or to delegate more authority to the employees.
The vertical organizational chart

Another type of organization chart is shown in figure 23.5, which shows the hierarchy in a vertical arrangement rather than horizontally. The chart shown also uses a decimal point system to help the viewer understand the management levels and reporting relationships. Such a decimal point system can be extremely useful for "sorting" and summation purposes when analysing a department or an organization as a whole.

The figure does not show the number of people involved at the various levels, but only infers the reporting levels (which may or may not have a bearing on the "importance level" within the organization.

Key span of control considerations

Below are listed several issues that should be examined as part of a comprehensive analysis of the work performed in an organization.

Direct reports The number of direct reports frequently depends on the amount of time needed to keep in touch with superiors (upwards), peers (lateral) and subordinates (downwards).

Distance and communication facilities To a great extent, the number of staff that one manager can manage depends on the distance between these people and the manager. Communications technology (electronic mail, voice mail, telephone, telex, telecopier, facsimile transmission) can help to reduce the problems of distance. For example, if several sales persons are scattered over a wide geographic area, the sales manager may not be able to train or control as many salespersons as would be possible in a city. The level of specialization of the job can also make it easier or harder for the manager to manage. A supervisor of clerks performing identical tasks in one office may be able to manage more than twenty personnel, assuming the process is relatively routine and requires minimal discretion.
Figure 23.5: Hierarchical organization chart
Empowerment  Today, most progressive companies are empowering the employees closest to the customer to make day-to-day decisions on customer service matters.

Technological innovations  Technological progress constantly offers managers new opportunities to systematize decision making. Artificial intelligence systems can now not only take day-to-day decisions but can also introduce a new dimension whereby the system can learn from its own experience. For example, the system can learn (just as the supervisor/manager learnt) that a certain class of customer will be more likely to demand compensation for shortages in shipments, defective merchandise, late deliveries and the like.

Other aspects  Other aspects which influence the span of control include the number and complexity of the channels of distribution, the flexibility required of the manufacturing system, and the risk/reward ratio of individual contracts.

To summarize, in improving office organization the following areas should be considered:

- Mission and functions
- Responsibility assignment
- Resource and skill allocation
- Authority levels
- Spans of control
- Degree of specialization
- Proximity
- Communication channels and mechanisms
- Interfaces and dependencies

2.3 Process and quality

Process and quality are concerned with the procedures required by individual work activities, and the mechanisms which link them together to produce output and impact. The techniques and technologies employed, the work flow among individuals and groups, the control points, the queuing points, the sequencing, and the information system employed—all these comprise the process which transforms input into output. The process and organization should reflect the final office work objectives and goals. Since the quality of office work is the main element in its effectiveness, it is particularly important that the process should be built around the quality of outcome as well as the consideration of cost.

Quality is defined as conforming to an internal or external customer’s requirements. Some studies show that 20 per cent of office work consists of correcting errors. This is called the cost of non-conformance. Other studies show that 20 per cent or more of office work relates to inspection and prevention of errors occurring in the first place. This cost is called the cost of conformance. Since around 40 per cent of all office costs are costs of quality, there is great scope here for cost reduction. These costs can be grouped under five headings, all of which should be examined.

Costs of prevention  Some of the process controls in an office involve job descriptions, practice and procedure manuals, batch control and the like. These are prevention costs.
Meetings can be an expensive prevention cost. Many meetings deal with planning a project or ensuring that the project will be delivered on time and within budget. Many managers spend up to half of their time in meetings. There may be ways to reduce the length of meetings and/or the number of participants.

Costs of inspection Many departments spend time inspecting input from supplier departments so that they can reject poor quality before it interrupts their work flow. In some instances these activities are excessive, building unnecessary barriers and reducing company effectiveness.

Internal failure costs Much office work results in a report. Often reports are thrown away because they are inaccurate or prepared too late for use in a meeting or just unnecessary. These costs are considered “internal” because the output is used within the same department.

Customer-supplier relationship Everyone is a customer to someone else. Many individuals or departments in an office have no contact with external customers, but they have still internal customers and suppliers. An appreciation of the customer-supplier relationship is important in meeting expectations and requirements. Frequently, partnering with a supplier can have a dramatic effect on servicing a customer.

External failure If internal correction fails it costs considerably more to correct an error that gets out of the department or worse yet, gets to the ultimate customer. Sometimes these costs increase exponentially. For example, it may cost only $1 to prevent an error, $10 to fix it internally but $100 or even $1000 to fix it if it gets to a customer.

The costs of quality are summarized in figures 23.6 and 23.7.

The most important areas to search for potential process improvement are:

- Work indication and definition
- Work methods
- Degree of work automation
- Work flow
- Work loading and backlog control
- Control and transfer points
- Resource coordination
- Quality assurance and control
- Technical training
### Figure 23.6: Cost of quality: summary chart

<table>
<thead>
<tr>
<th>Cost</th>
<th>Element</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conformance</td>
<td>Prevention</td>
<td>Cost of systems and procedures to prevent errors from occurring</td>
<td>Quality training programmes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Design reviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Backup computer systems</td>
</tr>
<tr>
<td>Appraisal</td>
<td></td>
<td>Cost of inspection to detect errors after they have occurred</td>
<td>Inspecting vendor-supplied computer programme code</td>
</tr>
<tr>
<td>Non-conformance</td>
<td>Internal failure</td>
<td>Cost of correcting errors found internally</td>
<td>Meetings that start late</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Computer downtime due to faulty code</td>
</tr>
<tr>
<td></td>
<td>External failure</td>
<td>Cost of correcting errors found by customers</td>
<td>Overly detailed reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cancellations by dissatisfied customers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Field service</td>
</tr>
</tbody>
</table>
Figure 23.7: The cost of quality iceberg
2.4 Motivation

Motivation reflects the office environment and its role in encouraging employees to achieve a high level of performance. Consider this example:

A company survey revealed that employees did not feel encouraged to perform well, but only to avoid mistakes. Negative reinforcement was the predominant technique employed by management. Employees heard from their supervisors if something went wrong, but were rarely congratulated if something went well. A supervisory training programme helped develop a more creative and supportive environment.

High turnover, always a good indicator of motivational problems, was especially noticeable among junior-level professional staff. A major cause of this problem was traced to the performance rating system. It operated on a one-to-five scale (in which one was the lowest score, five the highest), with a normal distribution of ratings expected across the department. Upon investigation, it was found that everyone in the department was being evaluated relative to everyone else, with no distinction for job grade or level of experience. The outcome was that approximately 90 per cent of the more junior professionals were receiving threes, while the fours and fives were reserved for managers or technical specialists. When ratings were based on expectations for the individual’s own level, morale improved among younger professionals and managers received a strong signal that their position would no longer guarantee high performance ratings.

An important motivational instrument (besides the financial incentives discussed in Module 14) is increasing staff autonomy and empowering people. At the same time it is important to have a strong organizer-culture, if managers decide to decentralize. As staff have an increasing degree of autonomy, they have an increasing ability to decide what activities to perform, when and how. At any given time they may or may not decide to perform activities that contribute to achieving office goals. If an office’s employees do not have a clear, common understanding of the office mission and goals, and how their activities help achieve those goals, they have no basis for choosing more or less productive activities at any given time, and no basis for determining the necessary standards of quality and quantity of work. Whether or not there are formal, written goals or standards for work, people actually perform according to organizational norms which usually develop informally. If there are formal goals, standards, and priorities set by management, or developed jointly by staff and management, there is a reasonable chance of getting employees to adopt these as their norms.

In the absence of goals, standards, and priorities set by management, it is unlikely that the organizational norms will match the office’s real needs for work achievement. Employees’ unwritten goals and performance standards will prevail. Also, employees with different priorities can work at cross purposes, or with no clear focus, leading to organizational drift.

Among the most important areas to look into while improving motivation, the following should be considered:

- Performance feedback
- Contribution to visibility and recognition
- Autonomy
Questions for discussion

1. Why must office staff - at all levels - have a clear understanding of the office mission and goals, and of the objectives and priorities of their work?
2. What is the interaction between productivity and quality?
3. What was a common finding concerning responsibility for quality in an enterprise?
4. What are the major potential areas for improving office work in an organization?
5. What findings show that organizations potentially have a lot to gain by examining the costs of quality?
UNIT 3: IMPROVING PROFESSIONAL AND MANAGERIAL PRODUCTIVITY

UNIT 3: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Determine the main areas of potential productivity improvement in the office.
2. Understand the use of work distribution diagnostic to analyse the time distribution of professional and management activities.
3. Distinguish between critical and non-critical activities.

UNIT 3: CONTENTS

3.1 The professional work distribution diagnostic
3.2 Finding opportunities for improvement
3.3 Applying “productivity of professionals” principles to managers

Annexes

I. Collecting the data
II. Example of activity reference information for staff estimating their time use
III. Completed process data collection form
IV. Completed activity matrix data collection form
V. Work distribution form
UNIT 3: IMPROVING PROFESSIONAL AND MANAGERIAL PRODUCTIVITY

Managers and professional knowledge workers are expected to contribute value to their organization worth three to five times what they cost. When they spend time on work that merely requires the skills of clerical or technical staff, the office incurs higher costs than are needed for that work. That loss is magnified because professional/managerial staff are frequently slower and less accurate than clerical/technical staff doing that work. Even worse, the more professional and managerial staff are forced to spend time on clerical or technical work, the less opportunity they have to contribute the high value expected of them. So the office also loses effectiveness.

Avoiding these losses of effectiveness and efficiency requires:

- an analysis of the way managers and professionals use their time, to establish whether it is used efficiently and effectively;
- a method for estimating potential improvements.

3.1 The professional work distribution diagnostic

Analyzing the time use of professional staff

Any recommendations for improving the productivity of professional staff must rest on information about the way in which those staff currently work. Suggestions on how to gather data can be found in Annex I to this unit.

Once gathered, the data must be analysed so that useful conclusions can be drawn. The techniques recommended here are based on the work of Epstein and Fass who refer to their methodology and the associated software as “professional productivity analysis.”

The analysis is carried out along four dimensions:

- Activities (what is done)
- Processes (the way in which it is done)
- Skills (or expertise needed to do it)
- Functions, or purpose of the work

These dimensions are examined below.

Activities

Each activity is measured or estimated in terms of the time taken to carry it out. Analysis of activity data (coupled with other information such as staffing, operations, working environment and culture) will often yield specific recommendations for improvement. However, the search for improvement opportunities is better focused when activities are defined in terms of each of the other three dimensions, so that the time used can be quantified along each dimension.
The aim of the analysis is to pinpoint improvement possibilities by finding opportunities to:

- reduce the time used for various activities;
- improve the goal-direction of effort;
- increase the value received for expenditure on professional judgement and skills.

To carry out the analysis, all the time spent on any one type of activity is “sorted” into process, function, and skill level and the resulting figures are added up for each dimension. The authors call this a “roll up”.

For example, if two skill levels are defined, a “skill level roll up” means that all the time spent on all activities at skill level 1 would be added together, as would the time on all activities at skill level 2, thus providing a comparison of total time spent at each skill level. A “functional roll up” compares the total time spent on each function, and a “process roll up” compares the total time spent on each work process. Figure 23.8 and 23.9 provide examples of such analyses for a project engineer.

Measuring staff-time by activity and by work process are traditional industrial engineering approaches to measuring the work of any type of staff, not just professionals. Functional roll ups or “function analysis”, and skill level roll ups or “skill/expertise level analysis” were developed especially to analyse the productivity of professional knowledge workers.

The key to using this type of work distribution analysis for improving the productivity of professionals lies in defining activities in such a way as to clearly differentiate the process used, the skill or expertise level required, and the function (or purpose) to which the activity contributes.

In the following sub-sections, processes, skills, and functions will first be defined, then some examples will be given to explain how these dimensions can be used for analytical purposes.
### Figure 23.8: Project engineers’ activities sorted by function

<table>
<thead>
<tr>
<th>Activity Code</th>
<th>Activity Description</th>
<th>ACTUAL % OF TIME</th>
<th>FUNCTION</th>
<th>SKILL LEVEL</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Visit and inspect field site</td>
<td>3.0</td>
<td>QA</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>Review, correct design</td>
<td>8.0</td>
<td>QA</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>03</td>
<td>Quality Assurance (QA) meeting: Internal review</td>
<td>6.0</td>
<td>QA</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>04</td>
<td>External QA meeting: Backup manager, supervisor</td>
<td>1.6</td>
<td>QA</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>05</td>
<td>QA meeting: Lead for office or negotiate change</td>
<td>.4</td>
<td>QA</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>06</td>
<td>Draft agreed-to design changes e.g., instruction letter</td>
<td>7.0</td>
<td>QA</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>07</td>
<td>QA writing (e.g., instruction letter)</td>
<td>1.0</td>
<td>QA</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>08</td>
<td>Project management (PM) writing—routine</td>
<td>6.0</td>
<td>PM</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>09</td>
<td>PM writing—non-routine, complex</td>
<td>2.0</td>
<td>PM</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Chair or run PM meeting</td>
<td>1.0</td>
<td>PM</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>Attend PM meeting: Lead for office</td>
<td>1.0</td>
<td>PM</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Attend PM meeting: Backup manager, supervisor</td>
<td>4.0</td>
<td>PM</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>JPM phone call: Coordinate, organize, direct</td>
<td>1.0</td>
<td>PM</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>PM phone call: Convey message about project</td>
<td>6.0</td>
<td>PM</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>Prepare for meetings or presentations</td>
<td>7.0</td>
<td>PM</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>Revise order of project workplan (non-routine)</td>
<td>2.0</td>
<td>PM</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>Update project milestones (routine)</td>
<td>4.0</td>
<td>PS</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>18</td>
<td>Search for, retrieve materials, information</td>
<td>8.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>19</td>
<td>File, put away, store materials</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>Project support (PS) writing (e.g., forms)</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>21</td>
<td>Copy materials</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>22</td>
<td>PS phone call (e.g., to request messenger)</td>
<td>1.0</td>
<td>PS</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>23</td>
<td>Review, approve bills; process for payment</td>
<td>1.0</td>
<td>PS</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>Attend professional training</td>
<td>.2</td>
<td>TR</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>25</td>
<td>Answer phone for other engineer, take message</td>
<td>4.5</td>
<td>NP</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td>Other non-project phone calls</td>
<td>1.5</td>
<td>NP</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>Breaks, personal time</td>
<td>3.0</td>
<td>NP</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>28</td>
<td>Non-project administration</td>
<td>3.9</td>
<td>NP</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>29</td>
<td>Miscellaneous, all other non-project activity</td>
<td>3.9</td>
<td>NP</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

**TOTAL PROFESSIONAL STAFF TIME: 100.0 per cent**

Guidance will also be given on how to identify improvement opportunities and how to evaluate the potential benefits of resulting recommendations.
Processes

Processes are (groups of) activities used to perform work. They include phoning, attending meetings, writing, calculating, travelling, searching/filing.

It may be possible to combine several activities, resulting in a smaller, more manageable number of processes to analyse. Exactly which processes to combine, and how to define them, will depend on how the data are to be analysed, which in turn should depend on expectations about specific productivity problems and opportunities for improvement. In many jobs both searching and filing may be lower-skilled activities, below professional level. If the same general solutions can reduce professional time on these activities (e.g. better records management, better office automation, more clerical support staff), then these processes can be combined as shown above.
## Figure 23.9: Project engineers’ activities sorted by skill level

<table>
<thead>
<tr>
<th>Activity Code</th>
<th>Activity Description</th>
<th>ACTUAL % OF TIME</th>
<th>FUNCTION LEVEL</th>
<th>SKILL</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Search for, retrieve materials, information</td>
<td>8.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>19</td>
<td>File, put away, store materials</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>Project support (PS) writing (e.g. forms)</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>21</td>
<td>Copy materials</td>
<td>4.0</td>
<td>PS</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>22</td>
<td>PS phone call (e.g., to request messenger)</td>
<td>1.0</td>
<td>PS</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>25</td>
<td>Answer phone for other engineer, take message</td>
<td>4.5</td>
<td>NP</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>26</td>
<td>Other non-project phone calls</td>
<td>1.5</td>
<td>NP</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>Breaks, personal time</td>
<td>3.0</td>
<td>NP</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>28</td>
<td>Non-project administration</td>
<td>3.9</td>
<td>NP</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>29</td>
<td>Miscellaneous, all other non-project activity</td>
<td>3.9</td>
<td>NP</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>06</td>
<td>Draft agreed-to design changes</td>
<td>7.0</td>
<td>QA</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>08</td>
<td>Project management (PM) writing—routine</td>
<td>6.0</td>
<td>PM</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>PM phone call: Convey message about project</td>
<td>6.0</td>
<td>PM</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>Update project milestones (routine)</td>
<td>4.0</td>
<td>PS</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>Review, approve bills; process for payment</td>
<td>1.0</td>
<td>PS</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>03</td>
<td>Quality assurance (QA) meeting: Internal review</td>
<td>6.0</td>
<td>QA</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>04</td>
<td>External QA Meeting: Backup manager, supervisor</td>
<td>1.6</td>
<td>QA</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>07</td>
<td>QA writing (e.g., instruction letter)</td>
<td>1.0</td>
<td>QA</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>Attend PM meeting: Backup manager, supervisor</td>
<td>4.0</td>
<td>PM</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>Prepare for meetings or presentations</td>
<td>7.0</td>
<td>PM</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>Revise order of project workplan (non-routine)</td>
<td>2.0</td>
<td>PM</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>Attend professional training</td>
<td>.2</td>
<td>TR</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>01</td>
<td>Visit and inspect field site</td>
<td>3.0</td>
<td>QA</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>09</td>
<td>PM writing—non-routine, complex</td>
<td>2.0</td>
<td>PM</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Attend PM meeting: Lead for office</td>
<td>1.0</td>
<td>PM</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>PM phone call: Coordinate, organize, direct</td>
<td>1.0</td>
<td>PM</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>05</td>
<td>QA meeting: Lead for office or negotiate change</td>
<td>8.0</td>
<td>QA</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Chair or run PM meeting</td>
<td>.4</td>
<td>QA</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

TOTAL PROFESSIONAL STAFF TIME: 100.0 per cent

**Skills:**

Skills are the levels of expertise or professional judgement required to perform a given activity competently. Skill/expertise-level analysis identifies what percentage of the time of
professional knowledge workers is used for higher-value, higher-skilled activities, and what percentage of their time is used for lower-value, lower-skilled activities.

As with work processes, the number of skill levels and their definition depend on how the data are to be analysed, which in turn depends on expectations about specific productivity problems and opportunities for improvement.

Too many levels can unnecessarily increase study cost and difficulty. Too few levels can cause improvement opportunities to be missed or the analysis to be oversimplified. Different possibilities for skill level analysis are shown in the box below.

**BASIC ANALYSIS USING TWO SKILL LEVELS**

*Level 1:* Sub-professional: The activity can usually be performed by a lower-paid person, not expected to have as high a level of expert judgement and skills as a professional knowledge worker.

*Level 2:* Professional: The activity usually requires the judgement or skill of a person in a professional job category.

**ANALYSIS USING THREE SKILL LEVELS**

*Level 1:* Little or no special skills or expertise required: The activity can usually be performed by a person with no more than common office skills (simple filing, answering phones, data entry, typing material written by others) or other common skills (driving a standard, non-emergency car or van).

*Level 2:* Sub-professional, but some special training required: For activities requiring paraprofessionals or technicians (e.g., an engineering intern or drafter), or generalists more highly trained than the average clerk or secretary (financial assistants who calculate bills, clerks trained to use complex filing systems or office equipment, administrative or project assistants who aid professionals in various ways).

*Level 3:* Professional: The activity usually requires the judgement or skill of a person in a professional job category.

**ANALYSIS USING FIVE SKILL LEVELS**

*Level 1:* Little or no special skill or expertise required.

*Level 2:* Paraprofessional, technician, or specially-trained generalist skill level required.

*Level 3:* Low to middle level of professional skill or expertise usually required.

*Level 4:* Middle to high level of professional skill or expertise usually required.

*Level 5:* High level of professional skill or expertise usually required.

Figure 23.10 illustrates a skill level analysis for project engineers.
Figure 23.10: Skill level analysis for project engineers

<table>
<thead>
<tr>
<th>SKILL/EXP LEVEL</th>
<th>% TIME AT EACH LEVEL</th>
<th>Interpretation of Skill/Expertise Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>37.8</td>
<td>1: Little or no skill or expertise required.</td>
</tr>
<tr>
<td>2</td>
<td>24.0</td>
<td>2: Paraprofessional (e.g., drafter, intern).</td>
</tr>
<tr>
<td>3</td>
<td>21.8</td>
<td>3: Low to mid professional skill/expertise.</td>
</tr>
<tr>
<td>4</td>
<td>7.0</td>
<td>4: Mid to high professional skill/expertise.</td>
</tr>
<tr>
<td>5</td>
<td>9.4</td>
<td>5: High professional skill or expertise generally required for these activities.</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>100.0 percent</td>
<td></td>
</tr>
</tbody>
</table>

Note: Most time is spent at the two lowest skill levels - below professional level.

Criteria for deciding the number of levels

If you know beforehand what type of employee will be needed to take on some of a professional's lower-skilled work, you only need to define one sub-professional skill level. If you want to determine how much professional time may be replaced by clerks, and how much by technicians or paraprofessionals, you need to define at least two sub-professional skill levels. It is necessary to define several professional skill levels only:

- When there are professional staff with different levels of experience, skill, or expertise (e.g. "junior" and "senior").
- When project engineers are spending too much time at skill/expertise levels 1 and 2, and too little time at levels 4 and 5. Note: Over half (51 per cent) of project engineers' time is on work which lower skilled staff could do. There may also be opportunities to decrease time...
on some of the lower skilled tasks that require engineers (level 3), and to challenge the project engineers with more higher-value, higher-skill work at levels 4 and 5.

- If you suspect management practices limit professional staff opportunities to perform higher-value work requiring more judgement or skill. For example, if staff spend too much time at internal meetings in which supervisors simply review their work and not enough time in problem solving or creative design meetings. Note: The same process (a meeting) takes on a higher or lower value depending on the level of professional skill and judgement involved.

- If you suspect there are other opportunities to challenge professional staff with more creative, higher-value work.

Some rules of thumb for defining skill/expertise levels and rating the skill level of activities

1. The word “usually” reduces the number of levels and keeps the analysis manageable.
2. If the distinction between higher and lower skill requirements is important, it may be useful to differentiate between “routine” (lower-skilled) and “non-routine” (higher-skilled) versions of the same activity.
3. If a rule or law that cannot be changed requires some activities to be performed by a qualified professional (e.g., accountant, engineer, architect), then those activities are rated as “professional” no matter what skill level is usually required.
4. If professional judgement is needed to decide whether an activity requires routine or professional skill, the activity should be considered professional level.

Functions

Functions are groups of activities associated with the same purpose for performing the work. Different specific functions must be defined for each professional office, and generally for each type of professional staff.

Four types of functions that are important for analysing professional staff are:

- mission-critical functions;
- mission-support functions;
- training and professional development functions;
- “other activities” (one or more “catch-all” functions for activities not directly related to accomplishing organizational missions or developing employees).

The definition of work according to these four categories can vary depending on the type of employee, and that employee’s relationship to the office mission. For example, if an office has architects and accountants, financial analyses which are sometimes done by accountants and sometimes by architects may be classified as “mission critical” for accountants and as “mission support” for architects. This approach helps determine the extent to which the critical tasks in an office are done by people with special skills. Figure 23.11 shows such a functional analysis for project engineers.

Distinguishing between mission-critical and mission-support functions

Mission-critical and mission-support functions are both required to achieve the office
goals. The distinction is that:

- **Mission-critical** functions involve goal-directed activities that generally must be performed by a specific type of knowledge worker, usually at a professional level of skill.
- **Mission-support** functions are needed to achieve goals (as the work is currently organized), but don’t generally require the knowledge, judgement, or skill of the particular type of professional worker considered.

It is necessary to define mission critical functions relating to how each type of worker’s special skills and expertise contribute to the mission and goals of the office.

**Figure 23.11: Function analysis for project engineers**

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>ACTUAL % TIME</th>
<th>DESIRED % TIME</th>
<th>ACTUAL - DESIRED</th>
<th>ABSOLUTE DIFFERENCE</th>
<th>% OF STAFF TIME BY TYPE OF FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Critical:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>57.0</td>
</tr>
<tr>
<td>QA Quality Assurance</td>
<td>27.0</td>
<td>42.5</td>
<td>-15.5</td>
<td>15.5</td>
<td>26.0</td>
</tr>
<tr>
<td>PM Project Management</td>
<td>30.0</td>
<td>42.5</td>
<td>-12.5</td>
<td>12.5</td>
<td>16.8</td>
</tr>
<tr>
<td>Mission Support:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.0</td>
</tr>
<tr>
<td>PS Project Support</td>
<td>26.0</td>
<td>5.0</td>
<td>21.0</td>
<td>21.0</td>
<td>16.8</td>
</tr>
<tr>
<td>Training &amp; Prof Dev.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.2</td>
</tr>
<tr>
<td>TR Training</td>
<td>.2</td>
<td>5.0</td>
<td>-4.8</td>
<td>4.8</td>
<td>.2</td>
</tr>
<tr>
<td>Other Activities:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.8</td>
</tr>
<tr>
<td>NP Non-Project Time</td>
<td>16.8</td>
<td>5.0</td>
<td>11.8</td>
<td>11.8</td>
<td></td>
</tr>
</tbody>
</table>

100.0% 100.0% 0.0% 65.6% 100.0%

**USING ANALYSIS APPROACH 1: POTENTIAL FUNCTIONAL TIME SHIFT FOR BETTER GOAL DIRECTION:**

42.8%

**USING ANALYSIS APPROACH 2: “ACTUAL – DESIRED”:**

**POTENTIAL FUNCTIONAL TIME SHIFT FOR BETTER GOAL DIRECTION:**

32.8%

Distinguishing between mission support and other activities

Mission support and other activities may include many of the same work processes, such as filling out forms or writing reports that do not require professional expertise.

A practical way to decide whether an activity is mission support or “other” is to think about what would happen to the amount of time an average employee would spend on that activity if the workload were increased without a change in the way the work was organized or performed.

- If time spent on that activity can be expected to increase as the workload increases - because the activity will be needed more often - then assign it to a mission support function. Example: Filling out a form to get a contractor paid. (Presumption: More work will involve more contractor payments).
- If time spent on the activity cannot necessarily be expected to increase, assign the activity to
“other activities”. Example: Filling out an employee timesheet, which presumably will occur the same number of times each year no matter what the workload is.

Training and development

Training and professional development are treated as a separate function because:

- Technology, professional standards, and practices constantly change - and at a faster and faster pace - so part of every professional’s time each year should be set aside for training programmes and conferences, reading journals, and keeping up with the field.
- In addition to training, professional development activities that help people develop their career are important. These activities can make professionals more useful to the office and can increase their motivation to support the organization’s goals.

Good supervisors integrate staff development into ongoing work by rotating assignments to “stretch” each person’s experience and correcting work in ways that encourage learning. If this happens, not all development activities can be separated out - they should be counted as part of appropriate mission-critical or mission-support functions. But a well-run office will often have one or more activities that are primarily “professional development”, such as supervisor-staff meetings to review personnel evaluations, or meetings to plan training and development experiences. These should be designated as professional development activities within the training and development function.

Collecting additional data

Analysis of activity data (combined with other information about an office and its staffing, operations and environment) can by itself lead to quite specific recommendations for improvement. Processes, skill levels and functions are important to ensure that activities are defined in such a way as to identify those needing further improvement, and to facilitate evaluation.

The kind of other information which may be needed to make valuable recommendations could include:

- Staffing patterns: the number of paraprofessional, clerical and other support staff, compared to the number of professionals, and how support staff assist professionals.
- Operating procedures and actual practices: The practices actually followed are often different from documented procedures.
- Incoming workload and how it varies: Variations in level of difficulty; how much incoming work can be fitted into regular work schedules, and how much must be responded to “on demand”.
- Office furniture and equipment: e.g., desks, files, copiers and how they are used; office layout; physical conditions.
- Technology, particularly for information and communications: e.g., computer hardware and software, networks, phones, fax machines and how professionals use the systems.
- Relationships between staff and customers: Consider all levels including supervisors and managers and all their customers, including internal and external customers.
- Specific performance data available: Office costs, quality, efficiency, or timeliness, especially data over time.
Module 23
Unit 3

- Comparable data on costs, quality, efficiency, or timeliness from other offices that do similar work.
- Actual or perceived problems: Are there problems of cost, efficiency, quality, or timeliness of office work? Are they recognized problems (documented in some way) or problems perceived by customers, management, or employees?
- Legal or professional standards: Distinguish between standards which the office must follow in performing its work, or which a professional association establishes as norms.
- Supervision of professional knowledge workers, including:
  - The degree of independent judgement and discretion allowed to professional staff in performing various duties.
  - Need for approval: The extent to which staff must obtain approval from supervisors or managers to take action.
  - How often staff complete their own work products compared with how often their outputs are closely reviewed, extensively corrected, re-done, or finished by supervisors or managers.
  - The extent to which supervisors develop staff professionally, to support the office and to help staff advance their careers.
  - The extent to which supervisors help clarify objectives and ensure that all staff understand how their work supports the overall office mission and goals.
- Elements of the office's "organization culture", including supervisor-subordinate relationships, such as:
  - Vision of the organization, including goal-direction: Function analysis shows how goal-directed staff time is used. Organization culture data can show whether people in the office have a common idea of organizational goals.
  - Patterns of communication. For example, do some staff not let others in the office know useful information, because they don't know it's useful, they think no one cares, or no one bothers to ask them?
  - Decision-making patterns, including consultation, decisiveness, and timeliness in reaching decisions.
  - Work patterns and norms, including hours worked, perception of effort, perception of professionalism and attention to quality, sense of personal accomplishment.

Information collected under the work distribution diagnostic outlined above will be used to identify which activities should be selected for improvement.

3.2 Finding opportunities for improvement

Using process analysis

Work-process analysis is a traditional part of work-distribution analysis as carried out in production environments. Process analysis can also indicate potential improvements for knowledge workers, as the following example indicates:
Figure 23.12: Process analysis for project engineers

<table>
<thead>
<tr>
<th>WORK PROCESS</th>
<th>ACTUAL % OF TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TIME IN THE FIELD: Site inspections</td>
<td>3.0</td>
</tr>
<tr>
<td>2. DESIGN WORK: Review, correction, drafting</td>
<td>15.0</td>
</tr>
<tr>
<td>3. PROJECT ADMINISTRATION: Preparation, planning,</td>
<td>14.0</td>
</tr>
<tr>
<td>draft, revision, payment processing</td>
<td></td>
</tr>
<tr>
<td>4. WRITING: Instructions, letters, memos, forms,</td>
<td>13.0</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td>5. ATTENDING MEETINGS</td>
<td>14.0</td>
</tr>
<tr>
<td>6. TIME ON THE PHONE</td>
<td>14.0</td>
</tr>
<tr>
<td>7. SEARCHING/COPYING/FILING: Project materials</td>
<td>16.0</td>
</tr>
<tr>
<td>8. NON-PROJECT ADMINISTRATIVE WORK</td>
<td>3.9</td>
</tr>
<tr>
<td>9. RECEIVING TRAINING</td>
<td>2</td>
</tr>
<tr>
<td>10. OTHER (e.g., breaks, personal, miscellaneous)</td>
<td>6.9</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>100.0 per cent</td>
</tr>
</tbody>
</table>

Process analysis helps indicate which activities might be automated or assigned to lower-skilled staff when a process that involves mostly low-skilled activities takes a high percentage of professional staff time.

In figure 23.12, activity No. 7 - searching/copying/filing is the most obvious candidate for close examination. It takes the most time (16 per cent), but is clearly a process involving mainly lower-skilled work. Activities No. 2 to 6 take not much less time (13 - 15 per cent), but the specific activities need to be examined closely to check for problems. For example, what is the nature of the meetings that take the most time? Do these meetings add value? How much time on the phone is productive, critical to moving projects along?

Some possible improvement opportunities:

Searching/copying/filing: Look for ways to automate, reduce or eliminate these activities, or in the last instance to assign them to lower-skilled staff who are paid less than engineers.

Time on the phone: With 14 per cent of project engineers’ time on the phone, check to see if the phone system meets their needs.

Writing: With 13 per cent of engineers’ time spent writing, are there opportunities for better office automation - more use of PCs?

Design: Engineering design and drafting can be automated by installing computer-assisted design and drafting (CADD) systems, with workstations for engineers. Because the project engineers work on designs submitted by consultants, installing CADD for project engineers will not work by itself. However, if the office is in a position to require the consultants to submit
designs in a compatible CADD format, a CADD system may be feasible to automate this process.

Process analysis can sometimes indicate which office “systems” should be examined for potential improvement. If knowledge workers spend a high percentage of time writing or making calculations, there may be opportunities to raise productivity by improving office automation, or increasing knowledge workers’ access to personal computers. However, sometimes the problem is not lack of automation or access to computers, but poor use of existing systems. Some knowledge workers may not be used to PCs, may not have been adequately trained to use them, or may fear them, so they don’t use PCs even if they are available. There may be opportunities to raise productivity by increasing the amount of time that knowledge workers spend using PCs, but training may be needed to help staff feel comfortable with computers.

**Using skill-level analysis**

Reducing the time that professional staff spend on activities not requiring their professional judgement and skills can be extremely cost-effective even if more paraprofessional, technical, clerical, or support personnel must be hired to perform lower-skilled tasks. Alternatively some of these tasks could be automated or computerized. This shift also focuses more highly paid professional time on higher-value work, and less on lower-value, non-professional work. Professionals are in fact used more for the things they are paid to do.

**Using function analysis**

Function analysis of activity data will reveal how much time professionals are spending on mission-critical functions and how much on less valuable activities. The aim of function analysis is to re-orient professionals’ work so that they spend more time on the activities which contribute most to the office mission and objectives.

Ask yourself what opportunities exist to:

- increase time spent on mission-critical functions;
- decrease time spent on mission-support functions;
- decrease time spent on “other activities”;
- ensure that time spent on training and professional development is at least enough to meet acceptable professional standards.

If some mission-critical activities can be made more efficient so that time can be saved on them without sacrificing quality or creativity, those time savings should be directed into other mission-critical activities so that total mission-critical time increases.

In reallocating the remaining available time, don’t expect to achieve 100 per cent of possible efficiency gains. There can be real advantages in not pressing for every last percentage of increased efficiency. For example, some of the time saved can be dedicated to new activities aimed at increasing creativity, innovation, and staff development. These might include:

- experiments with new or different work techniques
- quality circles or problem-solving teams

23 - 37
- special projects
- exploration of new technology

Such activities can result in improved morale and job satisfaction of professional knowledge workers, as well as higher productivity.

It is useful to set targets for the desired percentage of time for each function. To do this it is necessary to balance different mission-critical functions according to organizational priorities, using a professional standard for training and development time, and assuming inevitable residual amounts for mission support and other activities, even under ideal conditions.

Desired time targets should be based on the particular needs of the office and the professional group in question. For example, a professional standard may exist of 40 hours per year (roughly 2.5 per cent of an employee's work time) of continuing vocational education for a particular profession. A higher training and development target may be set to account for additional career development activities, or for extra training needs when the nature of the work changes or if the professional staff is generally weak in a critical area of expertise.

Evaluating potential benefits of recommendations

The need for quantitative estimates of benefits Implementing recommendations often involves costs (e.g., staff, computer systems) or risk, although some recommendations may involve no direct costs (e.g., changing supervision patterns). But any change involves a degree of disruption, and a risk of failure - the possibility that performance will get worse rather than better. Quantitative estimates of benefits show what difference the changes can make if they work. They help management to decide whether benefits will be worth the investment required and the risk involved in change.

Management may be unwilling or unable to implement all the recommendations, and it is usually impossible to evaluate each one separately as they are often interdependent. It is impractical to evaluate every possible combination of recommendations which may be implemented, so it is useful to group them into packages. Each package can then be evaluated incrementally, showing the results expected if only one package is implemented, or if two packages are implemented, etc.

Quantify the potential We shall now go a step further and show how to quantify the potential for shifting time to more valuable work. Two approaches are commonly used:

**Approach 1** This approach assumes that it will be possible to shift ALL the time spent on mission support and other activities to mission critical and training and development functions. The approach provides an estimate of the theoretical maximum improvement potential, but may often seem somewhat unrealistic, and is likely to meet employee resistance. If there is not enough mission-critical work to be done, employees are likely to view the approach as a first step towards reducing their number.

**Approach 2** This approach is based on agreed targets for the desired percentage of time for each individual function; the difference between the actual percentage of time spent and the desired percentage is then worked out. The differences are totaled and the time-shift potential is
calculated by taking HALF the TOTAL difference between the actual and the desired percentages.

The application of these approaches will be explained in the following example.

**A real-life example: Project engineers**

We shall use the example of the project engineers to show how to estimate the potential benefits of recommendations. The recommendation packages are based on groups of proposals approved by the organization.

It was relatively easy to get approval for one-time investments in systems and procedures and in new management or supervisory techniques, as long as no new staff were to be added. That led to recommendation package 1.

Any additions to staff, even lower-paid staff, were hard to get approved and took time to implement. So recommendations to add support staff were grouped into package 2.

The analyses on which these packages were based are shown in Annex IV. Some details of the recommendation packages are given below:

**Package 1: Systems, procedures, and management changes**

- Improve office systems and automation, especially for record keeping and project management.
- Increase internal delegation of interim design reviews.
- Increase average on-site field inspection time per project.
- Allocate at least five days per year to professional training for each engineer.
- Start using some supervisory contact time for staff development, and less for correcting work.

**Package 2: Add lower-paid staff to assist engineers**

- Clerical support staff
- Paraprofessionals and technicians, e.g., assistant engineers, drafters, project assistants.

**Estimated potential for improvement**

1. First we shall use the efficiency-oriented recommendations to estimate reduced times for lower-value activities (figure 23.13).
Figure 23.13: Project engineers’ functional time after reduction of lower-value activities, before reallocation to higher-value uses of their time

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>ACTUAL % TIME</th>
<th>% TIME REC&lt;sup&gt;a&lt;/sup&gt; PKG 1</th>
<th>% TIME REC&lt;sup&gt;b&lt;/sup&gt; PKGS 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission-critical:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality assurance</td>
<td>27.0</td>
<td>22.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Project management</td>
<td>30.0</td>
<td>27.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Mission-support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project support</td>
<td>26.0</td>
<td>12.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Training &amp; prof dev:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training &amp; development</td>
<td>.2</td>
<td>.2</td>
<td>.2</td>
</tr>
<tr>
<td>Other activities:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-project time</td>
<td>16.8</td>
<td>13.8</td>
<td>9.8</td>
</tr>
<tr>
<td><strong>TOTALS:</strong></td>
<td>100.0 per cent</td>
<td>75.0 per cent</td>
<td>55.0 per cent</td>
</tr>
</tbody>
</table>

Time available to be reallocated to higher-value uses: 25.0 per cent 45.0 per cent

**MAXIMUM POTENTIAL INCREASE IN EFFICIENCY:**

a) Foreseen time use of project engineers if recommendation package 1 is implemented.
b) Foreseen time use if recommendation packages 1 and 2 are implemented.

The percentages estimated for package 1 and for both packages combined rest on a range of calculations. In the case of package 1, much of the saving comes from system improvements. In the case of package 2, further savings of professional time arise from the transfer of lower-value tasks to lower-paid assistants.

2. Next, we shall allocate some of the available time to those activities or functions which can be expected to improve quality and ensure that adequate professional training and development are provided. In this case, increase on-site inspections (quality assurance) and increase training and development (see figure 23.14).
Figure 23.14: Project engineers’ functional time after initial
time reallocation for quality assurance and training

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>ACTUAL % TIME</th>
<th>% TIME REC PKG 1</th>
<th>% TIME REC PKGS 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission-critical:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality assurance</td>
<td>27.0</td>
<td>28.0</td>
<td>23.0</td>
</tr>
<tr>
<td>Project management</td>
<td>30.0</td>
<td>27.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Mission-support:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project support</td>
<td>26.0</td>
<td>12.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Training &amp; prof dev:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training &amp; development</td>
<td>.2</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Other activities:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-project time</td>
<td>16.8</td>
<td>13.8</td>
<td>9.8</td>
</tr>
<tr>
<td>TOTALS:</td>
<td>100.0 per cent</td>
<td>84.5 per cent</td>
<td>64.5 per cent</td>
</tr>
</tbody>
</table>

Time available to be reallocated: 15.5 per cent 35.5 per cent

POTENTIAL INCREASE IN EFFICIENCY: 23.1 per cent 69.6 per cent

3. Next, we shall allocate the remaining time available as appropriate to the office mission and then do a final analysis by type of function to check on what this achieves. We also compare the results of the recommendations with a “desired time allocation” established by the project engineers themselves (see figures 23.15 and 23.16).
Figure 23.15: Project engineers' functional time comparisons after final time reallocations

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>DESIRED % TIME</th>
<th>ACTUAL % TIME</th>
<th>% TIME REC PKG 1</th>
<th>% TIME REC PKGS 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission-critical:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QA Quality assurance</td>
<td>42.5</td>
<td>27.0</td>
<td>34.2</td>
<td>37.3</td>
</tr>
<tr>
<td>PM Project management</td>
<td>42.5</td>
<td>30.0</td>
<td>33.6</td>
<td>37.3</td>
</tr>
<tr>
<td>Mission-support:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS Project support</td>
<td>5.0</td>
<td>26.0</td>
<td>14.4</td>
<td>11.2</td>
</tr>
<tr>
<td>Training &amp; prof dev:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TR Training &amp; development</td>
<td>5.0</td>
<td>.2</td>
<td>4.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Other activities:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NP Non-project time</td>
<td>5.0</td>
<td>16.8</td>
<td>13.8</td>
<td>9.8</td>
</tr>
<tr>
<td>TOTALS:</td>
<td>100.0 per cent</td>
<td>100.0 per cent</td>
<td>100.0 per cent</td>
<td>100.0 per cent</td>
</tr>
</tbody>
</table>

PROJECTED EFFICIENCY INCREASE OVER ACTUAL: 20.0 per cent 60.0 per cent

Figure 23.16: Project engineers' functional time comparisons by type of function after final time reallocation

PROJECTED FUNCTIONAL TIME SHIFT FROM ACTUAL FOR BETTER GOAL DIRECTION: 14.6% 21.8%

POTENTIAL FUNCTIONAL TIME SHIFTS FOR BETTER GOAL DIRECTION
  USING ANALYSIS APPROACH 1: 42.8%
  USING ANALYSIS APPROACH 2 "ACTUAL - DESIRED": 32.8%

4. Finally we shall do a skill/expertise level comparison to ensure that the professionals’ time has been allocated to the higher-skill tasks for which they are paid (figures 23.17 and 23.18).
Module 23
Unit 3

Figure 23.17: After reduction of lower-value activities, and after initial time reallocation for quality and training, but before final time reallocation for efficiency gains

<table>
<thead>
<tr>
<th>SKILL/EXPTISE LEVEL</th>
<th>ACTUAL % TIME</th>
<th>REC % TIME</th>
<th>REC PKGS % TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>1</td>
<td>37.8</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>24.0</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>21.8</td>
<td>20.3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>7.0</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>9.4</td>
<td>9.4</td>
</tr>
<tr>
<td>HIGH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL:</td>
<td>100.0%</td>
<td>84.5%</td>
<td>64.5%</td>
</tr>
</tbody>
</table>

Interpretation of Skill/Exp Levels

1 = Lowest skill or experience.
2 = Paraprofessional level.
3 = Low to mid professional level.
4 = Mid to high professional level.
5 = High professional skill or experience level required.

Figure 23.18: Project engineers’ skill/expertise level comparisons after final time reallocation for efficiency gains

<table>
<thead>
<tr>
<th>SKILL/EXPTISE LEVEL</th>
<th>ACTUAL % TIME</th>
<th>REC % TIME</th>
<th>REC PKGS % TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>1</td>
<td>37.8</td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>24.0</td>
<td>21.6</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>21.8</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>7.0</td>
<td>16.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>9.4</td>
<td>12.0</td>
</tr>
<tr>
<td>HIGH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL:</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

20.0% 60.0% PROJECTED EFFICIENCY INCREASES

It is clear that a combination of packages 1 and 2 will yield the highest efficiency increase. A calculation of the costs of the recommended measures is required and the human resources consequences (redemption, recruitment) need to be studied before an implementation plan is drawn up.

3.3 Applying “productivity of professionals” principles to managers

Managers can be trained to apply these principles to their own jobs, taking a self-analysis approach at the function level. Once the managers’ functions have been identified, an alternative to using “desired percentage of time” on each function is for the managers to rate the level of importance of each function, using such expressions as:
The managers can then think about their actual use of time on each function, and how this compares with the importance ratings. They can then decide which functions to spend less time on, and how to do that, and which functions to spend more time on. Written surveys can be used to help managers carry out their self-analysis.

In the most fundamental way, office management is comprised of dual roles - perceiving and intervening, visualizing and planning, understanding and directing, detecting and controlling. This entails monitoring activities and results, identifying problems, taking corrective actions and assessing their effectiveness, and providing feedback on the need for other changes.

The most important potential areas for improving the effectiveness of office management are as follows:

- Risk analysis
- Resource planning and work scheduling
- Data compilation and reduction
- Utilization analysis
- Performance measurement and enhancement
- Quality reporting and correction
- Service level assurance
- Intervention methodologies
- Change initiation and control
- Problem identification, analysis and solving

Questions for discussion

1. How would an organization want to change the amount of time professional staff spend on the following activities: mission-critical functions, mission-support functions, training and professional development functions and other activities?

2. In what ways might an organization get professional staff to do more higher-skilled, higher-value work?

3. What are the ways to improve managerial effectiveness in office work?
ANNEX I

COLLECTING THE DATA

1. Four main approaches to data collection
   - Real-time trained observer techniques
   - Real-time self-recording techniques
   - Written surveys on perceptions of how staff use their time
   - Use of data from existing records or files

2. Real-time trained observer techniques

Two main variations:
   - **Observers follow the actual activities** of a sample of staff and record start and stop time on a form or timing device
   - **Work sampling**: observer records which staff are doing each activity at specific points in time

Main advantages:
   - enough observers working for a sufficiently long period can provide high levels of statistical precision
   - observers can generally provide highly objective data

Main disadvantages:
   - highest total cost approach: very costly to collect data
   - data handling can also be expensive
   - can be impractical or impossible for many staff or settings
   - hard for observers to remain non-intrusive: staff know they are observed and may change work patterns; reducing accuracy
   - study can “drag out” if seasonality is important

3. Real-time self-recording techniques

Two main variations:
   - **time ladder**: a sample of the staff record activity codes each time they change activity
   - **self-work-sampling**: a sample of the staff record activity codes on a form each time they hear a pre-programmed beeper

Main advantages:
   - a large enough staff sample recording for a sufficiently long period can provide high levels of statistical precision
   - can obtain real-time data on staff who travel and work independently, and activities can be coded for purpose

Main disadvantages:
   - highest data handling costs
   - can be costly and difficult to train the staff to record their time use accurately
   - most prone to inaccuracy: hard to keep staff well-motivated to be complete and accurate
• study can “drag out” if seasonality is important

4. **Written surveys on perceptions of how staff use their time**
   Generally recommended approach for office productivity studies

**Two main variations:**
- **Surveys completed by supervisors:** each person who supervises others in the study (from first line up to the top manager) completes the survey for each person supervised. Generally recommended for organizational diagnostic (may verify by having some lead staff review supervisors’ survey forms).
- **Surveys completed by staff:** all staff members in positions studied complete the survey for themselves. Generally recommended for professional diagnostic. A sample set of completed forms used for this purpose, together with a reference sheet explaining what is meant by each heading, is shown in Annexes II-IV.

Main advantages:
- a complete picture of the work performed can be captured quickly
- much less costly than real time approaches
- can ask special survey questions to capture perceptions of seasonal variations, without extending data collection

Main disadvantage:
- high statistical precision is sacrificed, but it is rarely needed for key decisions on how to improve.

5. **Use of data from existing records or files**
   This approach supplements other data collection approaches

useful, reasonably accurate data are often available from:
- central records: e.g., staff time traveling, in training, or on leave* from central personnel, budget, or expense files
- staff, supervisor, or work unit calendars or historical records may be accurate sources
- it may be wise for staff to verify data from files or records

Main advantages:
- lowest data collection cost
- as a supplement to other approaches, use of records can make the other approaches simpler

Main disadvantages:
- can rarely, if ever, be used to collect all the data needed
- modest extra data handling, programming, and analysis costs.

* Special note: we do not recommend using paid or unpaid leave, vacation, sick leave, etc. as work distribution activities, because they can obscure other activities. Absentee problems are better studied separately. However, leave data may be needed to develop a baseline of the average number of workdays or workhours per staff-year, for calculating other percentages.
Example of Activity Reference Information for
Staff Estimating Their Time Use

Reference information for determining percentage of time estimate
Sample activities for each work process for each purpose:

A. Review or Approval of Client Agency Plans, Applications, and Modifications
   (Annual plan for entire client agencies; applications for all programmes; all modifications.)
   Can include, for example:
   PHONE: Calls to and from client agencies to obtain information and explain corrections needed.
   MEETINGS: Meet with other internal staff reviewing same plan, application, or modification.
   READING, REVIEWING, ANALYSING, ETC: Reviewing original applications or corrections sent in; comparing service targets to previous years; analysing budgets; comparing proposed costs to service targets.
   WRITING, EDITING, ETC: Writing letters requesting corrections and changes; preparing notification of award letters; preparing material for memoranda of understanding, grants and contracts.

B. Formal Assessment (or Monitoring According to a Formal Guide)
   Can include, for example:
   PHONE: Calls to and from client agencies to discuss expectations for assessment visit.
   MEETINGS: Assessment team meetings before and after the assessment visit.
   READING, REVIEWING, ANALYSING, ETC: Reviewing requested documentation sent to you or your team before the assessment visit; reviewing materials after the visit.
   WRITING, EDITING, ETC: Preparing or contributing to the pre-visit letter or the post-visit assessment report.

C. Monitoring Compliance of Client Agencies
   Can include, for example:
   PHONE: Calls to and from client agencies to ask questions, obtain information to help determine compliance issues and otherwise assist monitoring; to discuss expectations for a monitoring visit.
   MEETINGS: Meet with internal staff to obtain information, analysis, or interpretation concerning whether a client agency is in compliance.
   READING, REVIEWING, ANALYSING, ETC: Review, compare, and analyse compliance-related reports or data available in, or sent to, your office (e.g., MIS forms and reports, service level data, client agency board minutes, audit reports, health or sanitation reports, client agency memos of understanding, subcontracts, and procedures).
   WRITING, EDITING, ETC: Write internal memos indicating compliance problems, issues, or progress including internal reports on field monitoring visits; write to client agencies requesting specific information.
ANNEX III

COMPLETED PROCESS DATA COLLECTION FORM:
AGEING SERVICES REPRESENTATIVES

Estimates of time spent in your office or other local offices on broad work processes over five typical days (40 hrs.) of office work

EXCLUDE formal group training of internal or external staff.

Time estimated for items 1-2 and 3.1-3.2 should only involve working with issues or information relating to:

- Anything substantive concerning services for the elderly, advocacy, problems, needs, or trends, whether involving client agencies, subcontractors, legislation, regulations, government agencies, or private organizations.
- Receiving direct personal supervision, on-the-job training, or a supervisor's or manager's evaluation of your work.

Time estimated for item 3.6 should cover all general (not programmatic) administrative tasks done in the office not covered by items 3.3 - 3.5, whether done alone, by phone, or in meetings. Estimate each item to the closest 1/2 hour. End each time estimate with either "0" for whole hours or "0.5" for half hours as appropriate.

Fill in time estimates totalling 40 hrs. for items 1 - 3:

1. PROGRAMMATIC TIME SPENT ON THE PHONE: 8.0 hrs.[1]
2. PROGRAMMATIC TIME IN MEETINGS OR GROUP WORK SESSIONS: 8.0 hrs.[2]
   Include local travel time across hall or floor, to another floor, to another local building.
3. TIME WORKING ESSENTIALLY ALONE PLUS TIME ON ALL GENERAL ADMINISTRATIVE TASKS (sum of 3.1 - 3.6): 24.0 hrs.[3]
   TOTAL OF ITEMS 1 - 3 (should Equal 40.0): 40.0 hrs.

Breakdown of time for item 3:

3.1 READING, REVIEWING, ANALYSING, CALCULATING, or VERIFYING written, printed or computer information: 15.0 hrs. (3.1)

3.2 WRITING, COMPOSING, EDITING, or COMPILING information. Include all handwritten work. Include work on typewriter, computer, or word processor ONLY IF YOU COMPOSE or EDIT IT AT THE KEYBOARD: 5.5 hrs. (3.2)

3.3 TYPING OR DATA ENTRY (typewriter, computer, word processor) from pre-written
work. NOT composing or editing at keyboard: 0.0 hrs. (3.3)

3.4 FILING, STORING, PUTTING AWAY; SEARCHING for or RETRIEVING; TRANSMITTING or SENDING files, reports, letters, other information: 1.5 hrs. (3.4)

3.5 COPYING. Include time to take item to copier or someone to take it for you. If you do job yourself or have it done “while you wait”, include time at machine, on line, and completing any copying forms: 0.5 hrs. (3.5)

3.6 OTHER GENERAL ADMINISTRATIVE TASKS, e.g, making travel arrangements, scheduling rooms and meetings, completing timesheets, reimbursement and other forms: 1.5 hrs. (3.6)

TOTAL 3.1-3.6 (Time working alone plus administrative tasks) should equal item 3 above: 24.0 hrs. [= 3]

23 - 49
### ANNEX IV

**COMPLETED ACTIVITY MATRIX (SUB-FUNCTION VS. PROCES)**

**DATA COLLECTION FORM: AGEING SERVICES REPRESENTATIVES**

<table>
<thead>
<tr>
<th>Percent of office time of each work process listed to the right used for PURPOSES of:</th>
<th>TIME ON THE PHONE</th>
<th>TIME IN MEETINGS or GROUP WORK SESSIONS</th>
<th>TIME READING, REVIEWING, ANALYZING or VERIFYING</th>
<th>TIME WRITING, COMPOSING or COMPILING</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Review or approval of client agency plans, applications &amp; modifications (annual, specific programs)</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>B. “Formal” assessment (or) monitoring according to a formal “Guide”</td>
<td>1</td>
<td>5</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>C. Monitoring compliance of client agencies</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>D. Assisting agencies in achieving compliance</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>E. Helping client agencies improve performance, programs, targeting, systems, practices, or organization BEYOND compliance</td>
<td>40</td>
<td>20</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>F. Advocating new services, programs, or service targeting</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>G. Representing, coordinating, supporting elderly interests &amp; services in State &amp; Federal governments &amp; with professional &amp; service organizations</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>H. Responding to special information requests (e.g., constituent letter, Governor, auditor, legal)</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>I. Assisting in analyzing, improving, or developing internal programs,policies systems, or procedures</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>J. Preparing Monthly Report</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>K. Reviewing reports, articles, or research on aging needs, trends, or services (NOT on specific agencies)</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>L. Receiving on-the-job direction, guidance, evaluation, or technical assistance from a supervisor or manager</td>
<td>0</td>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**YOUR TOTAL FOR EACH PROCESS:** 100 100 100 100

**COLUMN TOTALS SHOULD EQUAL:** 100% 100% 100% 100%
## WORK DISTRIBUTION FORM

### WORK DISTRIBUTION FORMS

**Date:**

**Organization:**

**Month/Day/Year:**

**Your Name:**

**Title:**

**Unit Description:**

**Extension:**

**Unit #:**

**Report To Unit #:**

**Name of Your Immediate Supervisor:**

**Title:**

**List the names of Supervisors/Managers who report to you (Last, First, Initial):**

1. **Name:**
   **Title:**
   **Phone no.:**

2. **Name:**
   **Title:**
   **Phone no.:**

3. **Name:**
   **Title:**
   **Phone no.:**

4. **Name:**
   **Title:**
   **Phone no.:**

5. **Name:**
   **Title:**
   **Phone no.:**

6. **Name:**
   **Title:**
   **Phone no.:**

7. **Name:**
   **Title:**
   **Phone no.:**

**List the major objectives of your department:**

1. 

2. 

3. 

4. 

5. 

6. 

7. 

8. 

9. 

10. 

**COMMENTS**

What are the things that would make your job easier if implemented?

... (Continued on next page)

### ORK DISTRIBUTION FORM

**Instructions:**

To complete this form, please refer to your activity directory, activity classification codes and the service work distribution form.

Please enter employee identification number, name, status, job title, salary and work characterization information on the 00. Those people who report directly to you, but do not supervise others, on lines 01 through 16.

Then, enter their information as detailed above. Continue the list on another worksheet if necessary.

<table>
<thead>
<tr>
<th>Org #</th>
<th>Unit #</th>
<th>Report To</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>02</td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td>03</td>
<td>03</td>
<td>03</td>
</tr>
<tr>
<td>04</td>
<td>04</td>
<td>04</td>
</tr>
<tr>
<td>05</td>
<td>05</td>
<td>05</td>
</tr>
<tr>
<td>06</td>
<td>06</td>
<td>06</td>
</tr>
<tr>
<td>07</td>
<td>07</td>
<td>07</td>
</tr>
<tr>
<td>08</td>
<td>08</td>
<td>08</td>
</tr>
<tr>
<td>09</td>
<td>09</td>
<td>09</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employee ID. #</th>
<th>Last Name</th>
<th>First Initial</th>
<th>Status</th>
<th>Job Title</th>
<th>Activity Code</th>
<th>Salary Grade</th>
<th>Work Shift</th>
<th>% of time spent for each activity</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
UNIT 4: IMPROVING THE PRODUCTIVITY OF CLERICAL STAFF

UNIT 4: LEARNING OBJECTIVES

Once you have learnt this unit you will be able to:

1. Appreciate the potential for improving clerical staff productivity.
2. Apply the organizational work distribution diagnostic to work analysis.

UNIT 4: CONTENTS

4.1 The hierarchy of work
4.2 The organizational work distribution diagnostic
4.3 Defining the analytical framework
4.4 Data collection and reporting
UNIT 4: IMPROVING THE PRODUCTIVITY OF CLERICAL STAFF

Potential productivity improvements are often hidden in the work organization of clerical staff. These potential improvements can be uncovered by a systematic work analysis, using the organizational work distribution diagnostic. "Organization" in this context means every functional group of employees, often working together in a unit or department.

Organizational work distribution analysis aims to:

- enhance organizational effectiveness;
- increase organizational efficiency;
- streamline the organization structure;
- analyse the value of the activities carried out.

It is used for work analysis, activity value analysis and organizational structure analysis and is most relevant to situations in which routine, repetitive tasks are performed. The method can be complemented by work measurement techniques where necessary.

The system is explained below, after an introduction to the hierarchy of work.

4.1 The hierarchy of work

Every organization operates a variety of systems. For instance, every business will have an accounts department, which may consist of about ten sections, carrying out up to a hundred activities each. Every activity is made up of several tasks, each involving a number of methods. One such system (or routine) is the payment of suppliers for goods and services rendered. This system is called accounts payable. The first step in the routine is to check and clear suppliers' invoices. For the sake of the example let us assume a manual system.

When an invoice is received from a new supplier, the vendor first has to be given a "vendor number", since the computer will not accept instructions to write a cheque or carry out a bank transfer without a vendor control number. Assigning a vendor number is an activity which involves looking up the appropriate table in the vendor number list (or ledger) and assigning the next number. That in turn requires the clerk performing the task to walk to the filing cabinet, find the vendor master file, extract it, look up the appropriate table, get the next assignable number, enter it on the invoice and in the ledger, return the ledger to the filing cabinet and return to the desk.

This example shows several levels of the hierarchy:

<table>
<thead>
<tr>
<th>Level</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a system</td>
</tr>
<tr>
<td>1 of 10</td>
<td>a subsystem</td>
</tr>
<tr>
<td>1 of 100</td>
<td>an activity</td>
</tr>
<tr>
<td>1 of 1,000</td>
<td>a task</td>
</tr>
<tr>
<td>1 of 10,000</td>
<td>a method</td>
</tr>
</tbody>
</table>

accounts payable
invoice clearance
assigning vendor numbers for new suppliers
looking up the table and assigning the next number
walking to filing cabinet, extracting file, completing assignment of new vendor number, returning to desk
4.2 The organizational work distribution diagnostic

This diagnostic provides a "snapshot" of the status quo. It is not intended as a method of work measurement, but as a means of ensuring that clerical work is directed as far as possible towards the mission goals of the enterprise and the office. It reveals:

- duplication of work in different parts of an enterprise;
- fragmentation of work, leading to inefficiency;
- poor time allocation favouring less important activities;
- activities being carried out at the wrong level (e.g. “doing” instead of “managing”), or in the wrong units;
- a sub-optimal organization structure, leading to delays in reaction time, communication problems and lack of clarity about responsibility and accountability.

Typically, the framework of the system is the activity level. The diagnostic tools used are:

- a data-gathering technique, based on “activity dictionaries”;
- a mission-related codification of activities;
- a method of analysis; and
- key reports for diagnosis.

Enhance organization effectiveness and efficiency

When implementing an organizational work distribution diagnostic, all work must be categorized in relation to the mission of the organization and the office. This allows activities which do not significantly contribute to the mission to be identified, reduced or eliminated. Some activities will be revealed as “horizontally misplaced”, i.e., they are performed in the wrong unit or department. Others are “vertically displaced” and should be delegated by supervisors to more appropriate grades of staff.

Some activities are performed in several units, which sometimes means a duplication of work. Such activities can be identified and rationalized. Some activities are fragmented, i.e., the work is done partly in one unit and partly in others. This tends to be inefficient, since each worker has to spend time becoming acquainted with the points at issue. The diagnostic reveals such work fragmentation, so that the task can be further examined and consolidated or else eliminated.

Streamline the organization structure

The diagnostic can be applied with or without detail on reporting relationships. If such detail is included, it provides information on the span of control of individual managers and supervisors. In many instances it will be found that managers are responsible for too few subordinates. In addition, the number of management levels is often excessive, leading to cumbersome lines of communication (with the risk of message distortion) and slow, uncompetitive reaction times. Organization charts showing where various kinds of work are performed will usually reveal opportunities to strengthen the organization and clarify issues of responsibility and accountability.
4.3 Defining the analytical framework

In order to carry out an organizational work distribution diagnostic, certain parameters need to be defined clearly:

**Organization structure**

The structure of each "organization" needs to be defined in terms of

- department
- unit
- head
- employee

No matter whether a computerized or manual method is used, a unique number should be assigned to each department, each unit, each employee and each distinct category of work to facilitate data analysis. The numbering system for employees and units should be hierarchical, e.g. organization, department, section, subsection, and employee. “Head” refers to the manager or supervisor; the system then reveals each managerial/supervisory span of control.

**The function - group - activity hierarchy**

A function usually represents a primary organization such as accounts, engineering, production, or sales. Groups are the departments within a function. For instance, within accounts there are usually groups such as general accounting, accounts payable, accounts receivable, cash management and others.

Activities are the work carried out by any member of the function. Each type of activity must be distinct and all identical activities should be given the same number, no matter where they are carried out in the organization. That is what reveals duplication and fragmentation of activities when the analysis is carried out. A diagrammatic representation of the hierarchy concept is shown in figure 23.19.
Activities need to be tightly defined, particularly in so far as they are mission related. That will avoid important activities being overlooked or rationalized out. Less important activities can more easily be lumped together, particularly if certain measures such as central filing, etc. have already been determined before the study.

The activity dictionary

The total list of all activities carried out becomes the activity dictionary (see sample in figure 23.20). The defined activities should be mutually exclusive and collectively exhaustive within any function or group. Mutually exclusive means that each activity is distinct from any other. Collectively exhaustive means that all the activities listed for that function or group comprise all the work that is done within that part of the organization. No work activities have been left out.
<table>
<thead>
<tr>
<th>FUNCTION CODE</th>
<th>GROUP CODE</th>
<th>ACTIVITY CODE</th>
<th>ACTIVITY</th>
<th>ACTIVITY DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Manage the Company</td>
<td>01 Direct Supervision</td>
<td>001</td>
<td>Supervision of Non-supervisory Staff Reporting Directly to Me</td>
<td>Supervising nonmanagement staff employees who report directly to me and controlling their performance against commitments.</td>
</tr>
<tr>
<td>02 Case Processing</td>
<td>01 Settlement</td>
<td>012</td>
<td>Claims Investigation</td>
<td>Identifying and compiling data needed to decide on the validity of a claim and negotiating a settlement.</td>
</tr>
<tr>
<td>03 Marketing</td>
<td>01 Publications</td>
<td>050</td>
<td>Company Publications/Policy Statements</td>
<td>Formulating and disseminating corporate or departmental policy statements, periodicals, and publications to employees, agents, policyholders, regulators, associations, media, etc.</td>
</tr>
<tr>
<td></td>
<td>02 Competition Analysis</td>
<td>062</td>
<td>Assessment</td>
<td>Preparing competition profiles to develop marketing/purchasing/operating plans, strategies, and comparisons.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>064</td>
<td>Rate Analysis</td>
<td>Analyzing rate comparisons to evaluate our relative competitive position, including reporting results. Includes the selection of the primary competitor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>066</td>
<td>Rate Support</td>
<td>Compiling, documenting, and distributing rate comparisons.</td>
</tr>
</tbody>
</table>
A well-defined activity dictionary is critical to a successful analysis. While it may be possible to get ideas from dictionaries defined for other companies, activities vary astonishingly between organizations (even within the same industry) in their purpose and the way they are performed. So do the missions of different organizations. There is no real substitute for effort in this connection. Each organization is unique.

On the one hand it is important not to define too many activities, since that greatly adds to the time and cost of analysis. On the other hand, it is also important to ensure that activities which appear similar but which are in essence different, are defined as separate entities. For example, salespersons may have different types of meetings with their customers, some more clearly related to their mission than others. If so, a distinction should be made between them.

Classifying activities

Activities need to be classified according to their value to the organization. Most ways of classifying them employ four levels of value: critical, essential, non-essential and optional.

<table>
<thead>
<tr>
<th>CRITICAL</th>
<th>MANDATORY</th>
<th>PRIMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESSENTIAL</td>
<td>ESSENTIAL</td>
<td>SECONDARY</td>
</tr>
<tr>
<td>NON-ESSENTIAL</td>
<td>OPTIONAL</td>
<td>VALUABLE</td>
</tr>
<tr>
<td>OPTIONAL</td>
<td>ERROR CORRECTION</td>
<td>OPTIONAL</td>
</tr>
</tbody>
</table>

These levels all relate to the link between the activity and the mission. They are slightly different from the definitions used to classify the functions of professional and managerial staff. However, the purpose is very similar: to separate activities that are critical or very important to the mission from those of lesser importance or not connected with it.

In the list above, the word “OPTIONAL” can be defined in two different ways.

- OPTIONAL to that office or that particular employee, but essential to the larger organization;
- OPTIONAL in the sense that the activity does not add value (or is not related to) the organization’s mission.

Depending on the definition used, one of two questions arises:

- Should this work be done by someone else?
- Should it be done at all?

While some categorizations are widely used, there is no fixed standard. Practitioners use whatever words they like. In view of the high cost of quality, it may also be valuable to categorize quality related activities into the four aspects of prevention, appraisal, internal failure and external failure.

4.4 Data collection and reporting

There are various methods of gathering and reporting data for the study. Once the data have
been collected, six reports are generally used for presenting the results. They are:

- The employee profile report
- The activity value report
- The work distribution report
- The work fragmentation report
- The high to low cost report
- The organization charts

The employee profile report (figure 23.21), is the fundamental document. It reports data collected on individual employees, showing the percentage of time the employees spend on each category of work, as well as the cost of that time. It is important to verify this information before sorting the activity data in different ways.

The activity value report (figure 23.22) provides a breakdown by value of the time and cost of each category of work for each function or unit separately and for the enterprise altogether. It reveals the extent to which different units (and the organization as a whole) use their time on activities of greater or lesser value to the mission and it can highlight opportunities for redirecting activities to higher value ones.

The work distribution report (Figure 23.23) focuses on all the costs of a single activity. It shows how each activity is distributed to employees in different units and on different grades, as well as the value categorization of that work in terms of the unit in which each employee is working.

The work fragmentation report (figure 23.24) provides “fragmentation percentages” and fragmentation ratios (the inverse of percentages) showing how the work is fragmented, i.e., how each type of work is spread across a number of people, often in different units. The report is helpful in determining which activities could be eliminated or consolidated and whether the office has enough cover for sickness and holidays. It also shows the actual and FTE (full time equivalent) number of people engaged in the work. An FTE is based on the assumption that each 40 hours a week spent on a given task is equivalent to the cost of one employee, including salary and fringe benefits. Using an average cost per full-time employee it becomes easy to establish the cost of such work.

The high to low cost report (figure 23.25) shows how the organization’s money is being spent, what percentage of cost is attributable to which activities and what portion of these activities is graded as less important or optional. By combining that with the fragmentation percentage and the FTE calculations emerging from the other analyses, a good picture can be built up of the activities that could be centralized or subcontracted.

The organization charts show spans of control and the logic of the chain of command. They also indicate differences in spans and opportunities to reduce the number of layers of management.

It should perhaps be emphasized again that the data themselves and their analyses merely show up opportunities for improvement and provide some means of assessing the benefits of achieving such improvements.
achievable. They do not, by themselves, suggest what should be done. That is for the practitioner to work out. The diagnostic does not prescribe cures, nor are the best measures necessarily obvious in all cases.

**Figure 23.21: Employee profile report**

<table>
<thead>
<tr>
<th>EMPLOYEE NAME</th>
<th>JOB TITLE</th>
<th>ACTIVITY</th>
<th>VALUE</th>
<th>COST $/TIME UNIT</th>
<th>% TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. KENNEDY</td>
<td>SALES MANAGER</td>
<td>SUPERVISION</td>
<td>I(^1)</td>
<td>4.5</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BUSINESS</td>
<td>C(^2)</td>
<td>4.5</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DEVELOPMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BILLING</td>
<td>1</td>
<td>6.8</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ACCOUNTS</td>
<td>1</td>
<td>20.3</td>
<td>45.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RECEIVABLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>OPERATIONAL</td>
<td>1</td>
<td>9.0</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PLANNING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^2\)CRITICAL \quad \(^1\)IMPORTANT \quad LESS IMPORTANT \quad OPTIONAL

<p>| COST     | 4.5 | 40.6 | 0.0 | 0.0 |
| % TIME   | 10.0| 90.0 | 0.0 | 0.0 |</p>
<table>
<thead>
<tr>
<th>ORGANIZATIONAL UNIT</th>
<th>CRITICAL</th>
<th>IMPORTANT</th>
<th>LESS IMPORTANT</th>
<th>OPTIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>% TIME</td>
<td>$</td>
<td>% TIME</td>
</tr>
<tr>
<td>SALES</td>
<td>100</td>
<td>21.7</td>
<td>300</td>
<td>65.2</td>
</tr>
<tr>
<td>PURCHASING</td>
<td>300</td>
<td>46.1</td>
<td>200</td>
<td>30.7</td>
</tr>
<tr>
<td>ADMINISTRATION</td>
<td>50</td>
<td>22.7</td>
<td>120</td>
<td>54.5</td>
</tr>
<tr>
<td>TOTAL FOR THE ORGANIZATION</td>
<td>450</td>
<td>33.8</td>
<td>620</td>
<td>46.6</td>
</tr>
</tbody>
</table>
Figure 23.23: Work distribution report

<table>
<thead>
<tr>
<th>ORGANIZATIONAL UNIT</th>
<th>VALUE OF THE ACTIVITY</th>
<th>FTE</th>
<th>COST per time unit</th>
<th>NUMBER OF EMPLOYEES: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADMIN</td>
<td>0.23</td>
<td>4.6</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>0.28</td>
<td>6.2</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>0.34</td>
<td>7.5</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>0.25</td>
<td>8.8</td>
<td>3.16</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>0.10</td>
<td>4.5</td>
<td>3.16</td>
</tr>
</tbody>
</table>

employee name | activity | critical | less important | optional | number of employees: 5 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S. BROWN</td>
<td>BILLING</td>
<td>0.0</td>
<td>4.60</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>T. JACKSON</td>
<td></td>
<td>0.0</td>
<td>2.0</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>J. MCMINN</td>
<td></td>
<td>0.0</td>
<td>2.0</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>L. TAYLOR</td>
<td></td>
<td>0.0</td>
<td>2.0</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>M. KENNEDY</td>
<td></td>
<td>0.0</td>
<td>2.0</td>
<td>0.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Figure 23.24: Work fragmentation report

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>PEOPLE</th>
<th>COST/LI &amp; O</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FTE&lt;sup&gt;3&lt;/sup&gt;</td>
<td>% RATIO</td>
<td>$</td>
</tr>
<tr>
<td>DATA ENTRY</td>
<td>3.0</td>
<td>12</td>
<td>4.0</td>
</tr>
<tr>
<td>TYPING</td>
<td>2.1</td>
<td>15</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>32</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>11</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>0.8</td>
<td>30</td>
<td>2.7</td>
</tr>
<tr>
<td>PHOTOCOPYING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATISTICAL COMPILATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FILING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL FOR THE OBJECTIVE ADMINISTRATIVE SUPPORT</td>
<td>7.5</td>
<td>57.2</td>
<td>26.7</td>
</tr>
<tr>
<td>TOTAL FOR THE FUNCTION SECRETARIAT</td>
<td>13.4</td>
<td>382.7</td>
<td>28.4</td>
</tr>
</tbody>
</table>

<sup>3</sup> FTE = FULL TIME EQUIVALENT
<sup>b</sup> LI&O = Less important and optional activities
<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>TOTAL COST</th>
<th></th>
<th></th>
<th>COST LI&amp;O</th>
<th></th>
<th></th>
<th>FTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>%</td>
<td>%CUM</td>
<td>$</td>
<td>%TOTAL</td>
<td>% FRAGMENTATION</td>
<td></td>
</tr>
<tr>
<td>TRAVELLING</td>
<td>127.0</td>
<td>27.6</td>
<td>27.6</td>
<td>18.4</td>
<td>14.5</td>
<td>40.0</td>
<td>3.2</td>
</tr>
<tr>
<td>DATA ENTRY</td>
<td>110.4</td>
<td>24.0</td>
<td>51.6</td>
<td>42.5</td>
<td>38.5</td>
<td>25.0</td>
<td>3.0</td>
</tr>
<tr>
<td>ACCOUNTS RECEIVABLE</td>
<td>90.5</td>
<td>19.6</td>
<td>71.2</td>
<td>4.3</td>
<td>4.7</td>
<td>35.8</td>
<td>5.4</td>
</tr>
<tr>
<td>SUPERVISION</td>
<td>42.7</td>
<td>9.3</td>
<td>80.5</td>
<td>0.0</td>
<td>0.0</td>
<td>42.6</td>
<td>2.3</td>
</tr>
<tr>
<td>NUMBER OF ACTIVITIES: 4</td>
<td>370.6</td>
<td></td>
<td></td>
<td>65.2</td>
<td></td>
<td></td>
<td>13.9</td>
</tr>
<tr>
<td>OTHER ACTIVITIES: 8</td>
<td>89.8</td>
<td>19.5</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>TOTAL NUMBER OF ACTIVITIES: 12</td>
<td>460.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.5</td>
</tr>
</tbody>
</table>
Questions for discussion

1. What is the hierarchy of work and how could it be used to improve the productivity of clerical staff?

2. Describe the uses of the main reports of an organizational work distribution diagnostic.

3. In an activity dictionary for a work distribution diagnostic, the definitions of activities must be mutually exclusive. What other characteristics are important in defining activities for a dictionary?
BIBLIOGRAPHY


Deming, W.E.: *Quality, productivity, and competitive position* (Cambridge, Massachusetts, MIT Center for Advanced Engineering Study, 1982).


GLOSSARY

ABC classification - In inventory management, classification of items in an inventory in decreasing order of volume of annual consumption, usually expressed in monetary value. The inventory items are split in three classes: A, B and C. Class A contains the items with the highest annual consumption, which are given the most attention. The medium class B receives less attention and class C, which contains the low-volume items is checked routinely. The ABC principle states that effort saved through relaxed controls on low value items will be applied to reduce inventories of high value items.

Accelerated depreciation - A system of depreciation accounting where the bulk of the depreciation costs of plant and machinery is charged to the first few years of operation - in contrast to the straight-line method of depreciation- thus providing some tax incentives during the early years in the life of the equipment or plant.

Accounts receivable - Accounts on which monies are due from customers; money collectible by the enterprise.

Action learning - Learning by implementing and gaining experience closely connected with the job.

Architecture - The structure, components and linkages within a computer system.

Area maintenance - A scheme where maintenance teams are assigned to specific production areas; also known as assigned maintenance.

Asset turnover ratio - The ratio of sales, usually for a year, to the total tangible assets of the enterprise.

Assets - Items which the business owns or over which it has a legally enforceable right. The assets include such items as buildings, land, inventories (or stocks), accounts receivable, cash, leasehold property, patents, etc.

Bar code - A series of alternating bars and spaces which represent digitally encoded information, the meaning of which is determined by each bar and space.

Basic time - In time study, the time required for carrying out an element of work at standard rating.

Batch production - A production system where processing of materials or parts is done in discrete quantities (batches); the batch is completely processed at one stage before the whole batch is moved to the next stage.

Bath tub curve - In maintenance, this is the curve which shows a decreasing failure rate during the early life of an equipment item followed by a period of constant rate, and then by an increasing rate of failure towards the end of its life.

Benchmarking - Identifying best practices (of other units within one's own organization, of competitors, or of other relevant organizations) and setting a target for attaining the same or a higher level of performance in order to enhance competitiveness.
Bill of materials - A listing of all the sub-assemblies, parts and raw materials that go into a product or an assembly, showing the quantity of each required to make the product or assembly.

Bottom-up approach - An approach by which productivity improvement ideas originate from the shop floor and are eventually adopted company-wide.

Brainstorming - A process of idea generation, problem solving or decision making. First group members spontaneously contribute their ideas, then the different ideas are analysed and evaluated, and finally, the best alternative is selected.

Break-even chart - A graphical tool showing the total variable costs and fixed costs curve along with the total revenue (price per unit x quantity) curve, for all possible outputs levels. The point of intersection of the total costs and revenue curves is defined as the break-even point, i.e., the level of production or volume of sales where revenues just equal costs.

Breakdown - Interruption of function due to failure.

Buffer stock - The surplus inventory carried to serve as a cushion against running out of items because of random variations in usage, lead time or supply.

Buffer - A storage area in the computer where data are held temporarily until the computer can process them.

Canadian National Award - The Canadian National Awards for Business Excellence were created in 1984 by the Government of Canada to honour businesses in all industry sectors for their outstanding achievements.

Capacity requirement planning - The function of establishing, measuring, and adjusting limits or levels of production capacity considering anticipated demand.

Central processing unit - The equipment and software within a computer system which control the storing and processing of information and act as the focal point for all elements and components of the system.

Centralized maintenance structure - A structure where all maintenance functions are performed by a single organizational unit.

Clean technology - Production technology that achieves maximum utilization of the energy and material inputs into the finished product or service, thus resulting in minimal pollution or waste during the production process.

Co-determination - Various schemes through which employees participate in decision making and management.

Collective bargaining - Negotiations which take place between an employer, a group of employers, one or more employers’ organizations, on the one hand, and one or more workers’ organizations, on the other, for determining working conditions and terms of employment, regulating relations between employers and workers, and/or regulating relations between employers and their organization(s) and workers’ organization(s).

Computer aided manufacturing (CAM) - The use of computers to programme, direct and control production equipment in the processing of a manufactured item.
Computer aided design (CAD) - The use of computers in an interactive engineering design process. Programmes complete the layout, geometric transformations, projections, rotations, magnifications and cross-sections of a part and its relationships with other parts.

Condition monitoring - Continuous observation of equipment in order to detect any deviation from normal behaviour or to provide information on the present condition of the equipment and its evolution.

Condition based maintenance - Also called predictive or auscultative maintenance, a breakdown prevention technique requiring no dismantling of equipment, is based on inspection by listening to the sounds it makes.

Contingency allowance - In time study, a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays, which cannot be measured economically because of their infrequent or irregular occurrence.

Corporate planning - The process of establishing corporate objectives and formulating the policies, strategies, and resource allocations that will best achieve these objectives.

Corrective maintenance - Also called breakdown maintenance or curative maintenance, where repairs are made on equipment only after partial or total stoppage or failure.

Cost of capital - The cost of maintaining the capital invested for a period of time, normally a year. This cost is expressed as a percentage and may be based on such factors as average return on alternative investments, bank interest rates on borrowing, and rate of return that the firm must attain to attract funds in the form of debt and share capital.

Cost centre - The subdivision of an organization for which costs are collected or assigned -such as a lathe department- to enable effective control of costs to be exercised. The criteria in defining cost centres are that the costs should be significant and the area of responsibility clearly defined. A cost centre normally encompasses several work centres.

Cost effectiveness - A analysis of the benefits of a particular expenditure to establish whether the same expenditure could be used more effectively, or whether the same benefits can be attained with less expenditure.

Cost-benefit analysis - A comparison of the costs of resources used in a project or an activity and the value of the benefits to be derived from the project by the beneficiaries and stakeholders, paying particular attention to social costs and benefits which do not normally feature in conventional costing.

Criticality index - The product of the ratings P x S x D where P is the probability of the type of failure occurring, S is the criticality of failure, and D is the difficulty of detecting the failure before the product is actually used by the consumer.

Criticality analysis (CA) - A method of grouping the failures of a system according to the gravity of their consequences in terms of performance, safety, total loss of function.

Cultural subsystem of organizations - Basic values, ideals, ideas and philosophy, habits and rituals, declared aims and objectives, policy and strategy; the core of it is the identity of an organization.

Current assets - Assets of the enterprise normally convertible into cash within one year; these
usually include cash, marketable securities, receivables, inventories and prepaid services.

Custom application - Computer software or programmes specially designed to assist a specific organization to solve a particular problem or control a specific process.

Database - A collection of data and information stored so that they can be updated, sorted and accessed in a useful way.

Decentralized maintenance - An arrangement whereby each production area has its own maintenance crew.

Demand management - The function of recognizing and managing all the demands for products to ensure that the master scheduler is aware of them. It encompasses the activities of forecasting, order entry, order promising, branch warehouse requirements, interplant orders, and service parts requirements.

Deming Award - A quality award system administered by the Union of Scientists and Engineers of Japan since 1951. The awards are given once a year to: (a) those who successfully complete theoretical studies with regard to industrial applications of statistical quality control methods; (b) those who successfully apply the theories; and (c) those who contribute substantially toward the promotion of quality.

Depreciation - The amount by which the value or effectiveness of capital equipment decreases over a period of time, as a result of wear and tear due to use in business operations or obsolescence due to technological advance. In finance, it refers to an allocation of some portion of the original value of the asset against current income to represent the decline in value of the asset as a cost incurred for that period.

Diagnostic - Identification of failures based on symptoms; also a system of checks to test whether a system is functioning as expected.

Direct maintenance costs - Costs which are directly linked to the performance of maintenance work; they include regular maintenance costs, labour costs, equipment costs, supplies and materials costs, training costs, subcontracting costs, etc.

Direct costs - Costs which can be readily attributed or traced to a particular job, operation or product.

Distribution costs - Costs incurred in the marketing and distribution of products.

Down time - The total period during which an item or a production line is not in a condition to perform its intended functions.

Ecology - The study of the relationships between living organisms and their physical environment.

Economic order quantity (EOQ) - The size of the purchase or production order that minimizes total inventory cost, i.e., ordering costs, carrying costs and stock-out costs.

EDP - Electronic data processing

Element - In time study, a distinct part of a specified job or task selected for convenience of
observation, measurement and analysis.

**Employee involvement** - A corporate system under which employees' initiatives are utilized in the decision-making process. The lowest degree of involvement starts with suggestion schemes and reaches the maximum level with participatory management in which employees take part in strategic decisions at a high level.

**Energy audit** - A detailed analysis of energy and material flows undertaken in order to evaluate the efficiency of energy use in an enterprise and to minimize energy loss and wastage.

**Energy equivalent** - The energy content or the consumption of the various forms of energy resource expressed in a common unit of measure such as the energy content of a barrel of oil or in energy units (gigajoules).

**Energy hogs** - Sections or equipment which are major energy consumers.

**Energy balance** - Based on the principle of conservation of matter and energy, equality between the energy inputs of a process and its outputs, plus energy losses incurred.

**Energy efficiency** - A measure of how well the energy inputs are used to produce the outputs of the production process.

**Energy management** - A systematic way of planning, organizing, implementing, monitoring and controlling energy use in an enterprise, with the aim of efficient utilization of energy inputs.

**Energy productivity** - Ratio of the outputs produced by the process or enterprise to the energy consumed in the production process; combines energy efficiency and effectiveness considerations.

**Energy managers** - Those charged with overseeing energy management in an enterprise.

**Energy productivity indices** - Optimal energy consumption per unit of output for a given operation, process or piece of equipment; can also refer to the ratio of current energy productivity to that of a base period.

**Ergonomics** - The study of the relationship between workers and their task, occupation, equipment and work environment. Particularly the application of anatomical, physical and psychological knowledge to the problems arising therein.

**External and internal customers** - External customers are purchasers of products and services in the market. Internal customers are fellow-workers in the subsequent process downstream, such as assemblers for workers in the parts and components manufacturing department, machine operators for maintenance workers, etc.

**Failure mode and effect analysis (FMEA)** - A method for analysing the reliability of equipment where the anticipated conditions of operation are used as a reference to study the most probable types of failure and their effects on the performance of the whole product or the whole system.

**Failure cost** - Costs arising from lost production and other losses due to the unavailability or breakdown of equipment.

**Failure analysis** - Statistical analysis of non-functioning equipment with the objective of
defining appropriate maintenance methods.

**Fatigue allowance** - In time study, a subdivision of the relaxation allowance made for the physiological and psychological effects of carrying out specified work under specified conditions.

**Fault tree analysis** - A systematic analysis of the non-functioning of an item by representing the relation between its main function and the possible faults that can occur, the representation being done in the form of a decision tree.

**Feature code** - An identifying code assigned to a distinct product feature which may contain one or more specific part number configurations.

**First-in first-out (FIFO)** - An inventory flow or costing system where the first materials received are the first issued.

**Fixed assets** - Tangible assets of a long-lasting and unchanging nature, e.g. land, buildings and machinery, which are used for producing and selling the product and services of the business and will not be sold or converted to cash as long as they are useful to the enterprise.

**Fixed costs** - Costs which do not change over a certain interval of time and are unaffected by changes in the volume of production or output, e.g. rent, property tax, salaries of certain personnel.

**Flow chart** - A tool to present graphically what happens in a process or an operation; various elements such as activities, material flow, storage, and equipment are shown.

**Flow diagram** - A graph diagram or model, substantially to scale, which shows where specific activities are carried out and indicates the route followed by workers, materials or equipment in the execution of operations.

**Flow production** - A production process where each job or item of production moves from one operation to the next in sequence.

**Gainsharing** - A generic term used to describe a broad range of systems for sharing with employees the benefits -savings or improved profits- derived from improved organizational performance arising from employee participation in the improvement process.

**Hardware** - The physically tangible elements of a computer system, e.g. processors, visual display, printers, etc.

**Hazardous waste** - That category of waste materials which can cause risk of injury or impairment of health to humans or animals.

**Housekeeping measures** - Energy-saving measures which involve improving the upkeep of the plant and equipment of the enterprise, thereby eliminating energy leakages and unnecessary energy use.

**Human resource strategy** - A policy and plan of action to attract, retain, appraise, reward and develop the kind of people who can best achieve the objectives of the organization.

**Human resource management** - The integrated approach to the planning, development, organization, deployment and utilization of the personnel of an enterprise, and the creation of a work
environment that is conducive to their effective contribution towards attaining the firm's strategic objective.

**IMPROSHARE** - A gainsharing plan -IMproved Productivity through Sharing- developed by Mitchell Fein where the savings derived from reduced actual labour hours to produce a certain number of units of a product (compared to standard labour hours) are shared fifty-fifty by the firm and the employees.

**Indirect costs** - Costs which are not readily attributable or traceable to a particular job, operation or product. Indirect costs such as certain utility costs can be either fixed or variable and are distributed over products through a system of overhead allocation rates.

**Industrial relations** - The relations between employers and employees and between their organizations.

**Information technology (IT)** - A generic term used to refer to all systems of hardware and software used to store, process, access and transmit information and data for any purpose.

**Inventory carrying costs** - The costs incurred due to stocking of materials; includes costs of capital tied up in stock, taxes, insurance, handling, storage, obsolescence and deterioration.

**Inventory control** - A set of measures to ensure that appropriate amounts of raw materials, supplies and finished goods are in the right place, at the right time and at optimum cost.

**Inventory** - A stock of materials, parts, supplies, or finished goods kept for the purpose of meeting future consumption, production or sales demand.

**Inventory turnover ratio** - The ratio of the annual cost of goods sold to the average inventory level.

**Inventory costs** - Costs associated with the operation of an inventory system, notably reordering costs, inventory carrying costs and stock-out costs.

**Job design** - Specification of the activities, tasks and responsibilities of a job.

**Job enrichment** - Expansion of the content of jobs including planning and controlling responsibilities besides carrying out tasks.

**Job enlargement** - Increase of the job's tasks (activities) without an increase in decision-making power and responsibility.

**Job rotation** - A system, usually part of a human resource development plan, of moving managers and employees among jobs to give them experience and know-how.

**Jobbing production** - A production system where manufacturing activities are designed for the particular job and assigned to particular equipment or work centres.

**Just-in-time (JIT)** - A method of minimizing inventory by having the materials and parts arrive at each operation just in time to be used. The implication is that each operation is closely synchronized with subsequent ones. In the narrow sense, just-in-time refers to the movement of materials so as to have only the necessary materials in the necessary place at the necessary time. In the broad sense, it refers to all activities of the manufacturing system which make the just-in-
time movement of materials possible.

*Kaizen* - The Japanese philosophy of gradual, unending improvement of everything in the business.

*Kanban* - A method of just-in-time production which uses standard containers with a single card attached to each. It is a pull system in which work centres which use the parts signal through the card that the feeder operations must replenish the supply of the parts. Kanban means "card" in Japanese.

*Key result area (KRA)* - Key functions where the results of actions significantly contribute to the achievement of organizational objectives.

*Labour productivity* - The output of products or services per unit of labour input measured in work-hours, number of persons, labour costs, etc.

*Lead time* - The period required to perform an activity, e.g. to meet a requisition order or a production order.

*Lean organization* - An enterprise organization emphasizing teamwork, flattening of hierarchies, multiskilling, improved vertical and horizontal coordination, elimination of unnecessary processes and unproductive resources, and continuous performance improvement through workers' participation.

*Linear programming* - A mathematical tool capable of analysing large numbers of alternative ways of scheduling and allocating the limited resources of a production system, thus helping decision makers select the best alternative.

*Load levelling* - Spreading out the orders or scheduling of operations so that the work is spread more evenly over time periods.

*Lot size* - The amount of a particular item that is ordered or produced at one time.

*Machine down time* - The time during which a machine cannot be operated owing to breakdown, maintenance requirements or other reasons.

*Machine capacity* - The potential quantity a machine is capable of producing under planned operating conditions.

*Maintainability* - Property of an item which indicates the ease of maintenance under defined operating conditions. Good maintainability means low average duration of all preventive and corrective maintenance activities during a certain period of time.

*Maintenance echelon* - Also called maintenance level; the different levels of complexity of maintenance intervention; generally 5 echelons are used.

*Make-to-order product* - The final product is produced only after receipt of a customer order. Frequently components with a long lead time are kept in stock so as to reduce delivery time to the customer.

*Make-to-stock products* - The product is shipped from finished goods "off the shelf" or "from stock", finishing does not await receipt of a specific customer order.
Malcolm Baldridge Award - An award system administered since 1988 by the Standards and Technology Administration of the United States Department of Commerce to enhance the competitive position of American industries. The system was initiated to identify quality leaders in American industry which could serve as models for others to follow.

Manufacturing cycle time - The total time of manufacturing a product which includes, handling, set-up, operations, storage, and delays.

Materials productivity - Output of useful products per unit of material inputs.

Method study - The systematic recording and critical analysis of existing and proposed ways of doing work, as a means of developing and applying easier, more effective and lower cost methods.

Method-time-measurement (MTM) - A system of predetermined time standards used in building up standard times for operations.

Mixed maintenance structure - An arrangement by which parts of the maintenance activity are centralized (e.g. planning office, store, workshop) and other parts are assigned to the production areas.

Modularization - Designing and producing components that can be combined or assembled in a variety of ways to produce different final products.

Multi-cost formula - In gainsharing, calculations and formulae that include other costs in addition to labour costs, which are then divided by the sales value of production and used as indicators of performance levels.

Multi-user computer system - A network of computers, input and output devices with common software applications, which is shared by a group of users.

Multiple machine work - A system of work assignment which requires the worker to attend to two or more machines running simultaneously.

Multiple activity chart - A chart on which the parallel activities of more than one subject (worker, machine or item of equipment) are each recorded on a common time scale to show their interrelationships.

Observed time - In time study, the time taken to perform an element or combination of elements obtained by direct measurement, e.g. by means of a stop-watch.

Operations research - Application of the scientific approach to complex problems arising in the operation and management of large systems of people, machines, materials and money in industry, business, government, etc. It is a quantitative approach to problem solving using mathematical models and analytical techniques permitting the comparison of a large number of alternative decisions and the selection of the optimal one.

Order entry - The process of accepting and translating what a customer wants into terms used by the manufacturer. This can be as simple as creating shipping documents for finished products, or a more complicated series of activities including engineering for make-to-order products.

Organization development - A planned organization-wide effort to help the members of an
organization to work effectively together to attain organizational goals.

*Organizational culture* - The mix of attitudes, values, beliefs, and typical patterns of relationships, behaviour, and performance that characterize the organization.

*Owners' equity* - The excess of a firm's assets over its liabilities; it represents the interest of the owner in the business.

*Pareto analysis* - A technique for identifying the vital-few from the trivial-many, used for determining major factors responsible for a problem, e.g. types of failure that cause most of the breakdowns, inventory items that tie up the most capital, products that contribute most to profitability, operations that cause most of the defects.

*Partial productivity measures* - Productivity measures that look at the ratio of the output to a single input, e.g. labour, capital, materials or energy. Examples are output per work-hour, output per employee, and output per unit of energy input.

*Participation* - Generic term for a variety of ways of increasing the involvement and commitment of employees to their own jobs and to corporate goals, usually through involvement in performance improvement, consultation mechanisms and joint decision making.

*Participative management* - A style of management that lays stress on workers' participation in decision making, ranging from problem solving at the workplace to consultation at corporate level.

*Planned maintenance* - Maintenance work which is known to be necessary, so that it can be planned and scheduled beforehand.

*Policy* - A statement of general principles, goals and procedures intended to guide and determine present and future decisions.

*Pollutants* - Substances that impair the physical environment or cause injury to the health of humans and animals.

*Power strategy for change* - A change of organization brought about by using power instead of convincing, training, involving people in preparing and implementing change.

*Predetermined time standards (PTS)* - A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job - which is made up of combinations of the basic motions - at a defined level of performance.

*Process layout* - A system of plant layout where production facilities and equipment are grouped according to the functions and processes they perform.

*Process consulting* - An approach where the consultant attempts to help the client organization solve its own problems by making it aware of organizational processes, of their likely consequences, and of intervention techniques for stimulating change. Instead of passing on technical knowledge and suggesting solutions, the process consultant's primary concern is to pass on an approach, methods and values which will help the client organization diagnose and solve its own problems.
Product life cycle - The four stages (introduction, growth, maturity and decline) that a product normally goes through during its presence in the market.

Product layout - A system of plant layout where production facilities and equipment are grouped according to the product range or groups they are used to produce.

Product cost structure - A cost breakdown of the product indicating the percentages of the various elements of costs that go into production.

Product-oriented organization - An organization structured into units which are equipped and to produce a product or product family independently.

Production control - The function of planning, directing and regulating the movement of goods through the entire manufacturing cycle from requisitioning of raw materials to delivery of finished products to inventory.

Production lead time - The time from the beginning of the production cycle to delivery of the final product.

Production capacity - The volume of output of a production equipment or facility under planned operating conditions.

Production schedule - A plan to manufacture a quantity of a specific item in a specific time.

Productivity bargaining - Negotiations between an employer and workers' representatives to reach a collective agreement on issues relating to the productivity improvement programme of the company, e.g. impact on employment, work assignment, participation, and gainsharing.

Profit sharing - A system where the enterprise shares company profits with employees, through bonuses and additional compensation, usually given at the end of the fiscal year. It is generally based on a definite formula specifying how much of the profit is to be distributed, how it is to be computed and how it will be shared.

Project network techniques (PNT) - A group of techniques for the description, analysis, planning and control of projects which consider the logical interrelationships of all activities. It includes techniques concerned with time, resources, costs, and other factors such as uncertainty.

Quality - The degree to which a product or service meets the standards and specifications on its nature, properties, dimensions, functions, performance, costs, etc. relative to its intended use and customer expectations.

Quality circles - A small group of employees in the same work area who voluntarily meet regularly to identify, analyse, and solve work-related problems or self-improvement needs leading to improvement in total performance and enrichment of working life.

Rating - In time study, assessment of the rate of working by the worker being observed relative to the analyst's concept of a normal pace. It also refers to the numerical value used to denote the rate of work.

Reconditioning - In maintenance, restoring an item to its original condition or function.

Recycling - The recovery and reuse of scrapped, wasted or discarded materials.
Rehabilitation - Operations performed on an item of equipment or an installation which has lost part of its ability to function; aimed at restoring or improving its performance.

Relaxation allowance - In time study, an addition to the basic time intended to enable the worker to recover from the physiological and psychological effects of carrying out the work under a specified condition. The amount of allowance will depend on how strenuous the job is.

Reliability - The probability that - under well-defined conditions - an item or equipment will assure a required function over a certain period of time.

Resource consulting - Also referred to as expert consulting. The consultant helps the client by providing technical expertise.

Retrofitting - Installing an energy-saving device after a plant or an equipment item has been installed and begun operating.

Return on investment (ROI) - The ratio of operating income (sales - cost of sales and other expenses) to the average value of total assets (current + fixed); this is the rate of return on capital employed.

Revenue - The amount of money that the business earns as result of selling goods or services to customers.

Routing - A document for the manufacture of a particular item which specifies the materials required, sequence of operations, work centres where the operations will be performed, machines and equipment to be used, transportation, storage, inspection required, etc.

Rucker plan - A gainsharing plan based on value-added labour productivity as the measure of overall performance of a work group. Its goal is to improve - through employee involvement - the output value (value added) for a given input value of payroll.

Scanlon plan - An organization-wide performance improvement plan designed to increase productivity through greater efficiency and reduced costs. The basic elements of the plan are the philosophy and practice of cooperation, the employees' involvement system, and the formulas to measure increased productivity and distribute the resulting gains.

Scrap rate - The percentage difference between the amount or number of units of product started in a manufacturing process and the amount or number of units completed at an acceptable quality level.

Sensitivity analysis - A "what if" analysis whereby the effects on the solution of a problem are analysed as the values of some parameters are varied or as some assumptions are changed.

Service parts - Parts used for the repair and/or maintenance of an assembled product. Typically they are ordered and shipped at a date later than the shipment of the product itself.

Set-up time - The time required to prepare a machine for a particular job. It includes removing the fittings used in previous tasks, cleaning, and fixing the tools necessary for the new job.

Shared savings contract - A scheme whereby the fees paid to an energy service company that installs energy-savings measures in an enterprise are calculated as a percentage of actual savings generated.
Small group activities - A generic name for a participatory approach to productivity improvement where enterprise staff - through small problem-solving groups - voluntarily participate in finding solutions to productivity problems or improving working conditions.

Social subsystem of an organization - This covers the overall structure of the organization, the individual jobs and functions, leadership styles, social climate, roles and relationships.

Soft loans - Loans that are given at low rate of interest, with liberal repayment terms.

Software - Programmes or instructions which control the operations of a computer system.

Stakeholders - Those who will be affected by an action, a decision, a policy, or the success or failure of an enterprise.

Standard time - The total time to complete a job at standard performance.

Standard performance - In time study, the rate of output which qualified workers will naturally achieve as an average without overexertion during the working day or shift, provided that they adhere to the specified method and apply themselves to their work. This performance is denoted as 100 in the standard rating and performance scale.

Technology modification - Energy-saving measures involving changes in production processes or major production equipment.

Therblig - The name given by Frank B. Gilbreth to each of the specific division of movement, according to the purpose for which the division is made. Therbligs cover movements or reasons for absence of movement.

Time study - A work measurement technique for recording the times and rates of performing the elements of a specified job carried out under specified conditions, and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.

Top down approach - Productivity improvement ideas and directives handed down by top management.

Total quality management (TQM) - A total, integrated organization-wide approach - involving all units of the organization and all managers and employees - aimed at ensuring that the processes, products and services of the business meet customer quality needs and expectations.

Total factor productivity - Productivity measures that look at the ratio of outputs to combined inputs, usually labour and capital. Ideally, however, all inputs must be considered.

Total productive maintenance (TPM) - A maintenance management approach that looks at maintenance as a productive function, and considers that it should be the concern of every unit in the enterprise; all levels in the organization must cooperate in ensuring the productive functioning of equipment and physical facilities.

Training costs: direct and indirect - Direct training costs are those that immediately arise from training activities e.g., salaries of trainers, administrative costs of training events, costs related to accommodation, training venue, equipment, etc. Indirect training costs are less easily identified and measured, but are still incurred as a result of training activity, e.g. cost of lost production time, opportunity costs, etc.
Tribology - The technology and service of lubrication.

Turnover - The number of times that assets such as raw materials or personnel are replaced during a stated period, usually a year. Also used to refer to sales during a certain period.

Two-handed process chart - In motion study, a process chart in which the movements of a worker's hands (or limbs) are recorded in their relationship to one another.

Universal maintenance standards - Standard time for the performance of specified maintenance tasks.

Waste management - The techniques and methods of waste prevention, reduction, recovery and disposal.

Work sampling - A work measurement technique using statistical sampling and random observation of work to determine the percentage of occurrence of particular work elements or activity and using these percentages to derive the time devoted to each activity over a certain period.

Work factor - A system of predetermined time standards.

Work measurement - The application of techniques to establish the time required for a qualified worker to carry out a specified job at a defined level of performance.

Work simplification - The organized application of common sense and questioning to arrive at easier and better ways of doing work.

Work study - A generic term for techniques - particularly method study and work measurement - which are used in the examination of human work and all the factors which affect its performance, with the objective of effecting improvements.

Work-in process - The partly finished product of a manufacturing concern, also known as work in progress or goods in process.

Zero-defects strategies - A programme for attaining quality improvement by involving workers in the quality control process so that they produce outputs without defects directly during the production process.